Mandatory disclosure of conflicts of interest: Good news or bad news?*

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Abstract

We investigate the welfare effect of disclosure of conflict of interest when an expert advises a client. In a model with verifiable information and uncertainty about the direction of the expert's conflict of interest and the informedness of the expert, we show that disclosure of the expert's bias is counterproductive when the magnitude of the expert's bias is not too large and the likelihood of the expert being informed is low. Moreover, the harm of disclosing the expert's conflict of interest is more significant when there is a larger uncertainty about the nature of the expert's conflict of interests.
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1 Introduction

Consider a scenario in which a homeowner wants to install solar panels at her house and is presented with two options: leasing or purchasing solar panels. One option may dominate the other depending on the productivity of solar panels, shade around her house, and the terms of government subsidies. She may not have gathered all the relevant information for decision making and has to rely on a salesman for recommendations. Nevertheless, the salesman may bias toward one of the options based on the structure of his commission, which is usually unknown to clients.[1] Decision-makers face similar problems when they seek advice from financial advisors, medical professionals, or politicians. It is often argued that such conflicts of interest should be disclosed in order to better inform the decision makers.

In this paper, we formally study this problem in a theoretical model of information transmission, where a biased expert communicates with a client who is uncertain about the direction of the expert's bias. We investigate whether and when mandatory disclosure of the expert's bias can improve the client's welfare. Conventional wisdom suggests that mandatory disclosure policy in principle enhances transparency and hence improves information transmission and benefits the client. However, much discussion has been focused on whether conflicts of interest should be avoided altogether or mere disclosure of such conflicts of interests would be deemed sufficient.[2] Academic researchers have come to different conclusions on this subject, both theoretically (Li and Madarasz, 2008) and experimentally (Cain et al., 2005; Chung

[1] For expositional convenience, we use "he" to refer to the advisor/expert/sender and "she" to the client/decision-maker/receiver.

[2] RBC Capital markets, for example, requires that "Research Analysts (and their Household Members, as defined in our internal Research policies) shall ordinarily not hold or trade the securities of any company that they cover or anticipate covering, or any company in the coverage sector that they cover." However, "In exceptional circumstances, RBCCM may approve such a holding which will be disclosed in the Research Analyst's research reports." See RBC Capital Markets (2019).

and Harbaugh, 2019; Ismayilov and Potters, 2013).[3] In this paper, we focus on an important consideration in such environments, namely, the type of information the expert holds and the way he could communicate it to the client. We identify environments in which mandatory disclosure of the expert's conflicts of interest may hurt clients. In particular, we show that when the magnitude of the expert's conflict of interest is not too large and the likelihood of the expert being informed is low, mandatory disclosure of conflicts of interest is harmful to the client. Moreover, the harm of mandatory disclosure of conflicts of interest is more significant if there is a larger uncertainty about the direction of the expert's bias. Our study identifies a novel tradeoff between transparency about conflicts of interest and utilization of the expert's information. In particular, the informed expert's feigning ignorance when he has unfavourable information would cause the client to draw unwarranted inference from the uninformed expert's inability to produce information. When the conflict of interest of the expert is not disclosed, this negative effect is smaller.

In our theoretical model, we adopt Crawford and Sobel's (1982) setup where the state is drawn from an interval and the expert and the client have preferences that are represented by quadratic loss functions. However, we assume information is hard, in the sense of Milgrom (1981). We focus on the case in which the expert can either fully disclose its information or stay silent, like Bhattacharya and Mukherjee (2013). There are two types of uncertainties about the characteristic of the expert–he could be informed about the state or not, also following Bhattacharya and Mukherjee (2013), and his conflicts of interest with the client could be one of two possible values, following Li and Madarasz (2008).

In previous work, Seidmann and Winter (1997) generalize Milgrom's (1981) "unravelling" result to the case where there is not a straightforward delineation between

[3]Loewenstein et al. (2014) provide a review of the relevant literature, with a special focus on behavioural models and experimental evidence.

"good news" and "bad news."[4] In particular, they show that in the uniform-quadratic case of Crawford and Sobel (1982), full revelation is a plausible equilibrium if the expert is able to make any true statement in the form of "the state of the world is in set S," and only such statements.

Li and Madarasz (2008) consider information transmission in a setting where Receiver does not know the *direction* of the bias of Sender, and show that in the "uniform-quadratic" setup if Sender can only use *cheap-talk* messages, both Sender and Receiver are strictly better off from not having the bias of Sender disclosed, as long as the magnitude of Sender's bias is not too big. Although our results share some similarity with Li and Madarasz (2008), the driving forces for the results are very different. In our model, the expert is not always informed and mandatory disclosure policy is harmful to the client when the expert is uninformed. In fact, in our setting, mandatory disclosure of interests benefits the client if the expert is always informed. By contrast, Li and Madarasz (2008) assume that expert is always perfectly informed.

