Public Reviews and Trust Formation in Disaster Risk Management

Tsuyoshi Hatori,*
Kiyoshi Kobayashi,**
Hayeong Jeong***

*Ehime University, 3 Bunkyo-cho, Matsuyama-shi, Ehime, 790-8577, Japan
Email address: hatori@cee.ehime-u.ac.jp
**Kyoto University, Yoshida, Sakyo-ku, Kyoto, 606-8501, Japan
Email address: kkoba@psa.mbox.media.kyoto-u.ac.jp
***Kyoto University, Katsura, Nishikyo-ku, Kyoto, 615-8540, Japan
Email address: hayeong@psa2.mbox.media.kyoto-u.ac.jp

ABSTRACT

This paper investigated two roles of public reviews in disaster risk management: 1) providing information to a policy maker about the desirability of a disaster risk management plan and 2) promoting stakeholders' trust in policy maker's decision. Our analysis was conducted by formulating two linked communication games, which described, respectively, information transmission from public reviewers to a policy maker and trust formation between the policy maker and an individual. It was shown that there exists an externality between the two games, and the policy maker accordingly faces a trade-off between the two roles of public reviews. Due to this trade-off, trust formation between the policy maker and the individual might be prevented. Finally, alternative institutional design for realizing trust formation between the policy maker and the individual through public reviews was discussed. It was pointed out that a communication protocol that disciplines the way in which reviewers express their opinions has to be designed in order to realize the two roles of public reviews.

Keyword: trust formation in disaster risk management, public reviews, subjective games

1 Introduction

Disaster risk management is often discussed around an extremely sophisticated judgment, which puzzles even local government in finding a clear solution. In this context, the use of public reviews in the development and determination of a disaster risk management plan has become increasingly widespread. Indeed, recently, local government often holds a public forum in which various experts and interested parties deliberate the desirability of a disaster risk management plan. Public reviews are expected to carry out a variety of functions from raising democratic potential to learning stakeholders' opinions of a disaster risk management plan. Among them, this paper examines two roles of public reviews in disaster risk management: 1) providing information to a policy maker (local government) about the desirability of a disaster risk management plan [1][2][3][4] and 2) supporting stakeholders' trust in a policy maker's decisions [5][6]

[7][8]. First, a policy maker frequently fails to solve disaster risk management problems involving environments of high uncertainty and ambiguity. In this context, a policy maker can reduce this uncertainty by consulting public reviewers. As a professional, a reviewer's judgment is indispensable in evaluating the appropriateness of disaster risk management from the standpoint of technical expertise.

Second, a regional policy maker is often confronted with the difficulty of convincing many stakeholders that the disaster risk management plan that she proposes is in their interests. Even if an innovative project is proposed by regional planners, it cannot be realized without community acceptance. To gain stakeholders' acceptance, the policy maker has primarily to be trusted by them. In this context, by introducing public reviews, stakeholders might be given reason to trust the policy maker. Thus, a trust relationship between the policy maker and stakeholders might be formed through public reviews.

The two roles of public reviews, however, cannot always be fulfilled [5][6]. We consider the problem of cognitive dissonance between a policy maker and a stakeholder [9]. Cognitive dissonance refers to the state resulting from inconsistency between individuals' internal representations by which they describe and make sense of real-world situations. A policy maker, who operates within a local area and is engaged in disaster risk management, is likely to describe a decision-making problem using technical terms or special terminology, while a non-professional stakeholder who lacks the relevant expertise might describe the issue using the ambiguous, general terms that make up the lexicon of his or her daily lives [10]. In other words, although they communicate with each other concerning the same management issues, they recognize these issues using different descriptions. Due to this cognitive dissonance, the policy maker might face a trade-off between the two roles of public reviews. On the one hand, in order to obtain the relevant information to carry out an appropriate disaster risk management plan, the policy maker needs to extract technical expertise such as accurate data and definite evidence from the reviewers. On the other hand, in order to gain stakeholders' trust in a disaster risk management plan, the policy maker needs to consult reviewers to persuade them to support the project from the standpoint of their daily lives remote from

the scientific world. However, these two requirements might not be satisfied simultaneously. Accordingly, the trade-off is likely to raise the problem of miscommunication and as a result, the optimal plan for disaster risk management might not be realized.

