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# Strategic Information Transmission through the Media

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## Abstract

We model media manipulation in which a sender or senders manipulate information through the media to influence receivers. We show that if there is only one sender who has a conditional preference for maintaining its credibility in reporting accurate information and if the receivers face a coordination situation without information about their opponents' types, the sender could influence the receivers to make decisions according to the sender's primary preference by manipulating the information through the media, which makes the report common knowledge. This is true even when the sender and the receivers have contradictory primary preferences. This result extends to the cases in which the sender has imperfect information or in which the sender's primary preference is to maintain its credibility. In the case of multiple senders, however, when there is enough competition among the senders or when simultaneous reporting takes place, the receivers could play their favored outcome against senders' preferences, which sheds light on a solution to the media manipulation problem.

*Journal of Economic Literature classification numbers:* C72, D82, D83.

*Keywords:* Arms Race, Common Knowledge, Information Transmission, Media Bias, Media Competition, Media Manipulation.

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# 1 Introduction

With rapid development of technology, the mass media have become an influential force in our daily lives as a means of information transmission. Without a systematic framework to analyze the effect of the media, we are unaware of the impact of media and are subject to their hidden yet powerful influence. This paper intends to make an initial contribution to the understanding of the systematic operation and the impact of the media. More specifically, this paper provides several simple models in which a sender or senders manipulate information through the news media, such as newspaper or television stations, in order to influence the decision-making process of receivers.

The setting of the models can be a general coordination game with incomplete information. Here, an arms race game is adopted as the setting of the models not only because it simplifies the model while clearly showing the power of the media, but also because the results from this setting can easily be generalized into a general coordination game with incomplete information. In the arms race game, there are two players, player 1 and player 2, each simultaneously choosing to build weapons or not to build weapons. In this game, player 2 has two possible types, either hawkish or dovish. If player 2 is hawkish, she wants to occupy a leading military position and therefore regards building weapons as a dominant action. If player 2 is dovish, she wants to maintain a harmonious relationship with player 1. Thus, dovish player 2 prefers not to build weapons as long as player 1 does not build weapons. As a dovish player who also wants to defend herself, however, dovish player 2 prefers to build weapons if player 1 builds weapons. In other words, dovish player 2 wants to match the action of player 1. Player 2's type is her own private information. On the other hand, player 1 is always dovish, so she always wants to match the action of player 2<sup>1</sup>. In this arms race game, there are two possible equilibrium outcomes: the building-weapons outcome in which both players choose to build weapons and the not-building-weapons outcome in which both players choose not to build weapons. Here, the not-building-weapons outcome is the favorite outcome for the dovish players.

In the basic model, I introduce a sender into the arms race game. The sender has the information about player 2's type and would report the information to players 1 and 2 before they make decisions on weapon building. The following three assumptions about the sender lead to the unique outcome of this game. First, the sender reports the information about player 2's type through news media. By the nature of the news media, the report from the sender is commonly known to both players. Second, the sender has a preference for player 1 to build weapons. Finally, the sender has a conditional preference<sup>2</sup> for maintaining its credibility in reporting

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<sup>1</sup>In the classic arms race game, both players have two possible types. By designating one player's type as permanent, I simplify the classic arms race game while preserving the same results as the classic models.

<sup>2</sup>This model can be considered as a simplified version of the repeated game in which a sender has two possible types: neutral or biased. A neutral sender always reports truthfully, while on the other hand, the sole concern of a biased sender is to make player 1 build weapons. In this repeated

accurate information. Whether a sender can successfully influence the players or not is determined by the players' own strategies. If player 1 uses a strategy to ignore the sender's report and consequently the sender cannot influence player 1 to build weapons, the sender would choose to preserve its credibility and thus report truthful information about player 2's type. However, if the sender can successfully affect player 1 to build weapons, then maintaining its credibility in reporting accurate information is no longer a concern to the sender and it could report untruthful information. With this sender in the arms race game, the basic model<sup>3</sup> shows that the only outcome in the Perfect Bayesian equilibrium, introduced by Fudenberg and Tirole (1991), is the building-weapons outcome.

To see why the players cannot achieve the not-building-weapons outcome in equilibrium, suppose that player 1 tries not to build weapons regardless of the report from the sender. Under this strategy of player 1, the sender cannot influence player 1 to build weapons, so the sender would report truthful information about player 2's type. Then when the sender reports that player 2 is hawkish, player 1 is certain that player 2 is hawkish and thus would build weapons. Accordingly, player 1 has an incentive to change her action from not building weapons to building weapons in order to match player 2's action. Therefore, in equilibrium, player 1 cannot completely ignore the report from the sender. Once player 1 responds to the sender's report, the sender can influence player 1 to build weapons by manipulating the information.

The result derived from the basic model shows that news media could be a powerful means of information transmission. By reporting through the news media, the sender can make player 1 build weapons in accordance with the sender's preference, and therefore players 1 and 2 lose the not-building-weapons outcome, which is a favorite outcome of the dovish players. In addition, this result is strong because it is robust against two parameters. The result is robust against the probability that player 2 is hawkish. It is also robust against the payoffs to the dovish players when they achieve the not-building-weapons outcome. That is, no matter how small, but positive, the probability of player 2's being hawkish or no matter how great the payoffs to the dovish players in the not-building-weapons outcome, players 1 and 2 cannot achieve the not-building-weapons outcome.

Moreover, this result is stable from two aspects. First, even if we introduce a cheap-talk between players 1 and 2 into the basic model, this result does not change. This is because if the players try to make their decisions according to their cheap-talk, then the sender cannot influence the players, which means that the sender's primary

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game, in response to the behavior that player 1 tries to distinguish a neutral sender from a biased sender, a biased sender pretends to be neutral in order to preserve its influence on player 1. In the basic model, to reflect this behavior of the biased sender, the concept of credibility is adopted and adapted so that the sender considers its credibility only conditionally. For more information about credibility in static games, see Kartik, Ottaviani, and Squintani (2006).

<sup>3</sup>This basic model can be exemplified by the Hitler's regime in the World War II. According to Shirer (1990), German citizens (player 1) openly objected to the war with the Poles (player 2). But, Hitler (the sender) successfully manipulated German citizens' opinions through the news media.

preference cannot be satisfied. Thus the sender would reveal the information because of its conditional preference. As a result, the players have an incentive to change their strategies, and eventually the sender can successfully influence the players to play the sender's favored outcome. Second, the setting of the model, the arms race game, can be replaced with a general coordination game with incomplete information<sup>4</sup>. In the general coordination game with incomplete information, if the following three conditions hold, then the result will be similar to the result in the basic model. First, in the general coordination game without a sender, the sender's favored outcome must be a possible equilibrium outcome when each player is a normal type, who does not have a dominant action; in the basic model, the sender's primary preference is to make player 1 build weapons and the building-weapons outcome is a possible equilibrium outcome when both players are dovish types, who do not have a dominant action. Second, when each player is normal, the sender's favored outcome consists of each player's strict best responses, that is, each player strictly prefers to stick to her action as long as the others do; in the basic model, each dovish player strictly prefers to build weapons if the other does so. Third, one of the receivers' types has a dominant action that is part of the sender's favored outcome; to build weapons, in the basic model, is a dominant action of hawkish player 2 and it is part of the sender's favored outcome, the building-weapons outcome. Under these three conditions, in the general coordination game<sup>5</sup> with a sender, the normal players and the types who have dominant actions that are part of the sender's favored outcome play the sender's favored outcome. Note that it is also possible that one of the players in the general game becomes a sender and sends its own information.

Furthermore, this result differs from the results in existing literature on information transmission. Crawford and Sobel (1982) and Kartik, Ottaviani, and Squintani (2006) showed that if a sender and receivers have contradictory preferences, then the sender cannot influence the receivers to play the sender's favored outcome (see also Milgrom, 1981; Sobel, 1985; and Krishna and Morgan, 2001). The basic model, on

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<sup>4</sup>For simplicity, the general coordination game is assumed to satisfy the following conditions. *i*) Each player has one or several types including a normal type who does not have a dominant action and the realizations of the players' types are independent. *ii*) When every player is normal, they solve a coordination game, and when a player is not normal, she has a dominant action.