Our theoretical framework is related to that of Shavell (1989) and Bhattacharya and Mukherjee (2013), who like us consider verifiable information and "reveal or not reveal" communication strategies. However, they do not consider uncertainty about Sender's bias. Wolinsky (2003) studies a model of communication with verifiable information and some uncertainty about Sender's preferences, but the form of uncertainty is different and he does not consider welfare consequences of disclosure of conflicts of interest.

2 Model

We consider a sender-receiver game in which both players have quadratic loss preferences. Sender's payoff is denoted by $u(\theta, y, \beta) = -\left(y - (\theta + \beta)\right)^2$ and Receiver's

[4]See Hagenbach et al. (2014) for a further generalization of their finding.

payoff is denoted by $v(\theta, y) = -(\theta - y)^2$, where θ is the state of the world, y is Receiver's action, and β is the random bias of Sender. We assume that θ is uniformly distributed on the interval $[0, 1]$, and $\beta \in \{-b, b\}$, with $b > 0$.

It is common knowledge that Sender is perfectly informed about θ with probability $qin(0, 1)$ and is uninformed with the complementary probability, and that Sender has a positive bias with probability $p \in (0, 1)$. Whether or not Sender is informed about the state of the world and the direction of his bias is Sender's private information.

Sender sends Receiver a verifiable message. He can withhold information but cannot lie about the state of the world. Sender's type is denoted by $t \in \{t_i, t_u\}$, where t_i denotes the informed sender (Expert) and t_u denotes the uninformed sender (Quack). When Expert learns the state of the world, he either truthfully reports it or reports no information. Hence, Expert's strategy is $m(\theta) \in \{\theta, \emptyset\}, \forall\theta \in [0, 1]$, where $\emptyset$ denotes no information. Quack sends the message $\emptyset$. After receiving Sender's message, Receiver takes an action $y \in [0, 1]$, and Receiver's strategy is $Y : [0, 1] \cup \emptyset \to [0, 1]$.

We characterize the perfect Bayesian equilibria when Sender does not disclose his bias and when he is required to do so.

3 Baseline

We begin with the baseline in which Sender's bias is upward or downward with equal probabilities, i.e. $p = \frac{1}{2}$. We analyze the equilibrium with general p in Section ***.

3.1 No Disclosure

To proceed, we first analyze the equilibrium when Sender does not disclose the direction of his bias. The analysis of equilibrium with mandatory disclosure of Sender's bias and the welfare implication of the disclosure policy follows.

Because Sender cannot lie about the sate of the world, in any perfect Bayesian equilibrium, Receiver either receives a message perfectly revealing the state of the world or the message $\emptyset$ indicating no information. Upon receiving the perfectly revealing message, Receiver takes an action which matches the message and obtains the payoff 0. Given Receiver's action, Sender's payoff is $u(\theta, y, \beta) = -(\beta)^2$.

If Receiver receives the message $\emptyset$, she forms the expectation about the state of the world based on the prior about Sender's type, the distribution of Sender's bias, and Sender's equilibrium strategy. Receiver then takes the action denoted by $y_\emptyset$ to maximize her expected payoff.

Now, consider the informed sender's decision about which message to send. Sender obtains $u(\theta, \theta, \beta) = -(\beta)^2$ by sending the truth revealing message and $u(\theta, y_\emptyset, \beta) = -(y_\emptyset - (\theta + \beta))^2$ by sending the no information message $\emptyset$. Because $u(\theta, \theta, \beta)$ is constant in θ and $u(\theta, y_\emptyset, \beta)$ is concave in θ, Sender prefers to withhold information if and only if $\theta \in (\max\{y_\emptyset - \beta - |\beta|, 0\}, \min\{y_\emptyset - \beta + |\beta|\})$[5]. Hence, Sender will send the message $\emptyset$ for $\theta \in (\max\{y_\emptyset - 2b, 0\}, y_\emptyset)$ if he has a positive bias and for $\theta \in (y_\emptyset, \min\{y_\emptyset + 2b, 1\})$ if he has a negative bias.

Upon receiving the message $\emptyset$, Receiver updates her expected state of the world to

$$E(\theta|\emptyset) = Pr(t_u|\emptyset)E(\theta|t_u, \emptyset) + Pr(t_i|\emptyset)\left[Pr(b|t_i, \emptyset)E(\theta|b, t_i, \emptyset) + Pr(-b|t_i, \emptyset)E(\theta|-b, t_i, \emptyset)\right], \quad (1)$$

where $Pr(t_u|\emptyset)$ is the probability that Sender is uninformed conditional on message $\emptyset$, $E(\theta|t_u, \emptyset)$ is the conditional expectation of θ when Sender is uninformed and sends $\emptyset$, $Pr(b|t_i, \emptyset)$ is the probability that Sender is upward biased conditional on that he is informed and sends $\emptyset$, and $E(\theta|b, t_i, \emptyset)$ is the conditional expectation of θ when Sender is informed, has the positive bias, and sends message $\emptyset$. The terms $Pr(t_i|\emptyset)$,

[5]Sender is indifferent between whether or not to report the state of the world when $\theta \in \{y_\emptyset - \beta - |\beta|, y_\emptyset - \beta + |\beta|\}$, and we assume that Sender reports the state of the world when he is indifferent.

