Discussion Paper No. 2015-004

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Market Quality Discussion Series

Project by
Complex Dynamic Analysis on Economic Crisis and Social Infrastructure
Grant-in-Aid for Specially Promoted Research （# 23000001）

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March 17, 2016

[1]We are grateful to Shozo Ota, whose recent survey on ochlocracy (Ota, 2013) and discussions with him have motivated this study. We are also grateful to Tadaaki Chigusa and Shigehiro Serizawa for useful discussion. A financial support from the JSPS science grant #23000001 is gratefully acknoledged.

Abstract

During the Fukushima nuclear accident, the government informed people that something bad was happening but provided little information as to exactly how bad it was. Obscurantism refers to such a phenomena, which has been observed in different forms many times in the history. In order to explain obscurantism during the accident, we build a cheap talk game and characterize a neologism-proof perfect Bayesian Nash equilibrium. This paper demonstrates that bad information is withheld if the public's assessment on the government's capability in maintaining an "orderly society" is too high and if the government places too much importance on this assessment.

Keywords: Neologism, Communication Game, Information Flows, Obscurantism, Extreme Crisis, Nuclear Accident,
JEL Classification Number: D82, C72, Q54

1 Introduction

Facing the catastrophic state during the 2011 Fukushima nuclear accident, the Japanese government was harshly criticized by foreign observers for withholding information on what was really happening at the nuclear plant.[1] This study addresses why that happened. For this purpose, it builds a cheap talk game (Crawford and Sobel, 1982) in which what we call idiosyncratic information and non-idiosyncratic information interact with each other. By focusing on a neologism-proof equilibrium (Farrell, 1993), the present study investigates the government's incentive to hide bad information in an extreme disaster. It identifies the importance of idiosyncratic information as a key determinant.

Before doing so, it is important to explain how dangerous a state Japanese people were in and in what ways vital pieces of information were withheld by the Japanese government. From the beginning of the accident, the country was facing a catastrophic situation. Naoto Kan (2014), then prime minister, writes,

> ". . . , then chairman of the Atomic Energy Commission of Japan, pointed out to me that, in the worst-case scenario, people within a radius of 155 miles would have to be evacuated, and they would not be able to return home for ten, twenty, or thirty years. The Tokyo metropolitan area, home to 50 million people and almost half of the entire population of Japan, is within this 155-mile zone."

In the end, this worst scenario did not come true, which Mr. Kan attributes to "*Kami no gokago*" (God's divine protection).[2]

What may have prompted the prime minister's expression may be explained in a program by the national broadcasting company, NHK (2013). That program reports that the Fukushima plant was in fact in a catastrophic state during the first week. The earthquake and accident occurred on March 11. It was known that, without power supply, the water that cooled spent nuclear fuel rods would evaporate in fourteen days; in addition, engineers feared the possibility that the pool was damaged so that water leaked out within first several days. Because they could not find a way either to add water or to restart power supply, officials in both the Japanese and the American governments thought they were facing an imminent danger resulting from nuclear explosions of overheated spent fuel rods. If that happened, it would become impossible to work on the three nuclear reactors that had already been melting down. That could lead to massive explosions; one

[1] See Tabuchi and Bradsher (*New York Times*, April 8, 2011).

[2] This expression appears in a Japanese version (Kan, 2014b) of Kan (2014a).

of the reactors used plutonium fuel, which is far more dangerous than uranium fuel. That, however, did not occur because a nearby pool happened to have been filled with water for an unrelated purpose. That water unexpectedly flowed into, and filled, the spent fuel pool, which engineers discovered much later. Normally, the second pool was not filled with water. If that had been the case, what Mr. Kan was afraid of would have become a reality.

During the accident, the public was given very little information. On the above sequence of incidents, for example, ordinary people could know only that the spent fuel pool was in a dangerous state. How dangerous, and why, were concealed completely.

Another example of information withholding relates to what is called the SPEEDI network. This network was introduced in 1993 to monitor real-time dose assessment in radiological emergencies (SPEEDI stands for the System for Prediction of Environment Emergency Dose Information). While the U.S. military forces were informed of data on the spread of radioactive materials within a few days of March 11, the Japanese public was not informed until March 23. Subsequently, SPEEDI data revealed that radio active plumes heavily contaminated the areas through which plumes went with the wind. Because the SPEEDI network was hidden from the public, this information could not be reflected in the public's voluntary evaluation decisions.[3]

Summarized in a stylized manner, what happened during the accident was as follows: From a very early stage of the accident, the government sent a clear message informing the public that an accident occurred and was not under control. For example, on the second day of the accident, the government ordered evacuation within the 20 kilometer range while, a few days later, the U.S. government advised their citizens living within the 80 kilometer to evacuate. In response to these messages, people living in surrounding areas took their respective actions. From the messages sent to the public, it was impossible to tell whether the accident was catastrophic, as Mr. Kan reported subsequently, or grave but eventually manageable. Many pieces of evidence have subsequently been revealed that the government significantly understated the gravity of the accident, in particular, during the first week.

The main purpose of this study is to address why the government failed to convey those vital pieces of information to the public during the Fukushima accident. The study demonstrates that, even if the government is concerned purely with the public's utility, it may hide a catastrophic disaster (such as the melt-down of a reactor) from the public. This result is attributable to what may be called idiosyncratic information, defined as information that does not influence the receiver's

[3]See Lochbaum, Lyman, and Stranahan (2015).

action (or self-protective effort against the nuclear accident) but his return.

In order to show this result, we build a cheap-talk game (Crawford and Sobel, 1982) with both idiosyncratic and non-idiosyncratic information. In our model, non-idiosycratic information is concerned with uncertainty on the scale of a tsunami (and that of a subsequent nuclear accident), which undoubtedly affects the public's own preparation against the accident. Idiosyncratic information is concerned with the public's evaluation of the government's capability in handling daily activities that are more broader than and not directly related to the accident.

For the sake of simplicity, this study calls it a Fukushima information partition if the partition separates morely the states without any serious consequences but does not separate the rest of the states by how dangerous they are. In order to analyze the information failure surrounding the Fukushima accident, the study addresses the following two specific questions:

> Question 1. Why could a Fukushima information partition be formed, in which the government only informs the public whether or not the accident is serious but withhold information as to how serious it is?
>
> Question 2. Why could not the government, facing a catastrophic state of an accident, break that *suboptimal* conventional information partition to convey a more accurate state of the accident?

In order to address Question 1, this study focuses on the perfect Bayesian Nash equilibrium. It demonstrates that a Fukushima information partition can be supported as a perfect Bayesian Nash equilibrium only if the public's assessment on the government's capability is not too important. If this assessment were too important, the public would severely lower its evaluation of the government capability by knowing that the accident is severe. If this would overwhelm the government's gain from having the public prepare properly against the accident, the government would state that the accident were not severe even if it would be facing a catastrophic state of the accident.