<sup>5</sup>For an example of the general coordination game with incomplete information, we can introduce a blindly peaceful type for player 2, who will not build weapons in any case, into the arms race game. In this example, if the probability that player 2 is blindly peaceful is not so high that the building-weapons outcome is a possible equilibrium outcome, and then all types except the blindly peaceful type build weapons in an equilibrium outcome according to the primary preference of the sender. Besides, this result does not change even when we introduce a cheap-talk between players 1 and 2 into this example. This is because the sender has the conditional preference for its credibility and thus the players cannot completely ignore the report from the sender in equilibrium. Therefore, in these examples, the sender can manipulate information through the media so that the players play its favored outcome. The same is true with the opposite assumption. If the not-building-weapons outcome is a possible equilibrium outcome and the sender's primary preference is to make player 1 NOT build weapons, then in an equilibrium outcome, player 1 does not build weapons in any case.

the other hand, shows that if receivers play the coordination game with incomplete information that satisfies the aforementioned three conditions, such as an arms race game in the basic model, and a sender has a conditional preference on its credibility and reports its information through news media, then the sender can influence the receivers to play the sender's favored outcome even when there are contradictory preferences between the sender and the receivers.

The setting of the model, the arms race game, is developed from Schelling (1960) and Baliga and Sjöström (2004). Schelling argued that reciprocal fear from surprise attack makes defensive action desirable and can cause a multiplier effect in which both sides generate and escalate negative expectations of their opponents. This multiplier effect induces arms race even when the probability of each side being hawkish is not high. Baliga and Sjöström formally modeled Schelling's insight. The aforementioned arms race differs from Baliga and Sjöström in that uncertainty lies only on one side and thus there is no multiplier effect. Even so, the basic model still shows that an arms race is always triggered by the sender's will because the sender uses the media as a means of information transmission and it has the conditional preference.

In this study, reports are relevant to payoffs, and this property evidently distinguishes this model from the cheap-talk games developed by Farrell and Gibbons (1989a), Farrell and Rabin (1996), and Battaglini (2002). In cheap-talk games, talk is irrelevant to payoffs. So, one player does not need to believe what other players talk about, and as a result only if they have a common interest in a degree, their cheap-talk can be effective (see also Farrell and Gibbons, 1989b; Stein, 1989; Farrell, 1993; Baliga and Morris, 2002; and Aumann and Hart, 2003; and Goltsman, Hörner, Pavlov, and Squintani, 2007). In the basic model, on the other hand, the payoffs to the sender depend on its report as well as on another player's action. This is done by assuming that the sender wants to preserve its credibility in reporting accurate information. This intention of the sender for its credibility makes the report from the sender effective even when the sender and the players have contradictory preferences. As a result, the sender's intention for its credibility ironically deprives the dovish players of their favorite outcome. Regarding main interests, the cheap-talk games are typically interested in how much information can be delivered in such limited situations. On the other hand, the basic model does not address this issue, yet it is intended to show how the sender can manipulate information through the media instead.

The basic model can be categorized as a signaling game. Its contribution to the literature of signaling games is to find sufficient conditions under which the sender can successfully manipulate information through the media and, consequently, to provide a systematic study about the effect of the media as a means of information transmission. Nevertheless, the basic model differs from the classical signaling games developed by Spence (1973), Cho and Kreps (1987), and van Damme (1989) in that the sender reports player 2's type. In these signaling games, senders only signal their own types or their own intention about their future actions (see also Bhattacharya,

1979; Milgrom and Roberts, 1986; Banks and Sobel, 1987; Manelli, 1997).

Besley and Prat (2004) and Baron (2005) also studied media manipulation in which the senders manipulate information through the media to influence receivers. Besley and Prat modeled a situation in which media outlets maintain a cozy relationship with the government. In exchange for compensation, such as a direct monetary payment or beneficial regulations, the media suppress embarrassing information about the government. Also contributing to this topic, Baron employed information competition between two interest groups, each advocating their positions through news media to influence public sentiment. In both papers, the extent to which the media reports information determines the degree of influence that the media exert on the public, which actualizes media manipulation (see also Dyck and Zingales, 2003; and Strömberg, 2004). That is, more reports bring stronger influence on the public, and so the influence of the media on the decision of the public is exogenously modeled. In the present study, however, the influence of the media on the decision of the players is endogenously created in equilibrium due to the coordination situation that the receivers face and the sender's conditional preference for its credibility.

Section 3 extends the basic model by introducing imperfect information so that the sender detects imperfect information about player 2's type. Here, if the signal about player 2's type indicates the true type of player 2 with sufficiently high probability, then the result in the basic model extends to the imperfect information model.

Section 4 examines the opposite case of the basic model in terms of the sender's preferences. In this modified model, the sender's primary preference is to preserve its credibility, and its conditional preference is to influence the decision-making process of the players. This is done by assuming that the sender is composed of a private media outlet whose preferences on players' choices represent media bias. This assumption leads to the fact that as long as its credibility remains intact, a profit-maximizing media outlet manipulates the information to increase the demand for its products. This modified model concludes that the media outlet can manipulate information, in order to influence the players to play a specific outcome, without undermining its credibility.

Section 5 extends the modified model to incorporate private media competition to study the effect of media competition on media bias. This media competition model shows that if the profits of private media outlets are affected by media bias more than by media competition, then the media outlets can successfully manipulate the information so that players choose the outcome that satisfies media outlets' concerns. However, when there are both media outlets who report truthfully and those who report untruthfully, if competition among media outlets is strong enough so that competition brings sufficient rewards to the media outlets who report truthfully, then eventually all media outlets can be forced to report truthfully and receivers can achieve the not-building-weapons outcome. Therefore, enough competition among the private media outlets can effectively curb their information manipulation through the media and consequently reduce their influences on the receivers. Also, simultaneous

reporting by at least two media outlets results in an outcome similar to the media competition case.

Section 6 presents summaries and conclusions.

## 2 Basic Model

In the basic model, a Ministry of Propaganda is the sender. There are three players; player 1, player 2, and the Ministry of Propaganda ( $M$ ). Players 1 and 2 have their own types. Player 2 can be either hawkish or dovish while player 1 is always dovish. The probability that player 2 is hawkish is  $h \in (0, 1]$ . In this model, uncertainty lies only in the type of player 2.  $M$  reports either *that player 2 is hawkish* ( $H$ ) or *that player 2 is dovish* ( $D$ ). Players 1 and 2 each choose either to *Build weapons* ( $B$ ) or *Not to build weapons* ( $N$ ).

This game proceeds as follows. At stage zero, Nature chooses player 2's type. Only  $M$  and player 2 detect player 2's type. At stage one,  $M$  reports  $H$  or  $D$ . What  $M$  has reported becomes common knowledge. At stage two, players 1 and 2 each simultaneously choose  $B$  or  $N$ . After all actions are taken, payoffs are realized.