$Pr(-b|t_i, \emptyset)$, and $E(\theta|-b, t_i, \emptyset)$ are defined analogously. Given that Receiver has the quadratic loss function, her optimal action upon message $\emptyset$ equals her expected state of the world. Hence, Sender's equilibrium action $y^*_\emptyset$ satisfies

$$y^*_\emptyset = E(\theta|\emptyset). \tag{2}$$

Note that the right hand side of (2) is a function of $y^*_\emptyset$ because Receiver's expected state of the world conditional on $\emptyset$ depends on Sender's equilibrium strategy, which in turn depends on Receiver's equilibrium action following the message $\emptyset$. Given our assumption on the distribution θ, there is a unique $y^*_\emptyset$ satisfying (2).

We characterize the unique perfect Bayesian equilibrium outcome in the following proposition:

Proposition 1. *There exists a unique equilibrium outcome with the following feature:*

- *If $b \leq \frac{1}{4}$, The upward biased Expert withholds information if and only if $\theta \in (\frac{1}{2} - 2b, \frac{1}{2})$ and the downward biased Expert withholds information if and only if $\theta \in (\frac{1}{2}, \frac{1}{2} + 2b)$. Receiver takes the action equal to the message if the message reveals the state of the world, and takes the action $y^*_\emptyset = \frac{1}{2}$ following the message $\emptyset$. Receiver's expected payoff is $E(v) = -\frac{8qb^3}{3} - \frac{1-q}{12}$.*

- *If $b > \frac{1}{4}$, The upward biased Expert withholds information if and only if $\theta \in [0, \frac{1}{2})$ and the downward biased Expert withholds information if and only if $\theta \in (\frac{1}{2}, 1]$. Receiver takes the action equal to the message if the message reveals the state of the world, and takes the action $y^*_\emptyset = \frac{1}{2}$ following the message $\emptyset$. Receiver's expected payoff is $E(v) = -\frac{q}{24} - \frac{1-q}{12}$.*

Upon receiving the message $y_\emptyset$, Receiver infers that she is in one of the three scenarios: i) Sender is uninformed, ii) Sender is informed and upward biased, and decides to withhold information, and iii) Sender is informed and downward biased, and decides to withhold information. Because the ranges of states in which the upward and downward biased Expert withholds information are symmetric around $\frac{1}{2}$, Receiver's expected state conditional on the message $\emptyset$ is $\frac{1}{2}$. Hence, it is optimal for Receiver to take the action $\frac{1}{2}$ when Sender withholds information.

Given that Receiver takes action $\frac{1}{2}$ following the message $y_\emptyset$, the upward biased Expert strictly prefers to truthfully reporting the state when it is greater than $\frac{1}{2}$ and withholding information for states lower than and close to $y_\emptyset$. Similarly, the downward biased Expert strictly prefers to truthfully reporting the state when it is lower than $\frac{1}{2}$ and withholding information for states greater than and close to $y_\emptyset$.

The range of states in which Expert withholds information depends on b, the magnitude of his bias . If $b < \frac{1}{4}$, Expert withholds information for states in an intermediate range and reports information for states close to the two extremes. Moreover, the range of states in which Expert withholds information shrinks in the magnitude of Sender's bias. When $b < \frac{1}{4}$, Sender and Receiver's ideal actions are not far apart. If the state is close to the extremes, it is too costly for Expert to induce the action $\frac{1}{2}$ by withholding information, and he is better off truthfully reporting the state. Sender and Receiver's preference are more aligned when Sender's bias is smaller. Hence, the range of states in which Expert withholds information shrinks in b. If $b \geq \frac{1}{4}$, Expert does not care much about the state and wants to induce the action as close as possible to the extremes. In this case, the upward biased Expert withholds information as long as the state is below $\frac{1}{2}$ and the downward biased Expert withholds information as long as the state is above $\frac{1}{2}$. In equilibrium, Receiver only learns half of the states.

3.2 Disclosure

In this subsection, we analyze the equilibrium when disclosure of bias is mandatory. Receiver knows the direction of Sender's bias but does not know whether or not Sender is informed. Similar to the case of no disclosure, in any perfect Bayesian equilibrium, Receiver either receives a perfectly revealing message or the message $\emptyset$. Suppose that Sender is upward biased. Following the same argument in the case of No disclosure, the upward biased Sender prefers to withhold information if and only if $\theta \in [\max\{0, y_\emptyset - 2b\}, y_\emptyset)$. Upon receiving the message $\emptyset$, Receiver's expected state of the world is

$$\begin{aligned} E(\theta|\emptyset, b) =& Pr(t_u|\emptyset, b)E(\theta|\emptyset, b, t_u) + Pr(t_i|\emptyset, b)E(\theta|\emptyset, b, t_i) \\ =& \frac{1-q}{q(y_\emptyset - \max\{0, y_\emptyset - 2b\}) + (1-q)} \frac{1}{2} + \\ & \frac{q(y_\emptyset - \max\{0, y_\emptyset - 2b\})}{q(y_\emptyset - \max\{0, y_\emptyset - 2b\}) + (1-q)} \frac{\max\{0, y_\emptyset - 2b\}) + y_\emptyset}{2}. \end{aligned} \tag{3}$$

Receiver's expected utility is maximized by $y_\emptyset = E(\theta|b, \emptyset)$. Since Sender's bias is symmetric, the analysis for the downward biased Expert is similar to the upward biased Expert.