During the Fukushima accident, as is noted above, the government provided at least some information to indicate that the accident is serious, as is shown by the evacuation order within the 20 kilometer range. People responded to that message in choosing their respective actions. These facts imply that the public's assessment on the government's capability were not important enough to withhold the mere fact that the accident was severe.

The concept of a perfect Bayesian Nash equilibrium is not suitable for addressing Question 2; it misses the incentive that the government might have in the face of a catastrophic state of an accident to convey more accurate information by breaking out of the conventional information arrangement. The neologism-proof refinement (Farrell 1993) captures this incentive well.[4]

A neologism is defined as a message that belongs to a completely new message space, not adopted in normal circumstances in which a perfect Bayesian equilibrium is formed, and that makes it possible for the sender to convey his/her exact intention to the receiver. It is often the case that in an extreme case, a skillful leader can come up with a new "language" to convey his/her intention more directly than in normal circumstances; so many times, we have observed in the middle of a military conflict that skillful leaders were able to stir people to fight more intensively.[5] A neologism may be thought of as capturing such an unconventional means of messaging.

On the one hand, as is noted above, a Fukushima information partition cannot be supported as a perfect Bayesian Nash equilibrium if the public's assessment on the government's capability is too important. On the other hand, it cannot be neologism-proof if the public's assessment on the government's capability is too unimportant. The less important the public's assessment on the government capability, the less the government cares about raising the assessment. Because the public would be better prepared by knowing of the exact state of accident, it creates an incentive for the government to inform the public of the accident more precisely, thereby enlarging the possibility of using a neologism successfully. If, in other words, the government would find the publics' assessment relatively less important, the government would adopt a neologism to convey more accurate information, thereby throwing off the existing perfect Bayesian Nash equilibrium. This gives rise to the lower bound for the importance of the public assessment on the government's capability with which the Fukushima-like information arrangement can be supported as a neologism-proof perfect Bayesian Nash equilibrium (neologism-proof equilibrium).

An important finding is that the Fukushima partition can be a neologism-proof equilibrium only if the public's prior assessment on the government's capability is sufficiently high. Suppose, instead, that the prior assessment is low. If the government were to reveal that the accident is catastrophic, it would not reduce the public's assessment. If so, the government would have no incentive to hide the catastrophic accident. Therefore, if the public's assessement on the government's capability is too low, the Fukushima partition cannot be neologism-proof.

This study is not the first to deal with idiosyncratic information, which is modelled as the sender's reputational concern; see, for example, Sobel (1985), Benabou and Laroque (1992), Trueman (1994), Morgan and Stocken (2003), Morris (2001),

[4] Also see Mathius, Postlewaite, and Okuno (1991), who extend Farrel (1993).

[5] Perhaps, the most famous example might be found in the life of Jeanne d'Arc

Ottaviani and Sorensen (2006), and Pavesi and Scotti (2014). Those studies assume different objective functions for the sender and the receiver. The present study, on the other hand, assumes the same objective function for them so as to show the possibility that the government does not reveal a catastrophic state of an accident even if it has no selfish incentive or is concerned purely with the benefit of the public.

Our idiosyncratic information model provides a basic framework for studying what is called an obscurantism. Historically, many obscurantisms have been known, in which a political or social authority misinformed ordinary people by expressing what the authority might not truly believe. Introducing what he calls a "noble lie," for example, Plato (380 BC) pushed an obscurantism; according to him, an "orderly society" could be maintained if people would believe the 'noble lie" that the ancient Greek class structure were a result of the fictitious human traits that Plato conceived. Since those days, in the history, various obscurantisms have been observed such as the burning of Jewish books in the 16th century, the suppression of heliocentrism, and anti-Darwinism movements. Although those ideas might have firmly been supported by truly believers, the ideas were often abused by political authorities, who advocated to maintain an "orderly society." What we mean by an obscurantism is such a phenomenon.

This study shows that an obscurantism in this sense is attributable to the interaction between idiosyncratic and non-idiosyncratic information. Non-idiosyncratic information, directly affecting particular actions of people, is concerned with a specific issue relating to those particular actions. In contrast, idiosyncratic information is concerned with more general well-being of the society, relating little to the particular actions.

Even in modern days, we encounter various obscurantisms. The most recent incident relates to the cover-up of attack on scores of young women in Cologne, Germany, on New Year's Eve by "gangs of men described by the authorities as having "a North African or Arabic" appearance" (New York Times (NYT), January 5, 2016). The incident took place shortly after Germany accepted a large number of evacuees from Mid East. According to the same NYT article, "The assaults set off accusations on the right and among some political commentators that the authorities and the news media had tried to ignore or cover up the attacks to avoid fueling a backlash against the refugees."

In this incident, the German government may be interpreted to face both a non-idiosyncratic concern, affecting the safety of locals, and an idiosyncratic concern, forwarding the humanitarian approach to the Mid-Eastern people. Our result shows that if the latter concern is very important, the government will choose to provide no information to the public.

In what follows, in Section 2, we will develop a basic model. In Section 3, we will present some preliminary results. In Section 4, by characterizing obscurantism in the model, we will demonstrate the possibly that the government may hide bad news from the public. In Section 5, we will investigate the government's incentive to convey the true state of the Fukushima accident by characterizing a neologism proof equilibrium. Section 6 relates our model and results to what happened in Fukushima. In Section 7, we discuss the possibility of applying our model to other obscurantic phenomena. Section 8 is for concluding remarks.

2 Model

In this section, we will build a cheap talk game capturing the essential aspect of the Fukushima accident. Around 2:45 pm, March 9, 2011, an earthquake of magnitude 9.0 occurred off the coast of the Tohoku area. It caused the huge tsunami, which arrived the coastal area by 3:15 pm. The Fukushima I nuclear power plant was attacked by the tsunami inundating the main buildings and stopping the electric power supply. This caused the meltdown of multiple nuclear reactors and the hydrogen-air explosions of the buildings that held the active reactors and stored used nuclear fuel rods. It took a way more than a month before a further deterioration of reactors was no longer feared so much. The failed reactors have continuously been cooled by water to avoid further nuclear explosions. This has been creating a huge amount of contaminated water, which has to be kept in tanks and leaked into the sea by a large quantity. The accident is classified at level 7, the highest on the international nuclear and radiological event scale introduced by the International Atomic Energy Agency (IAEA).[6] During this crisis, as is discussed in the Introduction, the government gave very little information to the public. This study investigates why.