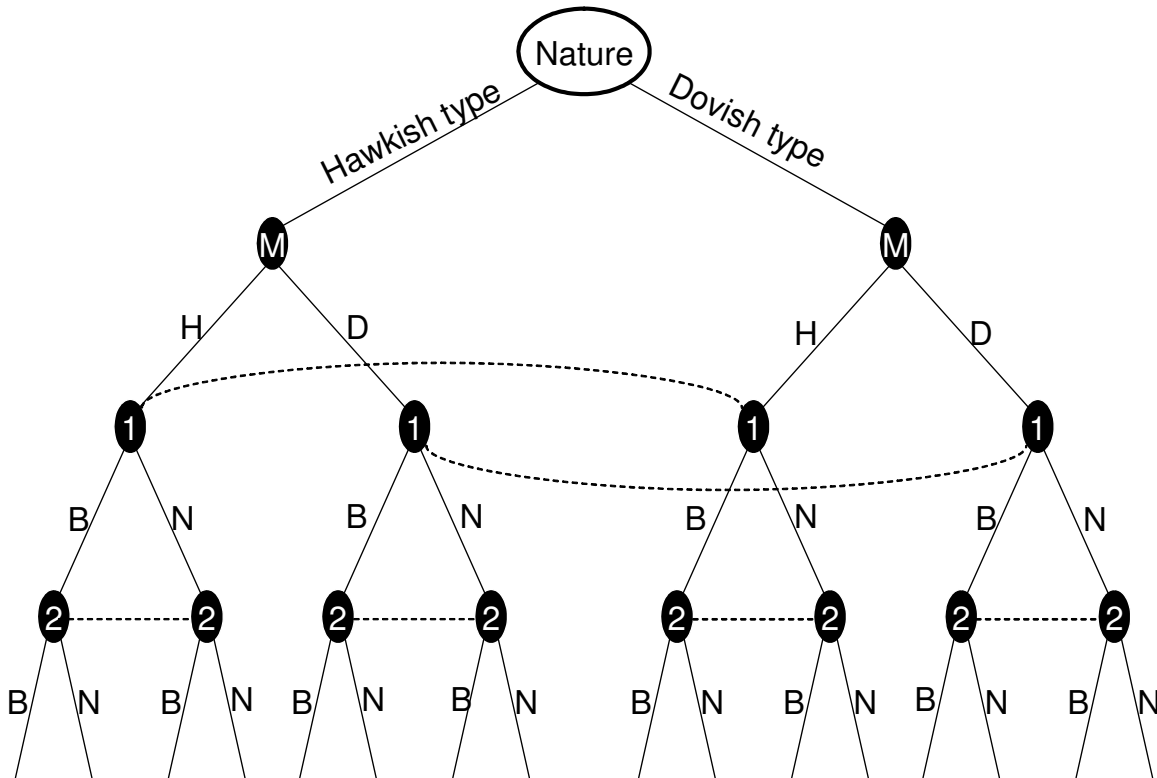


Figure 1: Game Tree of the Basic Model



The payoffs to  $M$  depend on its own reports as well as the players' actions. That is, given a report  $r \in \{H, D\}$  of  $M$  and actions  $a_1, a_2 \in \{B, N\}$  of the players, a real number  $u_{ra_1a_2}$  denotes the payoff to  $M$  when  $M$  reports  $r$  and players 1 and 2 choose  $a_1$  and  $a_2$ , respectively. For example,  $u_{HBN}$  denotes the payoff to  $M$  when  $M$  reports  $H$  and players 1 and 2 choose  $B$  and  $N$ , respectively. While in the traditional information transmission models studied by Crawford and Sobel (1982), Austen-Smith (1990), and Seidmann and Winter (1997), the payoffs to a sender or senders depend on receivers' actions only, in the present model, however, the payoffs to  $M$  depend on both its own actions and the players' actions.

Regarding its preferences, the primary preference<sup>6</sup> of  $M$  is to make player 1 build weapons; *i.e.*  $u_{rBa_2} > u_{r'Na'_2}$  for any  $r, r' \in \{H, D\}$  and  $a_2, a'_2 \in \{B, N\}$  in which the left side term denotes the payoff to  $M$  when player 1 builds weapons and the right side term denotes the payoff to  $M$  when player 1 does not.  $M$  might have a particular preference on player 2's actions. In this model, however, such a preference does not affect results as long as the primary preference of  $M$  is to make player 1 build weapons. So the preference of  $M$  on player 2's action is omitted.

In addition, when  $M$  is unable to influence player 1 to build weapons, the conditional preference of  $M$  is to preserve its credibility. In this model, there are two possible cases in which  $M$  might lose its credibility. In one case,  $M$  might lose its *Credibility related to Truthfulness (CT)*. A hawkish player has a dominant action  $B$ . So if  $M$  has reported  $H$  and player 2 plays  $N$ , then player 1 is certain that  $M$  has lied, and thus  $M$  would lose its *CT*. Hence if  $M$  cannot affect player 1 to build weapons and expects player 2 to play  $N$ , then  $M$  prefers to choose  $D$ ; *i.e.*  $u_{DNN} > u_{HNN}$ . In the other case,  $M$  might lose its *Credibility related to Accurate Warning (CAW)*. If  $M$  expects player 2 to play  $B$  and reports  $D$ , then  $M$  would fail to warn player 1 of the danger that player 2 would build weapons and thus lose its *CAW*. Hence if  $M$  cannot affect player 1 to build weapons and expects player 2 to play  $B$ , then  $M$  prefers to report  $H$ ; *i.e.*  $u_{HNB} > u_{DNB}$ .

However, not every inequality stated above to summarize the preferences of  $M$  affects the outcomes in equilibrium. Of the aforementioned inequalities, only the four listed below influence the outcomes. In this paper, emphasis is placed on the outcomes in equilibrium. Therefore, for simplicity, only the following four inequalities are assumed to describe *the preferences of the Ministry of Propaganda, M*;

- i)*  $u_{HBB} > u_{DNN}$  and  $u_{DBB} > u_{HNN}$  for the primary preference;
- ii)*  $u_{DNN} > u_{HNN}$  for *CT*; and *iii)*  $u_{HNB} > u_{DNB}$  for *CAW*.

The payoffs to players 1 and 2 are given by the following matrixes. In these matrixes, player 1 chooses a row and player 2 a column,

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<sup>6</sup>In the general coordination games with incomplete information, the primary preference of  $M$  can be flexible. So if the general games satisfy the aforementioned three conditions, then no matter what  $M$ 's primary preference is,  $M$  can successfully influence normal receivers, who do not have dominant actions, to play  $M$ 's favored outcome.

		When player 2 is hawkish		When player 2 is dovish	
		N	B	N	B
N	$\omega, 3$	$0, 4$	N	$\omega, \omega$	$0, 2$
B	$2, 0$	$1, 1$	B	$2, 0$	$1, 1$

Table 1: Payoff Matrixes of Players 1 and 2

such that  $\omega > 2$  where the first entry in each cell is player 1's payoff for the corresponding actions and the second entry player 2's. Player 1 is always dovish. A dovish player prefers to match the action of the other and prefers the  $NN$  outcome to the  $BB$ . For a hawkish player,  $B$  is a dominant action. So the  $BB$  outcome is the only pure-strategy equilibrium in the left side matrix. Moreover, when both players 1 and 2 are dovish, they want to match the action of the other. Consequently, in the right side matrix, there are two pure-strategy equilibria, the  $NN$  outcome and the  $BB$ . This two-player setting is similar to Baliga and Sjöström (2004).

The arms race game without  $M$  could have two pure-strategy Perfect Bayesian equilibrium outcomes. Players can achieve the  $BB$  outcomes regardless of player 2's type in which players' expected payoffs are ones. Also, if the probability  $h$  that player 2 is hawkish and the payoff  $\omega$  in the  $NN$  outcome satisfy that  $\frac{\omega-2}{\omega-1} > h$ , then the  $NB$  outcome when player 2 is hawkish and the  $NN$  when player 2 is dovish is a possible outcome combination in equilibrium. In this outcome, players 1 and 2 have their expected payoffs  $(1-h)\omega$  and  $4h + (1-h)\omega$ , respectively, and therefore both players prefer the latter outcome combination to the former because of the higher expected payoffs in the latter. Then, how does introducing  $M$  into the arms race game change the results? Theorem 1 answers this question.

**Theorem 1** *Pure-strategy Perfect Bayesian equilibria exist, and in the equilibrium outcomes players 1 and 2 choose Bs.*

**Proof.** Here, every pure-strategy of player 1 is examined. First, let player 1 play  $B$  always; *i.e.*  $(B, B)$ . Note that a dovish player prefers to match the action of the other player. On the other hand, a hawkish player has the dominant action  $B$ . Hence only player 2's strategy under which she always plays  $B$ , *i.e.*  $(B, B, B, B)$ , satisfies the best response to player 1's strategy in each continuation game. Finally, player 1's strategy  $(B, B)$  satisfies the best response to  $(B, B, B, B)$  in each continuation game. In this case, if  $u_{HBB} > u_{DBB}$ , then  $M$  prefers to report  $H$  always, *i.e.*  $(H, H)$ . Accordingly, the strategy profile  $\{(H, H), (B, B), (B, B, B, B)\}$  is an equilibrium. Similarly, the following strategy profiles are equilibria; if  $u_{HBB} < u_{DBB}$ , then  $\{(D, D), (B, B), (B, B, B, B)\}$ ; and if  $u_{HBB} = u_{DBB}$ , then  $\{(r_H, r_D), (B, B), (B, B, B, B)\}$  for  $r_H, r_D \in \{H, D\}$ , where  $(r_H, r_D)$  specifies that  $M$  reports  $r_H$  when it detects a hawkish type and  $r_D$  when it detects a dovish type. In all the cases,

players always choose  $Bs$  in the outcomes. Therefore, there exists a pure-strategy equilibrium of which players choose  $Bs$  in the outcome.