Proposition 2. *There exists a unique perfect Bayesian equilibrium outcome with the following feature:*

- *Suppose $b < \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$. If the informed Sender is upward biased, Receiver takes the action $y_\emptyset^b = \frac{1}{2} - \frac{2qb^2}{1-q}$, and Sender withholds information if and only if $\theta \in (y_\emptyset^b - 2b, y_\emptyset^b)$. If the informed Sender is downward biased, Receiver takes the action $y_\emptyset^{-b} = \frac{1}{2} + \frac{2qb^2}{1-q}$, and Sender withholds information if and only if $\theta \in (y_\emptyset^{-b}, y_\emptyset^{-b} + 2b)$. Receiver's expected utility is $E^d(v) = -(1-q)\left(\frac{4q^2b^4}{(1-q)^2} + \frac{1}{12}\right) - \frac{8qb^3}{3}$.*

- *Suppose $b \geq \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$. If the informed Sender is biased upward, Receiver takes the action $y_\emptyset^b = \frac{\sqrt{1-q}}{1+\sqrt{1-q}}$, and Sender withholds information if and only if $\theta \in [0, y_\emptyset^b)$. If the informed Sender is downward biased, Receiver takes the action $y_\emptyset^{-b} = \frac{1}{1+\sqrt{1-q}}$, and Sender withholds information if and only if $\theta \in (y_\emptyset^{-b}, 1]$. Receiver's expected utility is $E^d(v) = -(1-q)\left((y_\emptyset^b + \frac{1}{2})^2 - \frac{1}{12}\right) - \left(\frac{q(y_\emptyset^b)^3}{3}\right)$.*

When Sender's bias is known, Receiver's action upon message $\emptyset$ depends on whether Sender has the upward or downward bias. Expert's reporting strategy is similar to the equilibrium under no disclosure except that Receiver's action following message $\emptyset$ is $y_\emptyset^b$ for upward biased Expert and $y_\emptyset^{-b}$ for downward biased Expert.

Note that $y_\emptyset^b < \frac{1}{2} < y_\emptyset^{-b}$. So, If Sender withholds information, Receiver will take an action against Sender's bias. To see the intuition, consider the upward biased Sender. If Sender withholds information, Receiver infers that either Sender is uninformed or is informed but the state is low. If the Sender is uninformed, Receiver's expected state is $\frac{1}{2}$, but if the Sender is informed, the expected state is lower than $\frac{1}{2}$. Therefore, following the message $\emptyset$, Receiver's expected state is the weighted average of her posteriors conditional on Sender being informed and being uninformed respectively, where the weight is the probability that Sender is informed. As a result, it is optimal for Receiver to take an action lower than $\frac{1}{2}$. The intuition for Receiver's action following the message $\emptyset$ when Sender is downward biased is analogous.

When Sender withholds information, Receiver's actions are closer to the extremes if Sender is more likely to be informed (q is larger). If Sender is perfectly informed ($q = 1$), the unraveling argument holds and Sender reports all states.

3.3 Welfare

Proposition 3. *Define* $\hat{b}(q) \equiv \left(\frac{\sqrt{1-q}}{1+\sqrt{1-q}}\right)^{\frac{2}{3}} \left(\frac{3+\sqrt{1-q}}{32(1+\sqrt{1-q})}\right)^{\frac{1}{3}}$. *Disclosing Sender's bias reduces Receiver's welfare if* $b \leq \hat{b}(q)$ *and increases Receiver's welfare if* $b > \hat{b}(q)$.

Proposition 3 says that for a fixed q, disclosing Sender's bias reduces Receiver's utility for small biases and increases Receiver's utility for large biases. The intuition is best understood when $b < \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$. Recall that Receiver's expected utility is $E(v) = -\frac{1-q}{12} - \frac{8qb^3}{3}$ without disclosure and is $E^d(v) = -(1-q)\left(\frac{4q^2b^4}{(1-q)^2} + \frac{1}{12}\right) - \frac{8qb^3}{3}$ with disclosure. Comparing $E(v)$ and $E^d(v)$ side by side, the difference is $E(v) -$

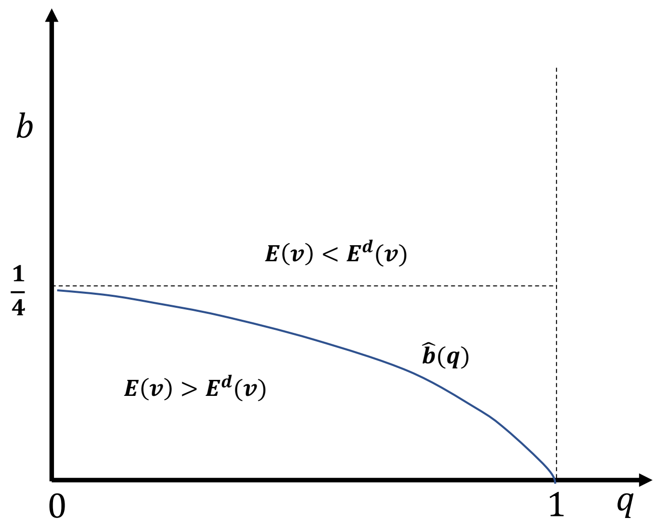

Figure 1: Comparison between disclosure and no disclosure.