In order to address this question, we focus on the interaction between idiosyncratic and non-idiosyncratic information. Assume that the public receives a disutility from the accident, $D(s, x)$, which depends on the scale of the accident, s, and the public's self-protection effort, x. The disutility function, D, satisfies $D_1(s, x) > 0$ for all (s, x), and $D_2(s, x) \leq 0$ at least for small level of x, which implies that the public can mitigate its disutility by spending resources x (self-protection effort).[7] Finally, $D_{21} < 0$, which guarantees that an increase in the scale of the situation increases the disutility-minimizing effort.

The public is also concerned with the government's capability for maintaining

[6] See the Intermediate Report by Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company.

[7] It does not prohibit $D_2 \geq 0$ for large values of x, which may be interpreted as the public's overreaction that may magnify the damage.

an orderly society, which is beyond control for the public. The public assesses the government's capability by observing its performance in everyday life as well as during the disaster. Denote as A the public's assessment.

The public's total payoff is additively separable on disutility D and assessment A; that is,

$$U = -D(s, x) + hA. \tag{1}$$

In general, it may be assumed that the government utility stems from the factors influencing the public utility; that is, the government's utility is

$$V = -D(s, x) + kA. \tag{2}$$

Idiosyncratic information is defined as that having no effect on the receiver's action. In the present context, we assume that information (probability distribution) concerning A is idiosyncratic whereas information concerning s is non-idiosyncratic. This implies that non-idiosyncratic information affects the public's self-protection effort, x, whereas idiosyncratic information does not. In this respect, $-D(s, x)$ may be thought of as the non-idiosyncratic information parts of both U and V whereas hA and kA as the idiosyncratic information parts. If the government and the public have the same objective, it holds that $k = h$, with which the main part of this study is concerned. Our main theoretical finding is that even in that case, an extreme disaster may be concealed.

In order to incorporate this aspect, we introduce a two-dimensional structure of uncertainty, in which the government selects a message that jointly affects idiosyncratic and non-idiosyncratic information. A joint message creates a trade-off between a loss from misinforming the public and a gain from maintaining an orderly society. If the gain is larger, an informational bias is created.

The first dimension of uncertainty is with respect to the tsunami impact on the nuclear facility. The second is with respect to the government's preparation against tsunami prior to the earthquake.

For the first dimension of uncertainty, assume that there are only two possible levels of the impact of tsunami on the nuclear facility: Small (1) and large (2). Let $\Omega = \{1, 2\}$, which represents the set of tsunami impacts.

Assume that the exact tsunami impact is known only to the government; the public will not know it in a foreseeable future. It is however common knowledge that the tsunami attacked the nuclear plant, i.e., that the current state is $\omega \in \Omega$. For the sake of simplicity, the probabilities of the events that the size of the accident is small (1) and large (2) are both one half,

$$\Pr[\omega = 1|\Omega] = \Pr[\omega = 2|\Omega] = \frac{1}{2}. \tag{3}$$

Note that these are conditional probabilities upon the event that tsunami has occurred. Of course, the unconditional probabilities of tsunami impacts can be very small (the Japanese supreme court defines an unforeseen event, which an economic agent is not responsible to take into account, as that with probability one millionth). However, we abstract from the unconditional possibilities of tsunami impacts by focusing on the moment after earthquake and tsunami has just occurred.

The second dimension of uncertainty is concerned with the preparation that the government makes against a potential accident. We capture this by assuming that in the pre-accident state, there are two possible types of government. Those that have prepared and not prepared against a possible accident (represented by $\gamma = 0, 1$, respectively). The public does not know the type of the government. Assume that ω and γ are independently distributed.

As is discussed in the Introduction, this study defines an obscurantism as an informational bias that is brought about by the trade-off that the government faces between a loss from misinforming the public and a gain from maintaining an orderly society. In order to incorporate this aspect, we assume that the public is concerned with the government's capability to foresee and prepare against a potential future problem or, more broadly, to maintain an orderly society.

We bring this aspect into our model by assuming that the public does not know whether or not the government is prepared against the possibility of a tsunami (or $\gamma = 1$ or $\gamma = 0$). Let Γ be the set of possible values for γ; i.e., $\Gamma = \{0, 1\}$. With respect to the government's preparation, the public holds a prior probability belief that the type of the current government is well prepared ($\gamma = 1$). Denote as p^o_Γ this prior probability ($\gamma = 1$), which may be thought of as capturing the government's capability. The probability that the government is not capable ($\gamma = 0$) is $1 - p^o_\Gamma$.

In summary, in our model, the state of nature at the moment at which the situation has just emerged is characterized by $\theta = (\omega, \gamma) \in \Theta = \Omega \times \Gamma$. The public's prior probability on θ is

$$\Pr[\theta] = \begin{cases} \frac{p^o_\Gamma}{2} & \text{if } \theta = (1,1) \\ \frac{1-p^o_\Gamma}{2} & \text{if } \theta = (1,0) \\ \frac{p^o_\Gamma}{2} & \text{if } \theta = (2,1) \\ \frac{1-p^o_\Gamma}{2} & \text{if } \theta = (2,0) \end{cases} \tag{4}$$

The scale of the situation that is caused by the tsunami depends on both the level of the tsunami impact, ω, and the government's preparation, γ. Without the preparation, the scale of the situation, s, will be equal to that of the impact of tsunami, $s = \omega \in \Omega = \{1, 2\}$, if $\gamma = 0$. With the preparation, the scale of the accident will be mitigated by one degree, i.e., $s = \omega - \gamma$, $\omega \in \Omega = \{1, 2\}$, if $\gamma = 1$. Thus, the set of scales of the situation is $S = \{0, 1, 2\}$; $s = 0, 1, 2$ imply that the situation will be small, medium, and large, respectively. Under this setting, the conditional probability of the event that the government is prepared ($\gamma = 1$)

conditional upon an accident scale s is as follows:

$$\begin{aligned} \Pr[\gamma &= 1|s=2]=0; \\ \Pr[\gamma &= 1|s=1]=p^o_\Gamma; \\ \Pr[\gamma &= 1|s=0]=1. \end{aligned} \tag{5}$$

In short, the public does not know either the tsunami scale, ω, or the level of the government's preparation, γ. This implies that the public knows that the tsunami causes the accident of which the scale will be in $S=\{0,1,2\}$ but does not know which scale it will be. The government knows both ω and γ.