Second, let player 1 play  $B$  only when  $M$  has reported  $H$ ;  $(B, N)$ . Then only player 2's strategy under which she plays  $N$  only when player 2 is dovish and  $M$  has reported  $D$ , *i.e.*  $(B, B, B, N)$ , satisfies the best response in each continuation game. Next, the best response of  $M$  to these strategies is to report  $H$  when  $M$  detects a dovish type because  $u_{HBB} > u_{DNN}$ , which denotes the primary preference of  $M$ . In this case, first, let  $M$  report  $D$  when it detects a hawkish type. Then  $M$  would report  $D$  when it detects a hawkish type and would report  $H$  when it detects a dovish type. So player 1 knows that player 2 is hawkish when  $M$  has reported  $D$ . Hence player 1 has an incentive to change her action from  $N$  to  $B$  when  $M$  has reported  $D$ . Consequently, the strategy profiles that contain player 1's strategy  $(B, N)$  and  $M$ 's strategy under which  $M$  reports  $D$  only when it detects a hawkish type, *i.e.*  $(D, H)$ , cannot be an equilibrium. Second, let  $M$  report  $H$  when it detects a hawkish type, then the player 1's strategy  $(B, N)$  satisfies the best response in each continuation game. Hence players choose  $Bs$  in this outcome.<sup>7</sup> Therefore, if a strategy profile in which player 1 plays the strategy  $(B, N)$  is an equilibrium, then players choose  $Bs$  in the outcome of this equilibrium.

Third, let player 1 play  $N$  only when  $M$  has reported  $H$ ;  $(N, B)$ . Then only player 2's strategy under which she plays  $N$  only when player 2 is dovish and  $M$  has reported  $H$ , *i.e.*  $(B, B, N, B)$ , satisfies the best response in each continuation game. Next, the best response of  $M$  to these strategies is to report  $D$  when it detects a dovish type because  $u_{DBB} > u_{HNN}$ , the primary preference of  $M$ . Similar to the previous situation, if  $M$  takes the action  $H$  when it detects a hawkish type, then the strategy profiles in which player 1 plays  $(N, B)$  and  $M$  plays  $(H, D)$  cannot be an equilibrium. On the other hand, if  $M$  reports  $D$  when it detects a hawkish type, then players choose  $Bs$  in this outcome.<sup>8</sup> Therefore, if a strategy profile in which player 1 plays  $(N, B)$  is an equilibrium, then players choose  $Bs$  in this equilibrium outcome.

Finally, let player 1 play  $N$  always;  $(N, N)$ . Then only player 2's strategy under which she plays  $N$  only when she is dovish, *i.e.*  $(B, B, N, N)$ , satisfies the best response to player 1's strategy in each continuation game. Next, the best response of  $M$  is to report  $H$  when it detects a hawkish type because  $u_{HNB} > u_{DNB}$ , the conditional preference for  $CAW$ , and to report  $D$  when it detects a dovish type because  $u_{DNN} > u_{HNN}$ , the conditional preference for  $CT$ . Hence when  $M$  has reported  $H$ , player 1 has an incentive to change her action from  $N$  to  $B$  because she is certain that player 2 is hawkish and thus player 2 will choose  $B$ . Therefore, the strategy profiles in which player 1 plays the strategy  $(N, N)$  cannot be an equilibrium. ■

Theorem 1 means that only the  $BB$  outcomes are possible in pure-strategy perfect bayesian equilibrium and  $M$  successfully manipulates the information through the news media. Therefore, introducing  $M$  into the arms race game lowers the players'

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<sup>7</sup>If  $u_{HBB} \geq u_{DNB}$  holds, then  $\{(H, H), (B, N), (B, B, B, N)\}$  is a perfect bayesian equilibrium.

<sup>8</sup>If  $u_{DBB} \geq u_{HNB}$  holds, then  $\{(D, D), (N, B), (B, B, N, B)\}$  is a perfect bayesian equilibrium.

payoffs. This result is strong in that it does not depend on  $h$  ( $> 0$ ), the probability that player 2 is hawkish, and  $\omega$  ( $> 2$ ), the payoff to the dovish players in the  $NN$  outcome<sup>9</sup>. In addition, this result is stable in that *any cheap-talk between players 1 and 2* cannot change the result and in that the setting of the model could be replaced with *the general coordination game with incomplete information* while preserving the result similar to Theorem 1.

In contrast to the outcomes in pure-strategy equilibrium, the outcomes in mixed-strategy equilibrium can result in players choosing  $N$ s with positive probabilities. However, a mixed-strategy equilibrium has negative features for the players. First, the expected payoffs in mixed-strategy equilibrium is relatively small compared with the expected payoffs in the combination of the  $NN$  outcome and the  $NB$ . If player 1 or player 2 is indifferent between playing  $B$  or  $N$ , then her expected payoff in that information set is  $\frac{\omega}{\omega-1}$ , which is less than 2, no matter which mixed strategy she plays. If  $\omega$  is large enough, then  $\frac{\omega}{\omega-1}$  is pretty small compared with  $\omega$ . Second, the set of parameters that admit mixed-strategy equilibria has a small size under the following assumptions. Suppose that  $u_{HBB} > u_{DBB}$  holds and the difference between  $u_{HBN}$  and  $u_{DBN}$ , or between  $u_{HNN}$  and  $u_{DNN}$  is large enough. Then the set of the parameters that admit mixed-strategy equilibria has measure zero.

### 3 Imperfect Information

The basic model is extended to the case in which  $M$  observes an imperfect signal about player 2's type. So in this extended model, instead of directly detecting player 2's type,  $M$  detects a signal that is exogenously given and is correlated with player 2's type. However, the signal can be empty. If the signal is empty, then it does not reveal any information about player 2's type. The probability that the signal indicates a hawkish type is  $p_{HH}$  when player 2 is hawkish and is  $p_{DH}$  when player 2 is dovish. The probability that the signal indicates a dovish type is  $p_{HD}$  when player 2 is hawkish and is  $p_{DD}$  when player 2 is dovish. Thus the probability that  $M$  detects an empty signal is  $p_{HE} = 1 - p_{HH} - p_{HD}$  when player 2 is hawkish and is  $p_{DE} = 1 - p_{DH} - p_{DD}$  when player 2 is dovish.

Here,  $M$  has three actions,  $H$ ,  $D$ , and  $E$ . The action  $E$  denotes *an empty report*. We can regard  $E$  as no new information reported. In this extended model,  $M$  has one more option,  $E$ , than in the basic model. If  $M$  tries to report truthfully, it cannot report anything when it detects an empty signal. Therefore, this setting reflects the fact that  $M$  might report truthfully because of its conditional preference. The other settings are the same as in the basic model except for the interpretation of the conditional preference of  $M$ .

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<sup>9</sup>If  $\omega$  is large enough, then players 1 and 2 have an incentive to pay  $M$  not to report anything. This incentive of the players can be an interesting topic to study. This model, however, does not address this topic in order to focus on the media as a means of information transmission.

In this imperfect information model,  $M$  might report  $H$  by mistaking a dovish type for a hawkish type. Hence player 1 does not know whether or not  $M$  gave a wrong report on purpose. As a result,  $M$  might not lose its credibility related to truthfulness when it has given a wrong report. Even then,  $M$  would lose its *Credibility related to Accurate Forecast (CAF)* if it fails to correctly forecast the action of player 2. This is because a hawkish type has the dominant action  $B$  and by reporting  $H$ ,  $M$  can forecast the action  $B$ . Accordingly, when  $M$  is unable to influence player 1 to build weapons,  $M$  prefers to report  $H$  only when it expects that player 2 would play  $B$ . In this model, therefore, the conditional preference of  $M$  is to preserve its *CAF*. The primary preference of  $M$  is still to make player 1 build weapons. Consequently, the following inequalities are assumed to describe *the preferences<sup>10</sup> of the Ministry of Propaganda, M, with imperfect information*;

- i)  $u_{HBB} > \max\{u_{DNB}, u_{DNN}, u_{ENB}, u_{ENN}\}$ ,  $u_{DBB} > \max\{u_{HNB}, u_{HNN}, u_{ENB}, u_{ENN}\}$ ,  
and  $u_{EBB} > \max\{u_{HNB}, u_{HNN}, u_{DNB}, u_{DNN}\}$  for the primary preference; and  
ii)  $u_{HNB} > \max\{u_{DNB}, u_{ENB}\}$  and  $u_{DNN} > u_{HNN}$  for *CAF*.

Theorem 2 shows that if the signal about player 2's type is informative, then Theorem 1 extends to the imperfect information model. More specifically, if  $p_{HH}$ , the probability that the signal correctly indicates a hawkish type, and  $p_{DD}$ , the probability that the signal correctly indicates a dovish type, are high enough, then players 1 and 2 choose  $B$ s in the equilibrium outcomes. Definitions 1 and 2 prescribe the levels of informativeness of the signal at which the signal could influence the decision-making process of  $M$  and player 1. Since player 2 knows her own type, the signal does not directly influence the decision of player 2. Hence the conditions in Definitions 1 and 2 are sufficient to support a result similar to Theorem 1.

Definition 1 exhibits the *levels of informativeness of the signal to M*. The informativeness of the signal is evaluated based on the payoffs to  $M$ .