$E^d(v) = \frac{4q^2b^4}{1-q} > 0$. It is easy to see that the gain from concealing Sender's bias stems from the scenario when Sender is uninformed, which occurs with probability $1-q$. If Sender does not have any information about the state, Receiver should take the action $\frac{1}{2}$ which maximizes her utility given the prior belief. So, Receiver takes the optimal action when Sender is uninformed under no disclosure and her expected utility in this case is $-\int_0^1(\frac{1}{2}-\theta)^2d\theta = -\frac{1}{12}$. By comparison, under disclosure, Receiver's action following the message $\emptyset$ is distorted away from $\frac{1}{2}$, resulting in an additional loss $\frac{4q^2b^4}{(1-q)^2}$ relative to the case with disclosure if Sender is uninformed.

Lemma 1. *Mandatory disclosure policy improves Receiver's welfare if Sender is more likely to be informed or has a large bias, and reduces Receiver's welfare if Sender is less likely to be informed or has a small bias.*

The cutoff bias $\hat{b}(q)$ is decreasing in q. We illustrate Receiver's utility with and without the disclosure policy in Figure 1. Concealing Sender's bias dominates disclosing the bias in the region below the downward sloping curve $\hat{b}(q)$ and vice versa in the region above the curve.

4 Conclusion

In this paper, we have studied the effect of disclosure of conflicts of interest on communication between an expert and a client. We show that even when the expert's information is verifiable, there may be circumstances under which disclosure of conflicts of interest is not conducive to informative communication. In particular, we identify an important tradeoff between disclosure of conflicts of interest and utilization of the expert's information. If the expert is not necessarily informed, then an informed expert would have the option of feigning ignorance and not being forced to reveal all the information he has, as the typical unravelling argument implies. This, however, would cause the client to draw unwarranted inference from the uninformed expert's inability to provide information. On the other hand, when the direction of the bias of the expert is not disclosed, this negative effect is smaller.

Our paper is a contribution to the theoretical literature on the effect of mandatory disclosure policies, as well as that on communication of verifiable information when Sender's bias is uncertain. We identify new environments in which mandatory disclosure policies are counterproductive, in addition to that of Li and Madarasz (2008).

It is worth noting that our analysis is focused on an environment in which both Sender and Receiver are fully rational. There is evidence that a client tends not to make the full negative inference about the expert's action to conceal information.[6] This may undermine the unravelling argument needed for the full revelation equilibrium in the case of disclosure of conflicts of interest and possibly tilt the comparison more in favour of nondisclosure of conflicts of interest.

5 Appendix

[6] See Brown et al. (2012) for empirical evidence and Jin et al. (2015) for experimental evidence.

Proof of Proposition 1. Define $\underline{y} \equiv \max\{0, y_\emptyset - 2b\}$ and $\bar{y} \equiv \min\{1, y_\emptyset + 2b\}$. In any perfect Bayesian equilibrium, informed Sender with the upward bias withholds information if and only if $\theta \in (\underline{y}, y_\emptyset)$ and informed Sender with downward bias withholds information if and only if $\theta \in (y_\emptyset, \bar{y})$. Given Sender's strategy, we derive $E(\theta|t_u) = \frac{1}{2}$, $Pr(t_u|\emptyset) = \frac{1-q}{1-q+(q/2)(\bar{y}-\underline{y})}$, $Pr(t_i|\emptyset) = \frac{(q/2)((\bar{y}-\underline{y}))}{1-q+(q/2)(\bar{y}-\underline{y})}$, $Pr(b|t_i, \emptyset) = \frac{y_\emptyset-\underline{y}}{(y_\emptyset-\underline{y})+(\bar{y}-y_\emptyset)}$, $Pr(-b|t_i, \emptyset) = \frac{\bar{y}-y_\emptyset}{(y_\emptyset-\underline{y})+(\bar{y}-y_\emptyset)}$, $E(\theta|b, t_i, \emptyset) = \frac{\underline{y}+y_\emptyset}{2}$, and $E(-b, \theta|t_i, \emptyset) = \frac{\bar{y}+y_\emptyset}{2}$. Substituting Receiver's posterior beliefs about Sender's type, direction of his bias, and the conditional expectation of θ into (2), the equilibrium condition becomes

$$y_\emptyset = \frac{1-q}{1-q+(q/2)(\bar{y}-\underline{y})}\frac{1}{2} + \frac{(q/2)(\bar{y}-\underline{y})}{1-q+(q/2)(\bar{y}-\underline{y})}\frac{\bar{y}+\underline{y}}{2}. \tag{4}$$