Before the state of nature θ is known, the government and the public understand that the government would send its message obeying a messaging rule $p_M(m|\theta)$. This messaging rule stipulates the probability with which a particular message, m, will be sent in the case of state θ. Let M be a Borel set of feasible messages (message space). Once the accident occurs, the government sends a message m on the scale of the accident, s, by obeying the messaging rule, $p_M(m|\theta)$. After receiving this message, m, the public updates its probability belief with respect to the scale of the situation, s, and the preparation of the government, γ. Denote as $p_S(s|m)$ the probability with which the public, receiving message m, believes that the scale of the situation is s and as $p_\Gamma(\gamma|m)$ the probability on the government's preparation, γ. The public's assessment on the government preparation, A, is identified with the posterior expected value of the government's preparation, $p_\Gamma(\gamma|m)$, i.e.,

$$A=\sum_\gamma p_\Gamma(\gamma|m)\gamma. \tag{6}$$

Under the above setting, the posterior probability distribution on the government's preparation, $p_\Gamma(\gamma|m)$, may be thought of as idiosyncratic information. That is, this probability distribution does not affect the public's self-defence effort, x, but affect only its utility, $U=U(s,x,p_\Gamma)$. In contrast, the posterior probability distribution on the accident scale, $p_S(s|m)$, may be thought of as non-idiosyncratic (material) information; since the public is assumed to maximize the expected utility, $E(U)=\sum p_S U$, without knowing the exact scale of the accident, s, probability distribution p_S affects the public's optimal x. Define

$$\Theta(s)=\{\theta\in\Theta:\theta=(\omega,\gamma),\ \omega-\gamma=s\}, \tag{7}$$

which is the set of combinations of the government's capability, γ, and the natural disaster that will lead to a particular scale of the situation, s.

Our solution concept is that of perfect Bayesian equilibrium (Fudenberg and Tirole 1991). In an equilibrium, (i) given $\theta=(\omega,\gamma)$ and the public's posterior belief, $p_S(s|m)$ and $p_\Gamma(\gamma|m)$, the government chooses its messaging rule, $p_M(m|\theta)$, so as to maximizes its payoff; (ii) receiving a message generated by this rule, m, but without knowing the true state of nature, θ, the public makes self-protection effort, $x(m)$, so as to minimizes its expected disutility; (iii) the public updates its beliefs on the scale of the accident and the government's capability, $p_S(s|m)$ and $p_\Gamma(\gamma|m)$, by the Bayes' rule. That is, a perfect Bayesian-Nash equilibrium is characterized by $p_M(m|\theta)$, $p_S(s|m)$, $p_\Gamma(\gamma|m)$, and $x(m)$ such that the following holds:

(1) (the government's optimal messaging rule)

$$p_M(\cdot|\theta) \in \arg\max_{p'_M(\cdot|\theta)} \int_M p'_M(m|\theta)[-D(s,x(m)) + kp_\Gamma(1|m)]dm \tag{8}$$

for $\theta \in \Theta(s)$.

(2) (the public's optimal self-protection effort: this description is incorrect)

$$x(m) = \arg\max_x \sum_s [-D(s,x) + hp_\Gamma(1|m)]p_S(s|m) \tag{9}$$

for $m \in M$.

(3) (the Bayes update rules on belief)

$$p_S(s|m) = \frac{\sum_{\theta\in\Theta(s)} p_M(m|\theta)\Pr[\theta]}{\sum_{\theta\in\Theta} p_M(m|\theta)\Pr[\theta]}, \tag{10}$$

and

$$p_\Gamma(1|m) = \frac{\sum_{\theta\in\{\theta|\theta=(\omega,1)\}} p_M(m|\theta)\Pr[\theta]}{\sum_{\theta\in\Theta} p_M(m|\theta)\Pr[\theta]} \tag{11}$$

for any m such that $\sum_\theta p_M(m|\theta)\Pr[\theta] > 0$.

Our game, (8) - (11), has three parameters, p_Γ^o, h, and k. As is discussed above, p_Γ^o is concerned with the public's prior believe with respect to the government's preparation. Parameters h and k are the importance that the public and the government, respectively, attach to the publics capability assessment, A. We will characterize the solutions to the game with respect to these parameters.

3 Obscurantism

For the analysis below, it is useful to define

$$M(s;p_M) = \{m : \sum_{\theta\in\Theta(s)} p_M(m|\theta) > 0\}, \tag{12}$$

which is the set of messages that, under p_M, the government may send when the scale of the accident is s. That $m \notin M(s; p_M)$ implies that if the government chooses a strategy, p_M, message m is never sent in the case of s, i.e., $p_M(m|\theta) = 0$ for any $\theta \in \Theta(s)$. In contrast, that $m_s \in M(s; p_M)$ carries some truth in the case of s, i.e., $p_M(m|\theta) > 0$ for some $\theta \in \Theta(s)$.

This study regards as an obscurantism the government's choosing a massaging rule (strategy), p_M, by which the public cannot distinguish multiple scales of an accident from each other or, in other words, p_M satisfying

$$M(s'; p_M) \cap M(s''; p_M) \neq \phi, \tag{13}$$

for some s' and s'' such that $s' \neq s''$.

In this study, we will mainly focus on a stronger type of obscurantism, which may be called a pure obscurantism. It is defined as an obscurantism such that $p_M(\cdot|\theta')$ and $p_M(\cdot|\theta'')$ are the same probability distribution if $\theta' \in \Theta(s')$ and $\theta'' \in \Theta(s'')$, given s' and s'' satisfying (13). If, instead, $p_M(\cdot|\theta')$ and $p_M(\cdot|\theta'')$ are different probability distributions, p_M may be called a mixed obscurantism.

This distinction between pure and mixed obscurantism stems from the fact that under a mixed obscurantism, given s, an equilibrium action eventually taken by the public is randomized; see Section 4 for details. For the sake of simplicity, by an obscurantism we mean a pure obscurantism unless otherwise specified.

We say that a messaging rule is a no-information obscurantism, denoted as p^n_M, if

$$p^n_M(\cdot|\theta_0) = p^n_M(\cdot|\theta_1) = p^n_M(\cdot|\theta_2) \text{ for any } \theta_i \in \Theta(s_i),\ i = 0, 1, 2. \tag{14}$$

In contrast, we say that it is an s-revealing obscurantism, denoted as p^s_M, if, given $\{s', s''\} = S \backslash \{s\}$,

$$p^s_M(\cdot|\theta') = p^s_M(\cdot|\theta'') \text{ for any } \theta' \in \Theta(s') \text{ and } \theta'' \in \Theta(s'') \tag{15}$$

and

$$M(s; p^s_M) \cap M(s'; p^s_M) = \phi \ \text{ and } M(s; p^s_M) \cap M(s''; p^s_M) = \phi. \tag{16}$$

Finally, we say that a messaging rule is a fully-revealing, denoted as p^f_M, if for any $s' \in S$ and $s'' \in S$, $s' \neq s''$,

$$M(s'; p^f_M) \cap M(s''; p^f_M) = \phi. \tag{17}$$

In our model, a pure obscurantisms can be associated with an information partition: A no-information obscurantism with $\{\{s, s', s''\}\}$; an s-revealing obscurantism with $\{\{s\}, \{s', s''\}\}$, where $S = \{s, s', s''\}$; a fully revealing obscurantism with $\{\{s\}, \{s'\}, \{s''\}\}$.