This paper elaborates a theoretical framework for examining the validity of the two roles of public reviews, i.e., information provision and trust formation, by using communication game theory. The remainder of this paper is structured as follows. In Section 2, the basic concept regarding the theoretical model is discussed. In Section 3, the basic model that describes information transmission from public reviewers to a policy maker is presented. In Section 4, we consider a situation where the policy maker has to persuade an individual in order to realize a disaster risk management plan as the extended model.

2 Basic Concepts

2.1 Concept of linked communication games

Our analysis is conducted by formulating two linked communication games, which describe, respectively, 1) information transmission from public reviewers to a policy maker and 2) trust formation between a policy maker and an individual who represents various stakeholders related to a disaster risk management plan. In what follows, we especially call the latter game the "trust game" [8][11][12]. Let us consider a situation where a policy maker must make a decision about a disaster risk management plan. The policy maker can choose between two alternatives, alternative X (undertaking a project) and alternative Y (maintaining the status quo), while she is uncertain about the properties of the project and cannot judge which alternative is better for her interests. Then, as will be described in the next section, public reviewers send their messages about the desirability of the two alternatives to the policy maker. The alternative that the policy maker selects after receiving the messages of the reviewers cannot be realized as a public choice unless it is accepted by the individual. The trust game analyzes whether the individual accepts the policy maker's decision.

As explained in the introduction, we consider a situation in which a policy maker and an individual recognize a disaster risk management plan by using different cognitive schemes. In this context, the policy

maker might be confronted with a trade-off with regards to the two roles of the public reviews. On the one hand, the policy maker is able to reduce the uncertainty that she is faced with by consulting public reviewers to provide information about the technical issues related to the management plan. Furthermore, information transmission between the policy maker and public reviewers may improve through the mechanism of check and balance among multiple reviewers [13]. On the other hand, a trust relationship between a policy maker and an individual can be realized by introducing public reviewers who examine the management plan from the standpoint of the individual's daily life. However, if the policy maker discloses the results of public reviews to the individual, it is possible that the reviewers will express their own opinions in a strategic fashion and try to prevent a desirable disaster risk management plan. As a result, the check and balance mechanism among reviewers might not be functioning well.

2.2 Concept of subjective games

A disaster risk management project (alternative X) is characterized by the properties of the project, while a policy maker and an individual recognize these properties by different cognitive schemes. This paper describes the cognitive dissonance between the policy maker and the individual as they play different subjective games [8][14][15]. Figure 1 shows the subjective framework of the trust game proposed in this paper. The left-hand side of this figure denotes the subjective game of the policy maker, and the right-hand side denotes the subjective game of the individual. Each entry in the matrix represents the payoffs to the two players (left for policy maker's payoffs, right for individual's payoffs) if the properties of the project are set by the corresponding properties in the rows and

the players choose the corresponding alternative in the columns as a collective choice. In both subjective games, both players can obtain a positive payoff, $x > 0$, if a desirable project is selected and a negative payoff, $\underline{x} \leq 0$, otherwise. The payoff from the status quo is assumed to be zero.

We should emphasize two key concepts of the subjective game, i.e., 1) property labels and 2) subjective payoffs. Firstly, it is assumed that the properties of alternative X can be represented by two different languages. On the one hand, a policy maker engaged in disaster risk management practices within a local area describes a disaster risk management project with real, specific terms that represent the technical conditions regarding the management plan. For example, she might evaluate each alternative by calculating the probability and impact of a natural disaster on the basis of scientific knowledge about the characteristics of disaster risks. On the other hand, the individual uses virtual, general terms that represent the influence on his realm of imagination of the disaster risk management plan. He might be concerned about environmental preservation matters from a global standpoint. We call the technical terms that the policy maker uses "technical property labels." Technical property labels are denoted by R_1 and R_2. Similarly, let non-technical terms be called "non-technical property labels," which are represented by V_1 and V_2. Each player recognizes the projects properties by means of his or her property labels, and they do not know how the other player will describe them. We assume a one-to-one correspondence between the two property labels. There exist the following possible correspondences:

Correspondence 1: R_1-V_1, R_2-V_2;
Correspondence 2: R_1-V_2, R_2-V_1.   (1)

Here, the former (correspondence 1) denotes the true correspondence between the two labels, while the