**Definition 1** *Suppose that  $u_{HNB} > \max\{u_{DNB}, u_{ENB}\}$  and  $u_{DNN} > u_{HNN}$ , *CAF*. Then the signal is said to be **informative to M** if the probabilities of the signals*

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<sup>10</sup>For Theorem 2, it suffices to assume that  $u_{HBB} > \max\{\frac{hs_{HD}u_{DNB}+(1-h)s_{DD}u_{DNN}}{hs_{HD}+(1-h)s_{DD}}, \frac{hs_{HD}u_{ENB}+(1-h)s_{DD}u_{ENN}}{hs_{HD}+(1-h)s_{DD}}, \frac{hs_{HE}u_{DNB}+(1-h)s_{DE}u_{DNN}}{hs_{HE}+(1-h)s_{DE}}, \frac{hs_{HE}u_{ENB}+(1-h)s_{DE}u_{ENN}}{hs_{HE}+(1-h)s_{DE}}\}$  instead of  $u_{HBB} > \max\{u_{DNB}, u_{DNN}, u_{ENB}, u_{ENN}\}$ ; to assume that  $u_{DBB} > \max\{\frac{hs_{HD}u_{HNB}+(1-h)s_{DD}u_{HNN}}{hs_{HD}+(1-h)s_{DD}}, \frac{hs_{HD}u_{ENB}+(1-h)s_{DD}u_{ENN}}{hs_{HD}+(1-h)s_{DD}}, \frac{hs_{HE}u_{HNB}+(1-h)s_{DE}u_{HNN}}{hs_{HE}+(1-h)s_{DE}}, \frac{hs_{HE}u_{ENB}+(1-h)s_{DE}u_{ENN}}{hs_{HE}+(1-h)s_{DE}}\}$  instead of  $u_{DBB} > \max\{u_{HNB}, u_{HNN}, u_{ENB}, u_{ENN}\}$ ; and to assume that  $u_{EBB} > \max\{\frac{hs_{HD}u_{HNB}+(1-h)s_{DD}u_{HNN}}{hs_{HD}+(1-h)s_{DD}}, \frac{hs_{HD}u_{DNB}+(1-h)s_{DD}u_{DNN}}{hs_{HD}+(1-h)s_{DD}}, \frac{hs_{HE}u_{HNB}+(1-h)s_{DE}u_{HNN}}{hs_{HE}+(1-h)s_{DE}}, \frac{hs_{HE}u_{DNB}+(1-h)s_{DE}u_{DNN}}{hs_{HE}+(1-h)s_{DE}}\}$  instead of  $u_{EBB} > \max\{u_{HNB}, u_{HNN}, u_{DNB}, u_{DNN}\}$ . These stronger assumptions are made for simplicity. However, they are innocuous in that they match the preferences of  $M$ , whose primary concern is to make player 1 build weapons.

satisfy the following two inequalities;

$$\frac{hp_{HH}u_{HNB} + (1-h)p_{DH}u_{HNN}}{hp_{HH} + (1-h)p_{DH}} > \max\left\{\frac{hp_{HH}u_{DNB} + (1-h)p_{DH}u_{DNN}}{hp_{HH} + (1-h)p_{DH}}, \frac{hp_{HH}u_{ENB} + (1-h)p_{DH}u_{ENN}}{hp_{HH} + (1-h)p_{DH}}\right\} \text{ and} \quad (1)$$

$$\frac{hp_{HD}u_{HNB} + (1-h)p_{DD}u_{HNN}}{hp_{HD} + (1-h)p_{DD}} < \frac{hp_{HD}u_{DNB} + (1-h)p_{DD}u_{DNN}}{hp_{HD} + (1-h)p_{DD}}. \quad (2)$$

Suppose that player 1 plays the strategy that specifies that she always plays  $N$ , i.e.  $(N, N, N)$ , and that player 2 plays the strategy that specifies that she plays  $B$  only when she is hawkish, i.e.  $(B, B, B, N, N, N)$ . In this case,  $M$  cannot influence player 1 to build weapons. If  $M$  fails to correctly forecast the action of player 2, then  $M$  gains nothing but loses its  $CAF$ . So if the signals indicate the true type of player 2 with significantly high probabilities, then  $M$  would truthfully report what it detects. Given the payoffs to  $M$ , inequalities 1 and 2 provide precise levels of probabilities with which  $M$  prefers to report truthfully. More concretely, inequality 1 shows that  $M$  prefers to report  $H$  when it detects a hawkish type and inequality 2 shows that  $M$  prefers not to report  $H$  when it detects a dovish type.

Definition 2 formulates the *levels of informativeness of the signal to player 1*. Similar to the case of  $M$ , the informativeness of the signal is evaluated based on the payoffs to player 1.

**Definition 2** *The signal is said to be **informative to player 1** if the probabilities of the signals satisfy the following two inequalities;*

$$\frac{hp_{HH} + 2(1-h)p_{DH}}{hp_{HH} + (1-h)p_{DH}} > \frac{\omega(1-h)p_{DH}}{hp_{HH} + (1-h)p_{DH}} \text{ and} \quad (3)$$

$$\frac{h(p_{HH} + p_{HE}) + 2(1-h)(p_{DH} + p_{DE})}{h(p_{HH} + p_{HE}) + (1-h)(p_{DH} + p_{DE})} > \frac{\omega(1-h)(p_{DH} + p_{DE})}{h(p_{HH} + p_{HE}) + (1-h)(p_{DH} + p_{DE})}. \quad (4)$$

First, let  $M$  report  $H$  only when it detects the signal of a hawkish type. Then inequality 3 provides precise levels of probabilities with which player 1 prefers to play  $B$  when  $M$  has reported  $H$ . Second, let  $M$  report  $H$  only when it detects either the signal of a hawkish type or an empty signal. Then inequality 4 provides precise levels of probabilities with which player 1 prefers to play  $B$  when  $M$  has reported  $H$ .

**Theorem 2** *Pure-strategy Perfect Bayesian equilibria exist, and if the signal is informative to both  $M$  and player 1, then in the equilibrium outcomes players 1 and 2 choose  $B$ s.*

**Proof.** It is easily seen that there exists an equilibrium that contains player 1's strategy  $(B, B, B)$  and player 2's strategy  $(B, B, B, B, B, B)$ , which specify that they always play  $B$ s. In the outcomes of this equilibrium, players play  $B$ s. Therefore, it suffices to show that if a strategy profile is an equilibrium, then players play  $B$ s in the outcomes of the strategy profile.

Let player 1 play  $N$  only when  $M$  has reported  $E$ ; *i.e.*  $(B, B, N)$ . Then only player 2's strategy under which she plays  $N$  only when she is dovish and  $M$  has reported  $E$ , *i.e.*  $(B, B, B, B, B, N)$ , satisfies the best response in each continuation game. Note that if  $M$  reports  $E$ , then its expected payoff is a weighted average between  $u_{ENB}$  and  $u_{ENN}$ . Thus the best response of  $M$  to the players' strategies is not to report  $E$  no matter what  $M$  detects because  $u_{HBB} > \max\{u_{ENB}, u_{ENN}\}$ , the primary preference of  $M$ . Finally, player 1's strategy  $(B, B, N)$  satisfies the best response in each continuation game. Therefore, players choose  $B$ s in this outcome. Similarly, players choose  $B$ s in the equilibrium outcomes in which player 1 plays the strategies  $(B, N, B)$ ,  $(B, N, N)$ ,  $(N, B, B)$ ,  $(N, B, N)$ , or  $(N, N, B)$ .

Finally, let player 1 play  $(N, N, N)$ . Then only player 2's strategy under which she plays  $N$  only when she is dovish, *i.e.*  $(B, B, B, N, N, N)$ , satisfies the best response in each continuation game. Under these strategies,  $M$  prefers to report  $H$  when it detects a hawkish type and prefers not to report  $H$  when it detects a dovish type because the signal is informative to  $M$ . Then player 1 has an incentive to change her action from  $N$  to  $B$  when  $M$  has reported  $H$ , because the signal is also informative to player 1. Therefore, the strategy profiles in which player 1 plays the strategy  $(N, N, N)$  cannot be an equilibrium. ■

**Corollary 1** *There exists  $\varepsilon > 0$  such that if  $\min\{p_{HH}, p_{DD}\} > 1 - \varepsilon$ , then the outcomes in pure-strategy Perfect Bayesian equilibrium are that players 1 and 2 always choose  $B$ s while  $M$  reports  $H$ ,  $D$ , or  $E$ .*

**Proof.** Since  $p_{DH} \leq 1 - p_{HH}$  and  $p_{HD} \leq 1 - p_{DD}$ , this result directly follows from Theorem 2 and inequalities 1, 2, 3, and 4. ■

We have examined and extended the basic model in which a sender's primary preference is to influence players' choices, such as by making player 1 build weapons, and its conditional preference is to preserve its credibility. In the next section, we study how the changes of the sender's value on its credibility affects outcomes. For this purpose, the opposite case of the basic model will be considered in which a sender's primary preference is to preserve its credibility and its conditional preference is to influence players' choices. This is done by assuming that a private media outlet who values its credibility most has its own preferences on players' choices and so the private media outlet tries to manipulate information.