In what follows, for the sake of convenience, we denote the scale of the situation $s = 0, 1, 2$ as s_0, s_1, and s_2, respectively. What we call the Fukushima partition in the Introduction is captured by the s_0-revealing obscurantism, $p_M^{s_0}$ or $\{s_0, \{s_1, s_2\}\}$. In this information partition, the government conveys the true state of nature in the case in which the accident scale is small, s_0. In the case in which the accident scale is either medium or large $\{s_1, s_2\}$, the government conveys only that the accident scale is not small, s_0.

As is stressed in the Introduction, during the first week of the Fukushima accident, the Japanese government believed that nearly half of the Japanese population were facing a catastrophic danger, which is captured by state s_2 in this study. This fact was, however, never revealed by the government; people were told merely that an unignorable scale of accident occurred or that event $\{s_1, s_2\}$ occurred.

Before moving to characterizing a perfect Bayesian Nash equilibrium in the above model it may be useful to note several basic lemmas relating to an obscurantism. As the lemma below shows, the more effort the public has to make in response to the government's message, the lower the public's revised evaluation of the government's capability. This demonstrates that our model captures a natural relationship between the public's evaluation on the government's capability in preparing against an incident and the level of self-protection effort that the public, actually facing the incident, has to make. Because the lemma is crucial for our characterization of obscurantism, it is stated at the outset (see the Appendix for a proof).

Lemma 1 *If, given a particular equilibrium, there are two on-equilibrium messages m_0 and m_1 such that $x(m_0) < x(m_1)$, then $p_\Gamma(1|m_0) > p_\Gamma(1|m_1)$.*[8]

The next lemma implies that if the accident is small ($s = s_0$), the government sends a message that induces the lowest action among all on-equilibrium messages, $m \in M(0; p_M)$.

Lemma 2 *Let $s = 0$. If $m \in M(s; p_M)$, $m \in \arg\min_{m' \in \cup_{s'} M(s'; p_M)} x(m')$.*

This follows from the fact (i) that the smaller the impact of tsunami, the lower the desirable preparation effort, x, at the same time (ii) that, by Lemma 1, the smaller the preparation effort, $x(m)$, the larger the public's evaluation on the government's capability, $p_\Gamma(m)$.

[8] A message m is on-equilibrium if $\sum_\theta p_M(m|\theta) \Pr[\theta] > 0$.

In order to characterize the equilibrium, this study adopts specific forms for the public's disutility function and its capability assessment function as follows: That is, on $x \in [0,2]$,

$$D(s,x) = (2s-x)^2 + \phi(s) + x^2 \tag{18}$$

Equation (18) satisfies the above requirements on D, i.e., $D_2 < 0$ for $x < s$ and $D_{21} < 0$. In this specification, $(2s-x)^2 + \phi(s)$ captures the direct cost of the situation (damage from the accident) to the public; x^2 is the cost of self-protection effort.[9] Assume that the larger the scale of a situation, the larger the disutility, no matter what damage control, x, is done; i.e., assume that for any $x \in [0,2]$,

$$D(0,x) < D(1,x) < D(2,x). \tag{19}$$

Note that this assumption can be guaranteed if $\phi(2) - \phi(1) > 0$ and $\phi(1) - \phi(0) > 0$ are sufficiently large.

We choose this specific form of the disutility function, (18), so as to guarantee the optimal choice of x is always equal to the expected value of s. That is,

$$x(m) = \sum_{s \in S} s p_S(s|m) \tag{20}$$

for any $p_S(s|m)$.

4 Fukushima and Other Obscurantic Equilibria

In this section, we will derive the conditions under which Fukushima and other obscurantisms are perfect Bayesian Nash equilibria. These conditions are derived under the assumption that the sender of information may send a biased information even if the sender and the receiver share a common objective (even if $k = h$). This result may be explained by the fact that in our idiosyncratic information game, (8) - (11), an equilibrium is independent of parameter h, capturing the importance that the public (receiver) places on the capability of the government (sender), A. An equilibrium does, however, depend on parameter k, capturing the importance that the government places on the public's capability assessment, $A = p_\Gamma$ by assumption (6).

This may be explained by the public's objective function,

$$E(U) = -\sum_{s} p_S(s|m) D(s, x(m)) + h p_\Gamma(1|m). \tag{21}$$

[9] For example, a survey by the newspaper Mainichi Shinbun reported approximately 1600 deaths related to the evacuation conditions, such as living in temporaty housing and hospital closure, which should be considered as the cost of self-protection from the disaster.

As is noted above, $p_\Gamma(\gamma|m)$ is idiosyncratic information, which the public cannot do anything about but accepts as it is. This implies that, on the one hand, the public's choice of an action, x, becomes independent of idiosyncratic information $p_\Gamma(\gamma|m)$; the action depends only on non-idiosyncratic information $p_S(\cdot|m)$, given that the public receives message m. This implies that the public's choice of an action, $x(m)$, is independent of h. Because, on the other hand, the government knows accident scale s, it adopts a messaging rule, $p_M(m|\theta)$, that attaches zero probability to every message that cannot maximize its return,

$$V = -D(s, x(m)) + kp_\Gamma(1|m). \tag{22}$$

Because the government's message, m, affects its return by changing both the public's choice of its action, $D(s, x(m))$, and its assessment on the government's capability, $A(p_\Gamma(1|m))$, the messaging rule that the government chooses, $p_M(m|\theta)$, depends on k.