	Subjective game of the policy maker				Subjective game of the individual		

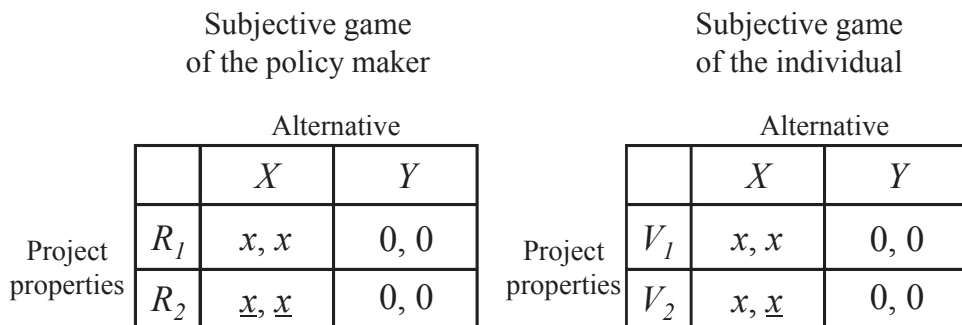|		Alternative				Alternative	
		X	Y			X	Y
Project properties	R_1	x, x	$0, 0$	Project properties	V_1	x, x	$0, 0$
	R_2	$\underline{x}, \underline{x}$	$0, 0$		V_2	$x, \underline{x}$	$0, 0$

Figure 1. Subjective games of communications between a policy maker and an individual

latter (correspondence 2) denotes the false correspondence. The true correspondence is assumed to be unknown to the two players. The policy maker and the individual have a preference over the property labels. Let us assume that the two players have common interests, and the most preferred properties are R_1 and V_1. The policy maker and the individual, however, are uncertain about which properties are to be realized by the project. What kind of label each player uses depends on his or her knowledge, experience, other psychological factors, and so on. In this paper, these labels are treated exogenously, and we shall not attempt to explain the process through which property labels are formed. The following analysis focuses on the question: Given property labels, what choices will each player make through a communication process?

Secondly, it is assumed that each player will maximize subjective payoffs in his or her subjective game. Let us consider a situation where the individual holds the stereotyped belief that the policy maker always makes no effort to reduce disaster risks, while in practice, the policy maker is sincere in making an effort for the individual. Subjective payoffs described on the left- and right-hand side of Figure 1 are set to represent such a situation. The reason that we impose these strong assumptions with regard to an individual's stereotyped beliefs is for the analysis of an institutional design under which an individual with stereotyped beliefs about a policy maker's behavior tends to trust the policy maker who is motivated to conduct disaster risk management activities in accordance with the individual's will. Each player who mentally organizes the world by using his or her subjective game cannot understand the subjective game of the other player. Furthermore, since the two players describe the situation using different languages, the policy maker has no means to inform the individual that she is making the optimal decision. The trust game proposed in this paper focuses on the problem of whether the individual trusts the policy maker in such a situation.

3 Model of Public Reviews

This section analyzes a simple game as the basic model in which a policy maker and public reviewers communicate with each other regarding a disaster risk management plan. As explained previously, the desir-

ability of a disaster risk management project depends upon the project's properties, which are unknown to the policy maker. The model assumes a situation in which project properties R_1 and R_2 (V_1 and V_2) are realized by the management plan (alternative X) to be state "s_1" and "s_2," respectively. The policy maker is assumed to hold the incorrect subjective belief about the true state of the world. It is assumed that in the initial state before receiving the messages of public reviewers, she chooses to maintain the status quo. In this context, the public reviewers make announcements to a policy maker about the desirability of a disaster risk management plan. The reviewer is supposed to be an expert or an interested party related to the management plan. For example, we can consider that a local government holds a public forum where several reviewers evaluate disaster risk management activities. In the model proposed in the following subsections, we assume that public reviewers have the ability to correctly evaluate the optimal alternative for a policy maker. This means that they possess perfect information about the state of the world. After observing the true state, reviewers send their messages to the policy maker about which alternative the policy maker should choose. As this section focuses upon a situation where the policy maker consults public reviewers to seek advice on the optimal alternative from a technical standpoint, it is assumed that the reviewer's message is represented by the technical property labels. Thus, a reviewer's message is denoted by $m = R_1$ or R_2. This assumption is removed in the next section, where the public reviewers are able to send their messages directly to the individual, who describes a disaster risk management plan using non-technical property labels. However, reviewers might have private interests in conflict with the policy maker. Furthermore, the model allows reviewers to send their messages strategically to the policy maker. Accordingly, they are able to manipulate the optimal alternative. Let us define a reviewer's message as a "correct message" if the message corresponds to the true state, and a "wrong message" otherwise. It is assumed that reviewers are differentiated into two types depending upon their interests 1) a reviewer who prefers alternative X regardless of the true state and 2) a reviewer who prefers alternative Y regardless of the true state. The first type can be regarded as a progressive reviewer who aims to promote a disaster