We firs show that strategies in Proposition 1 constitutes a perfect Bayesian equilibrium. Note the right hand side of (4) is a weighted average of $\frac{1}{2}$ and $\frac{\bar{y}+\underline{y}}{2}$. So, $y_\emptyset = \frac{1}{2}$ is a solution to (4) if and only if $\bar{y} + \underline{y} = 1$, which is satisfied if i) $\underline{y} = \frac{1}{2} - 2b$ and $\bar{y} = \frac{1}{2} + 2b$, or ii) $\underline{y} = 0$ and $\bar{y} = 1$. Condition i) holds if $b \leq \frac{1}{4}$ and ii) holds if $b > \frac{1}{4}$. Hence, Proposition constitutes a perfect Bayesian equilibrium.

Next, we show that there does not exist an equilibrium in which $y_\emptyset \neq \frac{1}{2}$. Suppose $y_\emptyset \neq \frac{1}{2}$. It is necessary to have a)$\underline{y} = y_\emptyset - 2b$ and $\bar{y} = 1$, or b)$\underline{y} = 0$ and $\bar{y} = y_\emptyset + 2b$. First, consider that a) holds. Then, $y_\emptyset > \max\{2b, 1-2b\}$ by the definition of $\bar{y}$ and $\underline{y}$. Moreover,

$$\frac{\bar{y}+\underline{y}}{2} = \frac{1+y_\emptyset-2b}{2} > \frac{1+\max\{0, 1-4b\}}{2} \geq \frac{1}{2}.$$

Because $y_\emptyset$ is the weighted average of $\frac{1}{2}$ and $\frac{\bar{y}+\underline{y}}{2}$, it follows that $y_\emptyset < \frac{1+y_\emptyset-2b}{2}$ which implies $y_\emptyset < 1-2b$. However, $y_\emptyset < 1-2b$ contradicts $y_\emptyset > \max\{2b, 1-2b\}$.

Now, consider that b) holds. Then, $y_\emptyset < \min\{2b, 1-2b\}$. Substituting $\bar{y}$ and $\underline{y}$, $\frac{\bar{y}+\underline{y}}{2} = \frac{y_\emptyset+2b}{2} < \frac{\min\{4b,1\}}{2} \leq \frac{1}{2}$. By the same argument for a), $\frac{y_\emptyset+2b}{2} < y_\emptyset$, which requires $2b < y_\emptyset$. But $2b < y_\emptyset$ contradicts $y_\emptyset < \min\{2b, 1-2b\}$. Since neither a) nor b) holds, there does not exist any equilibrium in which $y_\emptyset \neq \frac{1}{2}$.

Finally, we calculate Receiver and Sender's expected utilities, respectively. First, consider $b \leq \frac{1}{4}$. Receiver's expected utility is

$$\begin{aligned} E(v) &= (1-q)E(v(\theta)|t_u) + qPr(\emptyset|t_i)\left(Pr(b|t_i,\emptyset)E(v(\theta)|t_i,b,\emptyset) + Pr(-b|t_i,\emptyset)E(v(\theta)|t_i,-b,\emptyset)\right) \\ &= (1-q)\int_0^1 -(\frac{1}{2}-\theta)^2 d\theta + q\left(\frac{1}{2}\int_{\frac{1}{2}-2b}^{\frac{1}{2}+2b} -(\frac{1}{2}-\theta)^2 d\theta\right) \\ &= -\frac{1-q}{12} - \frac{8qb^3}{3}, \end{aligned} \tag{5}$$

where the second equality follows by substituting $Pr(\emptyset|t_i) = 2b$, $Pr(b|\emptyset, t_i) = Pr(-b|\emptyset, t_i) = \frac{1}{2}$, $E(v(\theta)|b, \emptyset, t_i) = -\frac{1}{2b}\int_{\frac{1}{2}-2b}^{\frac{1}{2}}(\frac{1}{2}-\theta)^2 d\theta$, and $E(v(\theta)|-b, \emptyset, t_i) = -\frac{1}{2b}\int_{\frac{1}{2}}^{\frac{1}{2}+2b}(\frac{1}{2}-\theta)^2 d\theta$.

The upward biased Sender's expected payoff is

$$\begin{aligned} E(u) &= (1-q)\int_0^1 -(\frac{1}{2}-(\theta+b))^2 d\theta + q\left[-b^2(1-2b) - \int_{\frac{1}{2}-2b}^{\frac{1}{2}}(\frac{1}{2}-(\theta+b))^2\right] \\ &= -(1-q)(\frac{1}{12}+b^2) + q(-b^2+\frac{4}{3}b^3) \\ &= -(\frac{1}{12}+b^2) + q(\frac{1}{12}+\frac{4b^3}{3}). \end{aligned} \tag{6}$$

Since Sender is symmetric in his direction of bias, the downward biased Sender's expected payoff is the same as the upward biased Sender's expected payoff.