We will first characterize the s_0-revealing obscurantism (or the Fukushima partition) that is a perfect Bayesian Nash equilibrium. Suppose that $e^{s_0} = (p_M^{s_0}, x^{s_0}, p_S^{s_0}, p_\Gamma^{s_0})$ is in a perfect Bayesian Nash equilibrium. Then, by using the Bayesian update rules (10), for $m \in M(s_1; p_M^{s_0}) = M(s_2; p_M^{s_0})$, we obtain

$$p_S^{s_0}(s|m) = \begin{cases} 0 & \text{if } s = 0 \\ \frac{1}{2-p_\Gamma^o} & \text{if } s = 1 \\ \frac{1-p_\Gamma^o}{2-p_\Gamma^o} & \text{if } s = 2. \end{cases} \tag{23}$$

Moreover, by (11), $p_\Gamma^{s_0}(m) = \frac{p_\Gamma^o}{2-p_\Gamma^o}$. Thus, by (20) and (23), we have

$$\left(x^{s_0}(m), p_\Gamma^{s_0}(m)\right) = (x_s^{s_0}, p_{\Gamma s}^{s_0}) \text{ for any } m \in M(s; p_M^{s_0}) \tag{24}$$

where

$$(x_s^{s_0}, p_{\Gamma s}^{s_0}) = \begin{cases} (0, 1) & \text{if } s = 0 \\ (\frac{3-2p_\Gamma^o}{2-p_\Gamma^o}, \frac{p_\Gamma^o}{2-p_\Gamma^o}) & \text{if } s \in \{1, 2\}. \end{cases} \tag{25}$$

Throughout the rest of this section, we denote by s' the real scale of the accident, which only the government can observe. Then, in general, an incentive for the government to announce a false scale of the accident, $s \neq s'$, is captured by the difference between $V(s', x(m), p_\Gamma(1|m))$ and $V(s', x(m'), p_\Gamma(1|m'))$, $m' \in M(s'; p_M)$ and $m \in M(s; p_M)$. By (1), this incentive can be expressed as

$$\begin{aligned} I &= V(s', x(m), p_\Gamma(1|m)) - V(s', x(m'), p_\Gamma(1|m')), \\ &= -[D(s', x(m)) - D(s', x(m')] + k\left[A(p_\Gamma(1|m)) - A(p_\Gamma(1|m'))\right], \end{aligned} \tag{26}$$

given $m' \in M(s'; p_M)$ and $m \in M(s; p_M)$. In general, the more correctly the public is informed of the scale of the situation, the smaller the disutility it will suffers from, (i.e., the smaller $D(s', x(m)) - D(s', x(m')) > 0$). Thus, unless the government raises the public's assessment (or unless $A(p_\Gamma(1|m)) - A(p_\Gamma(1|m')) > 0$), it has no incentive to misinform the public. This implies that the government never has an incentive to overstate the true scale of the accident.

In the present setting, as is proved below, an equilibrium can be characterized by a state in which the government has no incentive to understate the true scale of the accident. If an s_0-revealing obscurantism is in equilibrium, a messaging rule, $p_M^{s_0}$, can be characterized by information partition $\{\{s_0\}, \{s_1, s_2\}\}$. Under this messaging rule, the government has an incentive to understate the accident scale if the accident scale is $s' \in \{s_1, s_2\}$. In that case, to understate the accident scale means to send a message stating that the accident scale is $s = s_0$, i.e., $m \in M(s_0; p_M^{s_0})$. By (25), therefore, the incentive for understatement can be characterized as as follows:

$$I = \begin{cases} -\frac{2\left(3-2p_\Gamma^o\right)}{\left(2-p_\Gamma^o\right)^2} + 2k\frac{1-p_\Gamma^o}{2-p_\Gamma^o} & \text{if } (s', s) = (1, 0) \\ -\frac{2\left(9-6p_\Gamma^o\right)\left(3-2p_\Gamma^o\right)}{\left(2-p_\Gamma^o\right)^2} + 2k\frac{1-p_\Gamma^o}{2-p_\Gamma^o} & \text{if } (s', s) \in (2, 0), \end{cases} \tag{27}$$

given $m' \in M(s'; p_M^{s_0})$ and $m \in M(s; p_M^{s_0})$.

In this (27), the top expression captures the incentive to understate the scale of the accident when the true scale is medium ($s' = 1$), the bottom when it is large ($s' = 2$). Moreover, it shows that if there is no incentive for understatement in the medium-scale accident (if the top expression is negative), there is no incentive for understatement in the large-scale accident (the bottom expression is negative as well).

The above discussion gives rise to the following characterization for the Fukushima equilibrium, which is associated with information partition $\{\{s_0\}, \{s_1, s_2\}\}$.

Theorem 1 *Regardless of the value of h, an s_0-revealing obscurantism (Fukushima partition) $p_M^{s_0}$ is in a perfect Bayesian Nash equilibrium if and only if*

$$k \leq \frac{3 - 2p_\Gamma^o}{(1 - p_\Gamma^o)(2 - p_\Gamma^o)}. \tag{28}$$

Proof. In order to prove the theorem, it suffices to show the "if" part. Take a p_M such that $M(s; p_M) \cap M(s'; p_M) = \phi$ for $s = 0,\ s = 1$, $p_M(\cdot|\theta) = p_M(\cdot|\theta')$ for all $\theta \in \Theta(0)$, $\theta' \in \Theta(1)$, and finally, $\cup_{s \in S} M(s; p_M) = M$. By using this p_M, define x, p_S, and p_Γ^o satisfying equilibrium conditions (9), (10), and (11).

In order to complete the proof, it suffices to prove that this p_M satisfies (8). For this purpose, let $m_s \in M(s; p_M)$. Then, we may prove that for any $m \in M$, $V(s, x(m_s), p_\Gamma(1|m_s)) \geq V(s, x(m), p_\Gamma(1|m))$, which shows that p_M satisfies (8). ■

In Figure 1, the boundary of condition (28) is depicted by curve E^1. Under (or on) this curve, the s_0-revealing equilibrium (Fukushima equilibrium) emerges. The boundary of condition (28), E^1, shows that the upper limit of k (capturing the importance that the government places on the public's assessment on the government capability) below which an equilibrium can be sustained. That the boundary is upward-sloping implies that the lower the prior evaluation of the government preparation, p^o_Γ, the less likely this equilibrium is sustained. This is because the lower the prior assessment (p^o_Γ), the stronger incentive that the government holds to tell that the situation scale is small ($s = 0$) even if that is not the case ($s' \in \{1, 2\}$). As a result, an equilibrium would be less likely to be sustained.

Theorem 1 shows that the Fukushima partition can be supported as a perfect Bayesian Nash equilibrium if the importance that the government places on the public's assessment of its capability, k, is sufficiently small, or satisfies condition (28). For any parameter values satisfying this condition, however, other equilibria may coexist. In order to demonstrate this fact, we will characterize the other types of equilibria.

It is well-known that a no information (babbling) equilibrium exists for any parameter values. We note this result at the outset.

Fact 1 A no information obscurantism p^n_M is a perfect Bayesian Nash equilibrium for all parameter values.