risk management plan, while the second one can be regarded as a conservative reviewer who is skeptical of the project. The first and the second reviewer are hereafter called the "progressive reviewer" and the "conservative reviewer," respectively. The progressive reviewer obtains a positive payoff normalized to unity if the policy maker chooses alternative X, while the reviewer obtains payoff zero otherwise. The reverse holds for the payoffs of the conservative reviewer, that is, the payoff of the reviewer is unity if the policy maker chooses alternative Y, and zero otherwise. It is assumed that there is mutual knowledge about the types of reviewers among all the players.

As mentioned above, the present model allows for the possibility of reviewers behaving manipulatively. In reality, however, reviewers may not necessarily be motivated to manipulate the optimal alternative because they otherwise would suffer punishment or lose reward afterward. On the other hand, it might be difficult for the policy maker to evaluate and control reviewers' behavior completely, especially in the case where reviewers are discussing a technical judgment for disaster risk management that is difficult even for the policy maker to understand. Also, even if all reviewers have sincerely proposed the optimal alternative, it is possible that the policy maker and the individual cannot understand this and will then distrust the reviewers' opinions. Accordingly, it is important to develop a robust institution that is proof against reviewers' manipulation even if such dishonest reviewers were involved or against players' incorrect beliefs regarding reviewers' manipulation even if such reviewers were not involved in reality. This is our motivation behind the assumption of manipulative behavior of reviewers.

The strategy of the policy maker is denoted by probability ρ that she chooses alternative X. The strategy of the reviewer is denoted by σ^r ($r = P, C$), which denotes the probability that the progressive and conservative reviewer will send message R_1. Since the choice of the reviewer is conditioned on state of the world s_k ($k=1, 2$), we denote the strategies of the two reviewers as $\sigma^P(s_k)$ and $\sigma^C(s_k)$. The choice of policy maker depends on the messages of reviewers. Therefore, the strategy of the policy maker is represented by $\rho(m^r)$ for the case of a single reviewer, and $\rho(m^P, m^C)$ for the case of multiple reviewers. In what follows, we first analyze the basic model by a single reviewer, and then by multiple reviewers.

1) Single reviewer

Before studying the model with multiple reviewers, it is instructive to show that the policy maker can extract no information about the true state of the world from a single reviewer. In this game, the reviewers have no reason to be truthful, irrespective of their type. This is because the reviewer has an incentive to manipulate the desirability of the alternatives if the policy maker decides which alternative to choose according to the message of the reviewer. More precisely, the progressive reviewer would like to inform the policy maker that alternative X is better by sending message R_1 even if the true state is s_2. On the other hand, the conservative reviewer attempts to make the policy maker choose alternative Y, despite the fact that state s_1 is realized. Since both reviewers lack the means to send a truthful message to the policy maker, the policy maker remains skeptical of the reviewer's judgment. Eventually, the policy maker cannot trust the reviewers' judgments, and as a result, she chooses the status quo.

2) Multiple reviewers

Analysis of the policy game with a single reviewer shows that as long as the reviewer evaluates the alternatives independently, the policy maker does not believe what the reviewer says. To overcome this issue, we introduce a peer review system that comprises two types of reviewer. In particular, the mechanism of check and balance between reviewers is examined. The mechanism of check and balance forces two reviewers to be truthful through having one reviewer's statement checked against the other reviewer's statement. Under the mechanism of checks and balances, both reviewers cannot but send a correct message about the true state of the world. We assume that in the peer review system, each reviewer can obtain additional positive payoff $\mu > 0$ if the messages of the two reviewers coincide with each other. Payoffs μ are referred to statement rewards hereafter. Statement rewards represent both pecuniary rewards that a local government pays reviewers for the results of evaluation and non-pecuniary rewards such as prestige and reputation. Let us assume that the result of the communication game is more important for each reviewer than statement rewards, i.e. $1 > \mu > 0.5$.