Next, consider $b > \frac{1}{4}$. Receiver's expected payoff is

$$\begin{aligned} E(v) &= (1-q)\int_0^1 -(\frac{1}{2}-\theta)^2 d\theta + q\left(\frac{1}{2}\int_0^1 -(\frac{1}{2}-\theta)^2 d\theta\right) \\ &= -\frac{1-q}{12} - \frac{q}{24}. \end{aligned} \tag{7}$$

The upward (downward) biased Sender's expected payoff is

$$\begin{aligned} E(u) &= (1-q)\int_0^1 -(\frac{1}{2}-(\theta+b))^2 d\theta + q\left[\frac{-b^2}{2} - \int_0^{\frac{1}{2}}(\frac{1}{2}-(\theta+b))^2\right] \\ &= -(\frac{1}{12}+b^2) + q(\frac{1}{12}+\frac{4b^3}{3}). \end{aligned} \tag{8}$$

∎

Proof of Proposition 2. Consider the upward biased Expert. Suppose $y^b_\emptyset > 2b$, so (3) is reduced to

$$E(\theta|\emptyset, b) = \frac{1-q}{2bq + (1-q)}\frac{1}{2} + \frac{2bq(y_\emptyset - b)}{2bq + (1-q)}.$$

The equilibrium requires that $y^b_\emptyset = E(\theta|\emptyset, b)$ which gives unique solution $y^b_\emptyset = \frac{1}{2} - \frac{2qb^2}{1-q}$. The condition $y^b_\emptyset > 2b$ is satisfied if and only if $b < \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$.

Suppose $y^b_\emptyset \leq 2b$. Then, (3) becomes

$$\frac{1-q}{qy_\emptyset + (1-q)}\frac{1}{2} + \frac{qy_\emptyset}{qy_\emptyset + (1-q)}\frac{y_\emptyset}{2}.$$

Solving $y^b_\emptyset = E(\theta|\emptyset, b)$ yields the unique solution $y^b_\emptyset = \frac{\sqrt{1-q}}{1+\sqrt{1-q}}$. The condition $y^b_\emptyset \leq 2b$ is satisfied if and only if $b \geq \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$.

Given Receiver's action $y^{-b}_\emptyset$, the downward biased Expert prefers to withhold information if and only if $\theta \in (y^{-b}_\emptyset, \min\{y_\emptyset + 2b, 1\}]$. So, Receiver's expected state of the world conditional on $\emptyset$ is

$$\begin{aligned} E(\theta|\emptyset, -b) =& Pr(t_u|\emptyset, -b)E(\theta|\emptyset, -b, t_u) + Pr(t_i|\emptyset, -b)E(\theta|\emptyset, -b, t_i) \\ =& \frac{1-q}{q(\min\{1, y_\emptyset + 2b\} - y_\emptyset) + (1-q)}\frac{1}{2} + \\ & \frac{q(\min\{1, y_\emptyset + 2b\} - y_\emptyset\})}{q(\min\{1, y_\emptyset + 2b\} - y_\emptyset) + (1-q)}\frac{\min\{1, y_\emptyset + 2b\}) + y_\emptyset}{2}. \end{aligned} \tag{9}$$

Solving $y^{-b}_\emptyset = E(\theta|\emptyset, -b)$, we have $y^{-b}_\emptyset = \frac{1}{2} + \frac{2qb^2}{1-q}$ for $b < \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$ and $y^{-b}_\emptyset = \frac{1}{1+\sqrt{1-q}}$ for $b \geq \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$.

If $b < \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$, Receiver's expected utility is

$$\begin{aligned} E^d(v) =& \frac{1}{2}\left[(1-q)\int_0^1 -(y^b_\emptyset - \theta)^2 d\theta + q\int_{y^b_\emptyset - 2b}^{y^b_\emptyset} -(y^b_\emptyset - \theta)^2 d\theta\right] + \\ & \frac{1}{2}\left[(1-q)\int_0^1 -(y^{-b}_\emptyset - \theta)^2 d\theta + q\int_{y^{-b}_\emptyset}^{y^{-b}_\emptyset + 2b} -(y^{-b}_\emptyset - \theta)^2 d\theta\right] \\ =& (1-q)\left(-\frac{4q^2b^4}{(1-q)^2} - \frac{1}{12}\right) + q(-\frac{8b^3}{3}). \end{aligned} \tag{10}$$