## 4 Media Bias: Sender's Value on its Credibility

In this modified model, a private media outlet is the sender itself, and player 1 is the main audience to this media outlet. So, there are three players; player 1, player 2 and the private media outlet ( $M$ ). The other settings are the same as in the basic model except for the payoffs to  $M$ .

The payoffs to  $M$  depend on its reports and the action of player 2. That is, given a report  $r \in \{H, D\}$  of  $M$  and an action  $a_2 \in \{B, N\}$  of player 2, a real number  $u_{ra_2}$  denotes the payoff to  $M$  when  $M$  reports  $r$  and player 2 chooses  $a_2$ . This setting reflects the fact that  $M$  is mainly an information provider and the information from  $M$  would be evaluated in conjunction with the action of player 2. Thus the payoff to  $M$  is not affected by the action of player 1. This payoff setting for the private media outlet,  $M$ , could be considered the counterpart of the payoff setting for the Ministry of Propaganda in the basic model in terms of the action of player 1, since the payoff to the Ministry of Propaganda is most affected by the action of player 1.

Furthermore, in contrast to the Ministry of Propaganda, the primary preference of the private media outlet,  $M$ , is to preserve its credibility. Just like in the basic model, there are two possible cases in which  $M$  might lose its credibility; it may lose its *Credibility related to Truthfulness (CT)* or its *Credibility related to Accurate Warning (CAW)*. Gentzkow and Shapiro (2006) studied the behavior of the media outlets who prefer to provide accurate information, and they presented empirical evidence of such behavior. They also showed that the importance of credibility in media markets has been emphasized by the management of media outlets. For example, Heyward (2004), president of CBS News, remarked, "Nothing is more important to CBS than our credibility" (see also Kirkpatrick and Fabrikant, 2003; and Rather, 2004).

When  $M$  can preserve its credibility,  $M$  is assumed to prefer the case in which it correctly warns player 1 of the danger of player 2 than the case in which it correctly predicts peace, *i.e.*  $u_{HB} > u_{DN}$ <sup>11</sup>. This preference represents *media bias*. This assumption about the media bias reflects the following intuition: player 2's developing new weapons *i*) makes player 1 feel more insecure; so *ii*) induces player 1, who is the main audience to  $M$ , to pay more attention to  $M$ ; and thus *iii*) eventually increases the profit of  $M$  by expanding the demand for the products of  $M$ . This kind of assumption about media bias is not new in economic literature. Mullainathan and Shleifer (2005) modeled media bias based on a similar assumption in which profit-maximizing media outlets slant news stories to increase the demand for their products.

Formally, the following inequalities are assumed to describe *the preferences of the private media outlet,  $M$* ;

- i*)  $\min\{u_{DB}, u_{DN}\} > u_{HN}$  for *CT*; *ii*)  $u_{HB} > u_{DB}$  for *CAW*; and
- iii*)  $u_{HB} > u_{DN}$  for the media bias.

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<sup>11</sup>In the general coordination games with incomplete information, similar to the case of the basic model, the conditional preference of  $M$  can be flexible.



with these preferences of  $M$ , we can derive a result similar to Theorem 1.

**Theorem 3** *The unique outcome in pure-strategy Perfect Bayesian equilibrium is that  $M$  reports  $H$  and players 1 and 2 choose  $B$ s. If  $u_{HN}$  is small enough, there is no mixed strategy equilibrium except pure-strategy equilibrium.*

**Proof.** The proof of the first assertion is omitted because it is similar to the proof of Theorem 1.

To prove the second assertion, let  $\beta$  be the probability with which  $M$  reports  $H$  when it detects a dovish type. Also, let  $a_2$  and  $b_2$  be the probabilities with which dovish player 2 chooses  $B$  when  $M$  has reported  $H$  and chooses  $B$  when  $M$  has reported  $D$ , respectively. Finally, Let

$$a'_2 \equiv \frac{b_2 u_{DB} + (1 - b_2) u_{DN} - u_{HN}}{u_{HB} - u_{HN}} \text{ and}$$

$$a''_2 \equiv \frac{\beta(1 - h)(\omega - 2) - h}{\beta(1 - h)(\omega - 1)}.$$

If  $a_2$  is equal to  $a'_2$ ,  $M$  is indifferent between playing  $H$  or  $D$  when it detects a dovish type. Also, if  $a_2$  is equal to  $a''_2$ , player 1 is indifferent between playing  $B$  or  $N$  when  $M$  has reported  $H$ . However, given payoff parameters and  $h$ , if  $u_{HN}$  is small enough, then  $a'_2$  is greater than  $a''_2$  for any  $b_2, \beta \in [0, 1]$ .

Let  $a_1$  be the probability with which player 1 chooses  $B$  when  $M$  has reported  $H$ . First, if  $a_2 < a'_2$ , then  $M$  prefers to play  $D$  when it detects a dovish type. Note that  $M$  prefers to play  $H$  when it detects a hawkish type because  $u_{HB} > u_{DB}$ , the primary preference for  $CAW$ . Then player 1 knows that player 2 is hawkish when  $M$  has reported  $H$ . Hence, player 1 prefers to play  $a_1 = 1$ . Second, if  $a''_2 < a_2$ , then player 1 prefers to play  $a_1 = 1$ . If  $u_{HN}$  is small enough, then  $a_2 < a'_2$  or  $a''_2 < a_2$  because  $a''_2 < a'_2$ . Hence player 1 would play only  $a_1 = 1$ , and thus player 2 of a dovish type would also play only  $a_2 = 1$ . Then  $M$  would report only  $H$  because  $u_{HB} > u_{DB}$ , the primary preference for  $CAW$ , and  $u_{HB} > u_{DN}$ , the media bias. Therefore, there exists only a pure-strategy equilibrium. ■

Theorem 3 shows that even when the primary preference of the sender is its credibility, the receivers do not benefit more than they do in the basic model. This is because the availability of the information from  $M$  removes the possibility for players to choose  $N$ s. Consequently,  $M$ 's warning to player 1 induces both players to choose  $B$ s.

From  $M$ 's point of view, the worst payoff is when it is proved to have lied. Only the payoff parameter  $u_{HN}$  denotes this worst payoff. So, lower  $u_{HN}$  means that  $M$  values its credibility related to truthfulness,  $CT$ , more. Theorem 3 implies that more value placed on the sender's  $CT$  could result in worse outcomes for the receivers by removing a mixed-strategy equilibrium. Also, the payoff  $u_{HN}$  could be considered to be the punishment that player 1 inflicts on  $M$  when  $M$  has verifiably lied. This

is because player 1 is  $M$ 's main audience and so the payoffs to  $M$  depend largely on player 1's interest in  $M$ 's information. Then Theorem 3 implies that player 1 cannot improve her expected payoff by punishing  $M$  when  $M$  has verifiably lied and sometimes player 1 could even lower her expected payoff by punishing  $M$ .

DeFleur and Ball-Rokeach (1989) and Morris and Shin (2002) also analyzed the effects of information from the media (see also Gamson, Croteau, Hoynes, and Sasson, 1992; and Bernhardt, Krasa, and Polborn, 2006). They assumed that the degree of influence that the media exert on the public is determined by the extent to which the media reports its information, and thus the influence of the media on the public was exogenously modeled. In the present model, in contrast to their works, the structure of the model endogenously creates the influence of the media on the players' decision-making process.

We have seen two kinds of information transmission models: the basic model and the media bias model. In both models, there is only one sender, and the sender achieves its favored outcome by manipulating information through the news media. Then, what would occur if there are more than one sender? If there are more than one sender, the senders could compete with one another. Does the competition matter in these information transmission models? Does reporting simultaneously or reporting sequentially make a difference? The next section answers these questions.