Next we will characterize the s_2-revealing obscurantism, giving rise to a partition $\{\{s_0, s_1\}, \{s_2\}\}$, in equilibrium. In this case, the government has an incentive to understate the accident scale if the accident scale is largest, $s' = s_2$. In that case, to understate the accident scale means to send a message stating that the accident scale is either medium or small, $s \in \{s_0, s_1\}$. In a manner similar to the above derivation of (27), the incentive for understatement can be obtained as follows:

$$I = -\frac{2\left(2p^o_\Gamma + 1\right)^2}{\left(p^o_\Gamma + 1\right)^2} + k\frac{2p^o_\Gamma}{p^o_\Gamma + 1}. \tag{29}$$

The next theorem follows from (29).

Theorem 2 *Regardless of the value of h, an s_2-revealing obscurantism, $p^{s_2}_M$, is in a perfect Bayesian Nash equilibrium if and only if*

$$k \leq \frac{\left(2p^o_\Gamma + 1\right)^2}{p^o_\Gamma\left(1 + p^o_\Gamma\right)}. \tag{30}$$

In Figure 1, the boundary of condition (30) is depicted by curve E^2. Under (or on) this curve, the s_2-revealing equilibrium emerges. The boundary of condition (30), E^2, shows that the upper limit of k (capturing the importance that the government places on the public's assessment on the government capability) below which an equilibrium can be sustained. That the boundary is downward-sloping implies that the higher the prior evaluation on the government's performance, p^o_Γ, the less likely a s_2-revealing equilibrium is to be formed. This is because the higher the prior observation, the weaker the incentive that the government has to reveal the worst scenario.

Next we will characterize a fully revealing equilibrium, p^f_M. In this equilibrium, the government has an incentive to understate the accident scale if the true scale is either in $s' = s_1$ or in $s' = s_2$. If $s' = s_1$, to understate means to adopt a message $m \in M(s_0; p^f_M)$, where p^f_M is a fully revealing equilibrium messaging rule. If $s' = s_2$, to understate means to adopt a message $m \in M(s; p^f_M)$ with $s \in \{s_0, s_1\}$. This incentive can be characterized as follows:

$$I = \begin{cases} -2 + k(1 - p^o_\Gamma) & \text{if } (s', s) = (1, 0) \\ -16 + k & \text{if } (s', s) = (2, 0) \\ -2 + kp^o_\Gamma & \text{if } (s', s) = (2, 1). \end{cases} \tag{31}$$

The next theorem follows from (31).[10]

Theorem 3 *Regardless of the value of h, a fully revealing obscurantism,* p^f_M, *is a perfect Bayesian Nash equilibrium if and only if*

$$k \leq \min\left\{\frac{2}{p^o_\Gamma}, \frac{2}{1 - p^o_\Gamma}\right\}. \tag{32}$$

In Figure 1, the boundary of condition (32) is depicted by curve E^f. Under (or on) this curve, the fully revealing equilibrium emerges. The boundary of condition (32), E^f, shows that the upper limit of k (capturing the importance that the government places on the public's assessment on the government capability) below which an equilibrium can be sustained.

As Figure 1 shows, except for a no-information obscurantism, no obscurantism can be supported as a perfect Bayesian Nash equilibrium if parameter k is too

[10] A fully revealing equilibrium in this sense requires only the accident scales, s, are fully separated from each other. In this respect, it is somewhat non-standard; the standard sense of full revelation requires all the information that the government possess is conveyed ($\theta = (\omega, \gamma)$).

large. In order to explain this fact, note that a perfect Bayesian Nash equilibrium captures a state in which the government will not have any incentive to misinform the public after knowing the realized state of nature. In the present model, as is noted above, the government has no incentive to overstate the scale of the accident; that will lead the public to make a suboptimal self-protection effect at the same time that it will reduce the public's assessment on the government's capability. Because the government's payoff is based on the sum of the public's disutility and its assessment, the larger the weight on the public's assessment, k, the stronger the government's incentive to understate the accident scale. This is why the parameter region for each obscnrantic equilibrium has an upper bound except for a no-information equilibrium. In a no-information obscurantism, there is no room to understate the accident level.

Figure 1 also shows that the upper boundary for the Fukushima equilibrium mostly lies above that for the fully revealing equilibrium if $p_S^o > 1/2$. At $p_S^o = 1/2$, however, it does not. This is because if $p_S^o = 1/2$, the incentive is higher for the government to tell $s = 0$ in the case of $s = 1$ in the Fukushima equilibrium than in the fully revealing equilibrium; this is because $s = 1$ is pooled with $s = 2$ in the Fukushima equilibrium.

Before closing this section, note the following:

Proposition 1 *At any parameter value, there is no pure obscurantism other than babbling, best-scenario revealing, worst-scenario revealing obscurantism equilibrium and a fully revealing equilibrium.*

5 Neologism and Truth Telling

The main focus on this study is on whether or not the government reveals the true state of nature in the case in which a catastrophic accident occurs. The concept of a perfect Bayesian Nash equilibrium is not suitable for this purpose.

This is because a perfect Bayesian Nash equilibrium does not directly address whether or not the sender desires to convey the truth. Rather, this equilibrium is concerned only with what information (message generating rule, p_M) the sender desire to send, given a particular way the receiver interprets the information, represented by $V(s, x(m), p_\Gamma(1|m))$. In a framework in which the receiver can interpret information in his own way, it is rather meaningless to address whether or not a truth can be conveyed.

The concept of a neologism-proof equilibrium is, in contrast, to explain an incentive to reveal the true state of nature.[11] It is developed as a refinement of

[11] In our model, a neologism proof equilibrium and an equilibrium based on the refinement developed by Mathius, Postlewaite and Okuno (1991) give the same results.

a perfect Bayesian Nash equilibrium for a cheap talk game (Farrell, 1993). It is assumed that the set of neologisms (neologism space), $\mathfrak{N}$, is a language system that is completely different from the message space of the game, M. If the sender sends a neologism to the receiver, the receiver may take it in its face value. In the present context, therefore, it may be assumed that the neologisms, if limited to pure strategies, consist of subsets of accident levels. That is,

$$\mathfrak{N} = \{N : N \subset S = \{s_0, s_1, s_2\}\}.$$

As is noted above, the public is assumed to take a neologism in its face value. This implies that by receiving a neologism N, the public will calculate conditional probabilities for an accident scale and the government's preparation, $\Pr[s|N]$ and $\Pr[\gamma|N]$. Based on these probability distributions, the public chooses its self-protection effort, x, so as to minimize the expected disutility. In other words, the public's response to neologism N is $(x^N, {p_\Gamma}^N)$ satisfying

$$x^N = \arg\min_x \sum_s D(x, s) \Pr[s|N] \text{ and } p_\Gamma^N = \Pr[\gamma = 1|N].$$

Whether or not a neologism can break a perfect Bayesian Nash equilibrium depends on whether or not a neologism gives a higher payoff to the government that staying in the equilibrium. It is therefore convenient to express the government's payoff in equilibrium $e^* = (p_M^*, x^*, p_S^*, p_\Gamma^*)$, $* = n, s_0, s_2, f$, as $V^*(s)$. The incentive to convey a neologism N is captured by the difference between $V(s, x^N, p_\Gamma^N)$ and $V^*(s)$.