If $b \geq \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$, Receiver's expected utility is

$$E^d(v) = \frac{1}{2}\left[(1-q)\int_0^1 -(y_\emptyset^b-\theta)^2 d\theta + q\int_0^{y_\emptyset^b} -(y_\emptyset^b-\theta)^2 d\theta\right] + \tag{11}$$

$$\frac{1}{2}\left[(1-q)\int_0^1 -(y_\emptyset^{-b}-\theta)^2 d\theta + q\int_{y_\emptyset^{-b}}^1 -(y_\emptyset^{-b}-\theta)^2 d\theta\right]$$

$$= (1-q)\left(-(y_\emptyset^b - \frac{1}{2})^2 - \frac{1}{12}\right) + q\left(-\frac{(y_\emptyset^b)^3}{3}\right), \tag{12}$$

$$\tag{13}$$

where the second equality follows because

$$\int_0^1 -(y_\emptyset^b-\theta)^2 d\theta = \int_0^1 -(y_\emptyset^{-b}-\theta)^2 d\theta = -\left(y_\emptyset^b - \frac{1}{2}\right)^2 - \frac{1}{12}$$

and

$$\int_0^{y_\emptyset^b} -(y_\emptyset^b-\theta)^2 d\theta = \int_{y_\emptyset^{-b}}^1 -(y_\emptyset^{-b}-\theta)^2 d\theta = \left(-\frac{(y_\emptyset^b)^3}{3}\right).$$

∎

Proof of Proposition 3. The proof has three steps. Step 1 shows that $E(v) > E^d(v)$ if $b < \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$. Because $\frac{\sqrt{1-q}}{2(1+\sqrt{1-q})} \leq \frac{1}{4}$, the difference between Receiver's utility without and with mandatory disclosure is

$$E(v) - E^d(v) = \left[-\frac{8qb^3}{3} - \frac{1-q}{12}\right] - \left[(1-q)\left(-\frac{4q^2b^4}{(1-q)^2} - \frac{1}{12}\right) - \frac{8qb^3}{3})\right]$$

$$= \frac{4q^2b^4}{1-q} < 0. \tag{14}$$

Step 2 shows $E^d(v) < E(v)$ if $\frac{\sqrt{1-q}}{2(1+\sqrt{1-q})} \leq b \leq \hat{b}(q)$. First, we show $\hat{b}(q) < \frac{1}{4}$. Let $a \equiv 1 + \sqrt{1-q}$. Take the derivative $\frac{d\hat{b}(q)}{dq}$

$$\frac{d\hat{b}(q)}{dq} = \frac{d\hat{b}}{da}\frac{da}{dq} = -\frac{(\frac{a-1}{a})^{2/3}(\frac{2+a}{32})^{1/3}}{2(a-1)} < 0,$$

where the inequality follows because $a > 1$. Since $\hat{b}(0) = \frac{1}{4}$, $\hat{b}(q) < \frac{1}{4}, \forall q \in (0,1)$. So, for $\frac{\sqrt{1-q}}{2(1+\sqrt{1-q})} \leq b \leq \hat{b}(q) < \frac{1}{4}$, the difference between Receiver's utility without and with mandatory disclosure is

$$E(v) - E^d(v) = \left[-\frac{8qb^3}{3} - \frac{1-q}{12}\right] - \left[(1-q)\left(-(y^b_\emptyset - \frac{1}{2})^2 - \frac{1}{12}\right) + q\left(-\frac{(y^b_\emptyset)^3}{3}\right)\right]$$
$$= \frac{8q}{3}\left[\frac{(y^b_\emptyset)^3}{8} + \frac{3(1-q)(y^b_\emptyset - \frac{1}{2})^2}{8q} - b^3\right]. \tag{15}$$

Consequently, $E(v) > E^d(v)$ if and only if

$$0 < \frac{(y^b_\emptyset)^3}{8} + \frac{3(1-q)(y^b_\emptyset - \frac{1}{2})^2}{8q} - b^3 \Rightarrow$$
$$b^3 < \frac{(1-q)(\sqrt{1-q}+3)}{32(1+\sqrt{1-q})^3} \Rightarrow$$
$$b < \hat{b}(q) \equiv \left(\frac{\sqrt{1-q}}{1+\sqrt{1-q}}\right)^{\frac{2}{3}} \left(\frac{3+\sqrt{1-q}}{32(1+\sqrt{1-q})}\right)^{\frac{1}{3}}. \tag{16}$$

Next, we shows $\hat{b}(q) > \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$. Take the derivative of $E(v)$ for $b < \frac{1}{4}$,

$$\frac{\partial E(v)}{\partial b} = -8qb^2 < 0.$$

So, $E(v)$ is decreasing in b for $b < \frac{1}{4}$. By Proposition 2, $E^d(v)$ is constant in b for $b > \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$. Step 1 has shown that $E(v) > E^d(v)$ at $b = \frac{\sqrt{1-q}}{2(1+\sqrt{1-q})}$. Step 2 shows that $E(v) = E^d(v)$ at $b = \hat{b}(q)$. Because $E(v)$ is monotonically decreasing in b, $\frac{\sqrt{1-q}}{2(1+\sqrt{1-q})} < \hat{b}(q)$.

Step 3 shows $E(v) \leq E^d(v)$ for $b \geq \hat{b}(q)$. Because $E^d(v) = E(v)$ at $\hat{b}(q)$, $E^d(v)$ is weakly decreasing in b for $b \geq \hat{b}(q)$, and $E^d(v)$ is constant in b for $b \geq \hat{b}(q)$, $E(v) \leq E^d(v)$ for $b \geq \hat{b}(q)$. ∎

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