## 5 Media Competition: Multiple Senders

In this model, I extend the previous model by introducing another private media outlet. Therefore, there are four players; player 1, player 2, media outlet 1 ( $M_1$ ), and media outlet 2 ( $M_2$ ). Player 1 is still the main audience to both  $M_1$  and  $M_2$ . The media outlets report sequentially or simultaneously. When they report sequentially,  $M_1$  reports first. The other settings are the same as in the media bias model except the payoffs to the media outlets.

*The payoffs to each outlet depend on the reports from the other outlet as well as its own reports and the action of player 2.* That is, given reports  $r_1, r_2 \in \{H, D\}$  of the media outlets and an action  $a_2 \in \{B, N\}$  of player 2, a real number  $u_{r_1 r_2 a_2}^i$  denotes the payoff to  $M_i$  for  $i \in \{1, 2\}$  when  $M_1$  reports  $r_1$ ,  $M_2$  reports  $r_2$ , and player 2 chooses  $a_2$ . This setting allows us to examine the effect of media competition.

Regarding their preferences, just like in the media bias model, the primary preference of the media outlets is to preserve their credibility: *CT* and *CAW*. In this model, the conditional preference of the media outlets depends on both *media bias* and *media competition*. The media outlets have the same bias as in the media bias model. So the media outlets prefer the case in which they correctly warn player 1 of the danger of player 2 than the case in which they correctly predict peace. The following inequalities represent all possible cases of media bias;  $\min\{u_{HHB}^1, u_{HDB}^1\} > \max\{u_{DHN}^1, u_{DDN}^1\}$  and  $\min\{u_{HHB}^2, u_{DHB}^2\} > \max\{u_{HDN}^2, u_{DDN}^2\}$ . Media competition imposes another condition for the payoffs to the media outlets by tempt-

ing them to occupy a leading position in competition. That is, in competition, media outlets have more incentive to predict correctly while others predict incorrectly than while others also predict correctly. The following inequalities describe all possible cases of media competition;  $\min\{u_{DHN}^1, u_{HDB}^1\} > \max\{u_{HHB}^1, u_{DDN}^1\}$  and  $\min\{u_{HDN}^2, u_{DHB}^2\} > \max\{u_{HHB}^2, u_{DDN}^2\}$ .

However, the following two inequalities for media competition  $u_{DHN}^1 > u_{HHB}^1$  and  $u_{HDN}^2 > u_{HHB}^2$  directly contradict the inequalities for media bias  $u_{DHN}^1 < u_{HHB}^1$  and  $u_{HDN}^2 < u_{HHB}^2$ . Therefore, there are two possible cases: one case in which bias dominates competition and the remaining case in which bias does not dominate competition. *When bias dominates competition and the private media outlets report sequentially*, the following inequalities are assumed to describe *the preferences of the media outlets*;

- i)  $\min\{u_{HDB}^2, u_{HDN}^2\} > u_{HHN}^2$  for CT;
- ii)  $u_{HHB}^1 > \max\{u_{DHB}^1, u_{DDB}^1\}$  and  $u_{HHB}^2 > u_{HDB}^2$  for CAW; and
- iii)  $u_{HHB}^1 > \max\{u_{DDN}^1, u_{DHN}^1\}$  and  $u_{HHB}^2 > u_{HDN}^2$  for the media bias.

*When bias does not dominate competition and the private media outlets report sequentially*, the following inequalities are assumed to describe *the preferences*<sup>12</sup> *of the media outlets*;

- i)  $u_{DDN}^1 > u_{HDN}^1$  and  $u_{DDN}^2 > u_{DHN}^2$  for CT;
- ii)  $u_{HHB}^1 > \max\{u_{DHB}^1, u_{DDB}^1\}$  and  $u_{HHB}^2 > u_{HDB}^2$  for CAW; and
- iii)  $u_{HDN}^2 \geq u_{HHB}^2$  for the weakly dominant media competition.

Note that when bias dominates competition,  $u_{HHB}^2 > u_{HDN}^2$  is assumed. On the other hand, when bias does not dominate competition,  $u_{HHB}^2 \leq u_{HDN}^2$  is assumed. Finally, *when the private media outlets report simultaneously*, the following inequalities are assumed to describe *the preferences*<sup>13</sup> *of the media outlets*;

- i)  $u_{DDN}^1 > u_{HDN}^1$  and  $u_{DDN}^2 > u_{DHN}^2$  for CT; and
- ii)  $u_{HHB}^1 > u_{DHB}^1$  and  $u_{HHB}^2 > u_{HDB}^2$  for CAW.

**Theorem 4** *Suppose that the media outlets report sequentially. If bias dominates competition, then the unique outcome in pure-strategy Perfect Bayesian equilibrium*

<sup>12</sup>For Theorem 4, it suffices to assume that  $u_{DDN}^1 \geq u_{HDN}^1$  and  $u_{DDN}^2 \geq u_{DHN}^2$  instead of  $u_{DDN}^1 > u_{HDN}^1$  and  $u_{DDN}^2 > u_{DHN}^2$ ; and to assume that  $u_{HHB}^1 \geq \max\{u_{DHB}^1, u_{DDB}^1\}$  and  $u_{HHB}^2 \geq u_{HDB}^2$  instead of  $u_{HHB}^1 > \max\{u_{DHB}^1, u_{DDB}^1\}$  and  $u_{HHB}^2 > u_{HDB}^2$ . These stronger assumptions are made in accordance with the preferences about credibility.

<sup>13</sup>For Theorem 4, it suffices to assume that  $u_{DDN}^1 \geq u_{HDN}^1$  and  $u_{DDN}^2 \geq u_{DHN}^2$  instead of  $u_{DDN}^1 > u_{HDN}^1$  and  $u_{DDN}^2 > u_{DHN}^2$ ; and to assume that  $u_{HHB}^1 \geq u_{DHB}^1$  and  $u_{HHB}^2 \geq u_{HDB}^2$  instead of  $u_{HHB}^1 > u_{DHB}^1$  and  $u_{HHB}^2 > u_{HDB}^2$ . These stronger assumptions are made in accordance with the preferences about credibility.

is that both outlets report  $Hs$  and players choose  $Bs$ . In addition, if  $u_{HHN}^2$  is small enough, there is no mixed-strategy equilibrium except pure-strategy equilibrium. However, if bias does not dominate competition, then there exists a pure-strategy Perfect Bayesian equilibrium in which the media outlets report  $Hs$  and players choose  $Bs$  when player 2 is hawkish and the media outlets report  $Ds$  and players choose  $Ns$  when player 2 is dovish. Suppose that the media outlets report simultaneously. Then there also exists the pure-strategy Perfect Bayesian equilibrium in which the media outlets report  $Hs$  and players choose  $Bs$  when player 2 is hawkish and the media outlets report  $Ds$  and players choose  $Ns$  when player 2 is dovish.

**Proof.** First, suppose that the media outlets report sequentially. It is easily seen that there exists an equilibrium outcome in which players 1 and 2 play  $Bs$ . Therefore, it suffices to show that if a strategy profile is an equilibrium, then players play  $Bs$  in the outcomes of the strategy profile.

Let player 1 play  $B$  when both outlets have reported  $Hs$ . Then the best response of player 2 to this action is to play  $B$  when both outlets have reported  $Hs$ . Next, the best response of  $M_2$  to these actions is to play  $H$  when  $M_1$  has reported  $H$  because  $u_{HHB}^2 > u_{HDB}^2$ ,  $CAW$ , and  $u_{HHB}^2 > u_{HDN}^2$ , the media bias. Also, the best response of  $M_1$  to these actions is to play  $H$  because  $u_{HHB}^1 > \max\{u_{DHB}^1, u_{DDB}^1\}$ ,  $CAW$ , and  $u_{HHB}^1 > \max\{u_{DDN}^1, u_{DHN}^1\}$ , the media bias. Finally, the best response of player 1 is to play  $B$  when both outlets have reported  $Hs$ . Therefore, in this outcome, both outlets report  $Hs$  and players choose  $Bs$ .

Let player 1 play  $N$  when both outlets have reported  $Hs$ . Then the best response of dovish player 2 is to play  $N$  when both outlets have reported  $Hs$ . Next, the best response of  $M_2$  is to play  $D$  when it detects a dovish type and  $M_1$  has reported  $H$  because  $\min\{u_{HDB}^2, u_{HDN}^2\} > u_{HHN}^2$ ,  $CT$ . Note that if the media outlets detect a hawkish type, then they know that player 2 would play  $B$ , and thus they prefer to report  $Hs$  because  $u_{HHB}^2 > u_{HDB}^2$  and  $u_{HHB}^1 > \max\{u_{DHB}^1, u_{DDB}^1\}$ ,  $CAW$ . Hence, player 1 can be certain that player 2 is hawkish when both outlets have reported  $Hs$ . Consequently, player 1 has an incentive to change her action from  $N$  to  $B$  when both outlets have reported  $Hs$ . Therefore, a strategy profile in which player 1 plays  $N$  when both outlets have reported  $Hs$  cannot be an equilibrium. This completes the proof of the first assertion.