In the basic model with multiple reviewers, the policy maker chooses the following strategy:

$$\rho^*\left(R_1^P, R_1^C\right) = 1, \quad \rho^*\left(R_2^P, R_2^C\right) = 0 \,;$$

$$\rho^*\left(m^P, m^C\right) = 1/2 : \text{ if the other messages } (m^P, m^C) \text{ are sent.}$$

$$(2)$$

Thus, the policy maker selects alternative X (Y) if both reviewers recommend alternative X (Y). In case reviewers' messages do not satisfy the consistency condition, the policy maker chooses a mixed strategy because she cannot judge which message is correct. On the other hand, reviewers' strategies are represented by

$$\sigma^{r*}\left(s_1\right) = 1, \quad \sigma^{r*}\left(s_2\right) = 0 \quad (r = P, C). \tag{3}$$

Receiving the messages of reviewers who follow the above strategies, the policy maker can obtain perfect information about the desirability of the alternatives.

In this game, the mechanism of checks and balances works well, and the message of one reviewer is always checked against the message of the other reviewer. As a result, any deviation from the equilibrium is worse for both reviewers, and accordingly, each reviewer is forced to be truthful.

Proposition 1: Under the mechanism of check and balance among multiple reviewers, the policy maker can obtain perfect information about the desirability of a disaster risk management plan.

4 Model of Trust Formation

4.1 Trust formation in disaster risk management

As the previous analysis shows, if the check and balance mechanism among multiple reviewers is working well, the policy maker can obtain perfect information about the desirability of a disaster risk management plan. For simplicity, in what follows, we assume the true state is s_1, and that alternative X is optimal for the policy maker and the individual. In many situations, however, the policy maker's proposal has to be approved by individuals. This section examines the extended model that describes trust formation between the policy maker and the individual in addition to the communication process between the policy maker and the public reviewers. As a preliminary analysis, let us consider a situation where the review process is not conducted in public and the check and balance function among reviewers is working well. We call the model presented in this section extended model A. As

shown in proposition 1, the policy maker can choose the optimal alternative (alternative X) based upon the reviewers' messages in her subjective game described on the left-hand side of Figure 1. Therefore, this section focuses on the individual's choice in his subjective game. Analysis of the model shows whether the individual who has stereotyped beliefs about a policy maker's behavior can trust the policy maker. However, emphasis should be placed on the fact that the equilibrium strategies employed in what follows are appropriate only in an individual's subjective game. It does not mean that each player selects the equilibrium strategies in respective subjective games. In particular, an equilibrium strategy of the policy maker in an individual's subjective game might differ from the actual policy maker's choice in her subjective game.

The strategy of the individual is represented by probability τ that he chooses to accept the policy maker's proposal. The strategies of the policy maker and reviewers are denoted by ρ and σ^r ($r = P, C$), respectively, in the same way as in the basic model. In this model, there exists a unique equilibrium, where the individual chooses not to trust the policy maker. In what follows, we call this equilibrium distrust equilibrium. In the distrust equilibrium, policy maker's strategy is $\rho(s_k)^* = 1$ regardless of state s_k (k=1, 2). Therefore, the individual does not trust the policy maker, that is $\tau^* = 0$.

In extended model A, the individual conceives the idea that the policy maker would constitute a moral hazard if he trusted her. The equilibrium strategy of the policy maker represents the stereotyped beliefs of the individual about the policy maker's behavior. As a result, the individual distrusts the policy maker, although the policy maker chooses optimal alternative X in practice. In this model, the policy maker is assumed to describe the game using technical property labels that cannot be understood by the individual. Yet, even if the policy maker uses the same language as the individual (i.e., non-technical property labels), the individual cannot trust in the policy maker as long as he holds the stereotyped beliefs with respect to the policy maker's payoffs. In sum, unless the individual is able to understand that the policy maker chooses the desirable disaster risk management plan, he does not trust her regardless of her actual choice.

4.2 Disclosure of public reviews

In extended model A, the policy maker cannot maintain trust relationships with the individual as long as the individual holds stereotyped beliefs regarding the policy maker's behavior. In this context, the policy maker has to persuade the individual that she is able to carry out a disaster risk management plan to meet the individual's expectations. In this section, we focus upon the second role of the public review, that is to say, supporting individual's trust in the policy maker's decision. We consider a scenario where the policy maker makes the result of the public reviews open to the public and consults reviewers to persuade the individual. In what follows, the model is referred to the extended model B. If the individual understands that the policy maker decides on a disaster risk management plan according to reviewers' messages, he might trust the policy maker. In extended model B, it is assumed that reviewers can choose which property labels they use for sending their messages.

The strategies of the policy maker, the individual, and reviewers are set by ρ, τ, σ^P, and σ^C respectively. In this model, the individual observes the messages of two reviewers. Accordingly, the individual's strategy is denoted by $\tau(m^P, m^C)$. Apparently, an individual's trust is more likely to be generated by disclosing public reviews to the individual, since the individual can obtain more information about the actions of the policy maker. As will be shown, however, the difference in languages between the two reviewers invalidates the mechanism of check and balance and leads to a distrust equilibrium, which is the same result as that of extended model A.

To understand the rationale behind this result, let us assume a situation where the mechanism of check and balance is working well as shown in the basic model. In this context, the strategy of each reviewer is represented by (3). Since reviewers send a correct message, the policy maker selects the strategy (2). However, although the individual is observing correct messages of public reviewers, he is unable to understand the technical property labels. As a result, he might not accept the policy maker's proposal. Furthermore, even if the individual accepts the plan on observing the reviewers' messages, this behavior is not robust against players' deviations. In this case, the individual's strategies are represented by

$$\tau^*\left(m^P, V_1^C\right)=1, \quad \tau^*\left(m^P, V_2^C\right)=0. \tag{4}$$

The above strategy means that the individual follows the judgment of the only conservative reviewer who shares the same language as the individual. But this strategy gives the conservative reviewer an incentive to deviate from sending the correct message to sending the wrong one represented by non-technical property labels. This deviation, in turn, makes the individual disregard the message of the reviewer. Furthermore, the policy maker who cannot understand non-technical property labels cannot evaluate which message is correct. As a result, the individual who has no information about the action of the policy maker does not trust her. Therefore, a distrust equilibrium is obtained as a unique equilibrium. In this equilibrium, the strategies of the policy maker and the individual are given by $\rho^* = 0$ and $\tau^* = 0$, respectively. Since reviewers cannot affect the behavior of the policy maker or the individual, they are indifferent about which message to send. Equilibrium strategies of reviewers are represented by

$$\sigma^{r*} = const. \quad (r = P, C), \tag{5}$$

where *const* denotes the constant value given independently of the true state of the world. We have thus established the following proposition:

Proposition 2: In extended model B, the mechanism of check and balance among multiple reviewers is not working well, and as a result, the individual distrusts the policy maker.

4.3 Design of a communication protocol

The result of extended model B suggests that the disclosure of public reviews has the potential to subvert the first role of reviewers, i.e., information provision to the policy maker. The drivers behind the inefficient outcome are that the language of reviewer's message is used arbitrarily. As the public reviewers are allowed to freely decide the property labels with which to send their messages in extended model B, they express themselves in a strategic fashion and try to prevent a desirable disaster risk management plan. As a result, public reviewers communicate with each other by using different languages, and the check and balance function among reviewers is not working well. In order to realize the check and balance mechanism among them, introducing a communication protocol in the review process that makes reviewers follow a fixed procedure for sending their messages is required. As extended model C, we consider a situation

in which reviewers have to be coordinated in discussion with each other by using a common language. For example, it is considered that the coordinator or the facilitator in charge of guiding the discussion forum examines reviewers' statements and shows clear differences in their viewpoints. In what follows, such a situation is modeled as there are two peer review systems in which reviewers are limited to using the common language respectively. We call the review system that imposes constraints on using technical (non-technical) property labels upon reviewers in sending their messages "panel A (B)." Thus, the messages of reviewers in panel A are represented by $m_A^r = R_1$ or R_2 ($r=P, C$). Similarly, the messages of reviewers in panel B are represented by $m_B^r = V_1$ or V_2 ($r=P, C$).