The proof of the second assertion is omitted because it is similar to the proof in Theorem 3.

To prove the third and the fourth assertions, let player 1 play  $B$  only when both outlets have reported  $Hs$ ; *i.e.*  $(B, N, N, N)$ . Then only player 2's strategy under which she plays  $B$  either when she is hawkish or when both outlets have reported  $Hs$ , *i.e.*  $(B, B, B, B, B, N, N, N)$ , satisfies the best response in each continuation game.

Suppose that bias does not dominate competition. Then when  $M_2$  detects a dovish type, one of the best responses of  $M_2$  is to report  $D$  no matter what  $M_1$  has reported because  $u_{DDN}^2 > u_{DHN}^2$ ,  $CT$ , and  $u_{HDN}^2 \geq u_{HHB}^2$ , the weakly dominant media competition. Next, when  $M_1$  detects a dovish type, the best response of  $M_1$

is to report  $D$  because  $u_{DDN}^1 > u_{HDN}^1$ ,  $CT$ . Note that if  $M_1$  detects a hawkish type, then it would report  $H$  because  $u_{HHB}^1 > \max\{u_{DHB}^1, u_{DDB}^1\}$ ,  $CAW$ . Also, if  $M_1$  has reported  $H$  and  $M_2$  detects a hawkish type, then  $M_2$  would report  $H$  because  $u_{HHB}^2 > u_{HDB}^2$ ,  $CAW$ . Under these strategies of player 2,  $M_1$ , and  $M_2$ , player 1's strategy  $(B, N, N, N)$  satisfies the best response in each continuation game. Therefore, there exists an action  $r_{HD}^2 \in \{H, D\}$  of  $M_2$  such that the strategy profile  $\{(H, D), (H, r_{HD}^2, D, D), (B, N, N, N), (B, B, B, B, B, N, N, N)\}$  is an equilibrium, where  $r_D^2$  specifies the action of  $M_2$  when it detects a hawkish type and  $M_1$  has reported  $D$ . In this strategy profile, the media outlets report  $H$ s and players choose  $B$ s when player 2 is hawkish and the media outlets report  $D$ s and players choose  $N$ s when player 2 is dovish.

Finally, suppose that the media outlets report simultaneously. Then when the outlets detect a hawkish type, each outlet prefers to report  $H$  if the other outlet would report  $H$  because  $u_{HHB}^1 > u_{DHB}^1$  and  $u_{HHB}^2 > u_{HDB}^2$ ,  $CAW$ . Also, when the outlets detect a dovish type, each prefers to report  $D$  if the other would report  $D$  because  $u_{DDN}^1 > u_{HDN}^1$  and  $u_{DDN}^2 > u_{DHN}^2$ ,  $CT$ . Finally, player 1's strategy  $(B, N, N, N)$  satisfies the best response in each continuation game. Therefore, the strategy profile  $\{(H, D), (H, D), (B, N, N, N), (B, B, B, B, B, N, N, N)\}$  is a pure-strategy equilibrium and in this equilibrium the media outlets report  $H$ s and players choose  $B$ s when player 2 is hawkish and the media outlets report  $D$ s and players choose  $N$ s when player 2 is dovish. ■

Therefore, as long as bias dominates competition and the media outlets report sequentially, players 1 and 2 cannot improve their expected payoffs. Just like in the media bias model, the punishment for an untruthful report does not improve players' expected payoffs, and sometimes even lowers their payoffs. However, media competition and simultaneous reporting each can make the media outlets report truthfully, and consequently players can improve their expected payoffs. In fact, the outcome combination in which players 1 and 2 play  $B$ s when player 2 is hawkish and they play  $N$ s when player 2 is dovish gives player 1 the best payoff out of all outcome combinations such that hawkish player 2 plays  $B$ , and player 1 can achieve this combination only when the media outlets reveal the information about player 2's type. Also, when there are more than one sender in the basic model, if the senders report simultaneously or if competition among the senders is strong enough, then players can achieve this outcome combination. Therefore, **enough competition and simultaneous reporting can each solve media manipulation problems in this study.**

The media competition model can be extended by introducing more media outlets and imperfect signals about player 2's type. In this case, if bias dominates competition, then we can derive a result similar to Theorems 2 and 4. That is, if the signal is informative to player 1 and to the media outlets, then the unique outcome in pure-strategy equilibrium is that all outlets report  $H$ s and players choose  $B$ s. However, if competition dominates bias, then the result depends on media outlets' *herd behavior*

in reporting, which was studied by Scharfstein and Stein (1990) and Banerjee (1992), and the result might differ from Theorems 2 and 4. Here, herd behavior in reporting means that media outlets just follow other outlets' actions regardless of their own information about player 2's type.

To see how the result can be affected by the herd behavior, suppose that player 1 plays  $N$  if at least one media outlet reports  $D$ . If competition dominates bias and there is no herd behavior, then this strategy of player 1 influences the media outlets to report truthfully. However, in the imperfect information case, when media outlets truthfully report and it turns out that only one outlet has reported  $D$  and the other all outlets have reported  $Hs$ , player 1 has an incentive to change her action from  $N$  to  $B$ . This is because the probability that player 2 is hawkish is much higher than the probability that player 2 is dovish. Since player 1 would not play her strategy suggested above, the media outlets lose an incentive to report truthfully. In this case, if there is herd behavior in reporting, then even when all media outlets except one outlet have reported  $Hs$ , the probability that player 2 is hawkish might not be high. This is because most of the outlets just followed previous reports and accordingly just a few media outlets reveal their information about player 2's type. Consequently, if the payoff  $\omega$  of player 1 in the  $NN$  outcome is large enough, then player 1 can rationally play  $N$  even when all media outlets except one outlet have reported  $Hs$ . Therefore, player 1 can achieve her favored outcome,  $NN$ . In this sense, media outlets' herd behavior in reporting is considered to improve player 1's expected payoff.

This model focuses on the effect of media bias as a part of general endeavor to understand the media as a means of information transmission. A large literature about the media, on the other hand, focuses on the occurrence and persistence of media bias. Most of them assume irrational players to a certain extent and explain why media bias happens and continues based on the irrational player assumption. Mullainathan and Shleifer (2005), Baron (2006), and Gentzkow and Shapiro (2006) studied media bias and examined whether media competition can reduce media bias. Baron explained that the occurrence and persistence of media bias can arise from the supply side by journalists who are willing to accept lower wages for the sake of their discretion. Mullainathan, Shleifer, Gentzkow, and Shapiro showed that media bias can, however, come from the demand side. They argued that profit-maximizing media outlets could cater to the preferences or prior beliefs of their audience, who can be considered as irrational players, to increase the demand for their products; this behavior represents media bias. Regarding media competition, Mullainathan, Shleifer, and Baron concluded that competition by itself may not be powerful enough to reduce media bias. On the other hand, Gentzkow and Shapiro found that competition among independently owned media outlets can lead to lower bias. In the present model, similar to Gentzkow and Shapiro, sufficiently strong competition can lead the media outlets to report truthfully.

## 6 Conclusions

Suppose that receivers are in a situation of potential conflict and a sender reports its information through the news media. In addition, suppose that the sender has a conditional preference for maintaining its credibility in reporting accurate information. Then even when the sender and the receivers have contradictory preferences, the sender can make the receivers play the sender's favored outcome. This result extends to the imperfect information case. That is, when the information includes noise, if the information is informative enough, then the sender can achieve its favored outcome.

This result does not change even when the sender values more its credibility in reporting accurate information. This is because the availability of the information from the sender removes the possibility for the players to play  $N$ s. However, if there are more than one sender, then the result could change. If competition among the senders is strong enough or if at least two senders report simultaneously, then the senders can be forced to report truthfully, and as a result, the receivers' expected payoffs can improve. Therefore, enough competition and simultaneous reporting can be a solution to the media manipulation problem in this study.

The findings derived from the arms race game could be extended to the general coordination game with incomplete information where there can be more than two receivers and also more than two actions for each receiver. This is because, just like the receivers in the arms race game, receivers in the general coordination games cannot completely ignore the report from senders. As a result, the senders can successfully influence the receivers to play their favored outcome by manipulating information through the media.

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