The strategies of the policy maker, the individual, reviewers in panel A, and reviewers in panel B are set by ρ, τ, σ_A^r, and σ_B^r ($r=P, C$), respectively. In this model, the policy maker and the individual can observe the messages of four reviewers. Accordingly, their strategies are denoted by $\rho(m_A^P, m_A^C, m_B^P, m_B^C,)$ and $\tau(m_A^P, m_A^C, m_B^P, m_B^C,)$. Extended model C has an equilibrium where the policy maker obtains the correct information from panel A and the individual trusts the policy maker according to reviewers' messages in panel B. In equilibrium, the third reviewers follow strategy (3) to send the correct message. Receiving the messages of reviewers in panel A following this strategy, the policy maker can obtain perfect information about the desirability of alternatives. The strategy of the policy maker is represented by

$$\rho^*\left(R_1^P, R_1^C, m_B^P, m_B^C\right)=1, \quad \rho^*\left(R_2^P, R_2^C, m_B^P, m_B^C\right)=0;$$

$$\rho^*\left(m_A^P, m_B^C, m_B^P, m_B^C\right)=1/2: \text{ if the other messages}$$

$$(m_A^P, m_A^C, m_B^P, m_B^C) \text{ are sent.}$$

$$(6)$$

Thus, the policy maker chooses one alternative if and only if the reviewers' messages in panel A are consistent with each other. On the other hand, from the reviewers' messages in panel B, the individual can judge whether the policy maker's recommendation is better for her. Accordingly, the individual trusts the policy maker. The individual's strategy is represented by

$$\tau^*\left(m_A^P, m_A^C, V_1^P, V_1^C\right)=1, \quad \tau^*\left(m_A^P, m_A^C, V_2^P, V_2^C\right)=0;$$

$$\tau^*\left(m_A^P, m_B^C, m_B^P, m_B^C\right)=1/2: \text{ if the other messages}$$

$$(m_A^P, m_A^C, m_B^P, m_B^C) \text{ are sent.}$$

$$(7)$$

Therefore, the individual trusts the policy maker if and only if both reviewers in panel B inform him that the alternative is in the individual's interest. He does not trust the policy maker if both reviewers recommend the status quo. In case the reviewers' messages do not satisfy the consistency condition, the policy maker and the individual choose a mixed strategy, because they cannot judge which message is correct.

In this equilibrium, the mechanism of check and balance is working well, and the message of one reviewer is always checked against the message of the other reviewer. The check and balance mechanism is sustained by the constraints of a common language.

Proposition 3: In extended model C, the policy maker obtains perfect information about the desirability of a disaster risk management plan, and the individual trusts the policy maker.

5 Conclusion

This paper examined two roles of public reviews in disaster risk management: 1) providing information to a policy maker about the desirability of a disaster risk management plan and 2) supporting stakeholders' trust in a policy maker's decision. Our analysis was conducted by formulating two linked communication games, which described, respectively, 1) information transmission from public reviewers to a policy maker and 2) trust formation between the policy maker and an individual. It was shown that there is an externality between the two games, and the policy maker accordingly faces a trade-off between the two roles of public reviews. As a result, this might preclude trust formation between the policy maker and the individual. Finally, an alternative institutional design for realizing trust formation between the policy maker and the individual through public reviews was discussed. It was pointed out that a communication protocol that disciplines the way in which reviewers make their statements has to be designed in order to realize the two roles of public reviews. An important role of a coordinator or a facilitator in public debate is to manage such a communication protocol to prevent reviewers' manipulation and thereby to make different languages common to stakeholders.

The following subjects still remain for future study. First, the analytical results obtained in this study stand upon several assumptions about players'

knowledge and languages. The framework presented in this study can be extended in various directions. For example, it is possible that, in contrast with the assumptions of the present model, reviewers possess limited information about the state of the world or cannot understand the language of the individual (i.e., non-technical property labels). Analysis of regional learning and trust formation processes under a variety of assumptions about knowledge and language structures across agents might provide further insight for disaster risk management [16]. Second, while we have highlighted the important role of a coordinator or facilitator of having a common language used, how they can and should make different languages common to participants has not been sufficiently explored. For this issue, discourse analysis of an actual debate might contribute to an empirical understanding of cognitive inconsistency among participants [17] and so to an improvement in coordination and facilitation techniques.

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