Let $C(N)$ be the set of states in which the government desires to convey neologism N, i.e.,

$$C(N) = \{s : V(s, x^N, p_\Gamma^N) > V^*(s)\}.$$

Farrell (1993) assumes that in order for a neologism to be credible, this set, $C(N)$, must coincide with the neologism itself, i.e., $N = C(N)$. A perfect Bayesian Nash equilibrium is neologism proof if no neologism is credible relative to it.

The next fact follows directly from the definition.

Fact 2 *The fully revealing perfect Bayesian Nash equilibrium, p_M^f, is neologism proof.*

5.1 Credible Neologism during the Fukushima Accident

In this section, we will characterize the neologism-proof Fukushima equilibrium. In doing so, we examine why the government failed to convey true information while it faced the catastrophic state during an early stage of the Fukushima accident, as described in the Introduction.

As is discussed above, a neologism N is a non-standard message with which the government conveys exactly what it wants to tell to the public. By definition, that $s \in C(N)$ implies that if s is the state of nature, the government desires to use neologism N to break a perfect Bayesian equilibrium; that is, $V(s, x^N, p_\Gamma^N) > V^*(s)$. If $s \in C(N)$ but $s \notin N$, it implies that what in state s, the government desires to convey a neologism, N, that does not contain state s; in other words, N is a naked lie. Such a lie is not regarded as credible; a credible neologism N must satisfy the condition that $s \in C(N)$ if and only if $s \in N$, i.e., $C(N) = N$.

As this shows, a credible neologism captures the government's willingness to tell the truth. It is therefore suitable for investigating why the Japanese government failed to convey that Japanese people were in a severe catastrophic state during an early stage of the accident.

In order to address this question, suppose that an s_0-revealing obscurantism (Fukushima partition) is a perfect Bayesian Nash equilibrium. The next theorem characterizes neologism $N = \{s_2\}$ that is credible.

Theorem 4 *Suppose that an s_0-revealing obscurantism (Fukushima information partition) is a perfect Bayesian Nash equilibrium. Then, $N = \{s_2\}$ is a credible neologism ($C(\{s_2\}) = \{s_2\}$) if and only if*

$$k < \frac{2}{p_\Gamma^o \left(2 - p_\Gamma^o\right)}. \tag{33}$$

Subset $\{s_2\}$ is a unique credible neologism ($N = C(N)$) such that $s_2 \in N$.

Proof. Take a neologism $N = \{s_2\}$. It may be proved that

$$V(s, x^{\{s_2\}}, p_\Gamma^{\{s_2\}}) - V^{s_0}(s) = \begin{cases} -8 - k & \text{if } s = s_0 \\ -\frac{2\left(3-2p_\Gamma^o\right)}{\left(2-p_\Gamma^o\right)^2} - k\frac{p_\Gamma^o}{2-p_\Gamma^o} & \text{if } s = s_1 \\ \frac{2}{\left(2-p_\Gamma^o\right)^2} - k\frac{p_\Gamma^o}{2-p_\Gamma^o} & \text{if } s = s_2. \end{cases} \tag{34}$$

By (34), $V(s_2, x^{\{s_2\}}, p_\Gamma^{\{s_2\}}) > V^{s_0}(s_2)$, i.e., $s_2 \in C(\{s_2\})$, if and only if (33) holds. Since $V(s_0, x^{\{s_2\}}, p_\Gamma^{\{s_2\}}) < V^{s_0}(s_0)$ and $V(s_1, x^{\{s_2\}}, p_\Gamma^{\{s_2\}}) < V^{s_0}(s_1)$, this implies $\{s_2\} = C(\{s_2\})$ if and only if (33). The second statement is obvious. ■

It is conceivable that before the accident, neighbor the government nor the public know that the government can convey exactly what it intends to convey to the public. It is also conceivable that even in that case, once the accident occurs, a social condition will develop in that the government can convey the truth to the public. The above theorem is useful to examine whether or not the government will convey the truth to the public in such circumstances.

The messaging rule that might be formed between the government and the public that do not know that the government can convey exactly what it intends to convey to the public may be described by a perfect Bayesian Nash equilibrium. With this in mind, suppose that the government and the public are in an s_0-revealing perfect Bayesian Nash equilibrium before the accident. Suppose, moreover, that after the accident, the government will realize that it can convey exactly what it intends to convey to the public (or a neologism). If the accident scale is large (s_2), it can choose a neologism $\{s_2\}$.

Theorem 4 shows that even in those circumstances, the government may not convey the truth to the public, i.e., neologism $\{s_2\}$. That is, the government will use neologism $N = \{s_2\}$ to convey the truth (that is, the accident level is large) if and only if (33) is satisfied. If not, the government will not convey the truth. In that case, the public will receive the message stipulated in the initial perfect Bayesian Nash equilibrium, $s' \in \{s_1, s_2\}$, i.e., that it is not a minor accident, s_0.

In Figure 2, the boundary for condition (33) is depicted by curve $N^0_{\{s_2\}}$. Below curve $N^0_{\{s_2\}}$, the government will convey the true if the large accident occurs (if s_2 is realized). By (28) and (33), we may conclude that given that state s_2 is realized, the government does not tell the truth (that state is in s_2) but only tell that the accident is not under control (that state is not in s_0) if parameter vector (p^o_Γ, k) lies between curves $N^0_{\{s_2\}}$ and E^0 or satisfies

$$\frac{2}{p^o_\Gamma\left(2-p^o_\Gamma\right)} \leq k \leq \frac{3-2p^o_\Gamma}{\left(1-p^o_\Gamma\right)\left(2-p^o_\Gamma\right)}. \tag{35}$$

In other words, if (35) is satisfied, the Fukushima partition may be thought of as a "conditional neologism-proof equilibrium," given state s_2.

5.2 Neologism-proof Equilibria

In what follows, we will derive the conditions under which the perfect Bayesian Nash equilibria obtained in Section 4 are neologism proof.

First, we continue to focus on the s_0-revealing obscurantism (Fukushima partition) that is a perfect Bayesian Nash equilibrium. The next theorem characterizes neologism $N = \{s_1\}$ that is credible.

Theorem 5 *Suppose that an s_0-revealing obscurantism (Fukushima information partition) is a perfect Bayesian Nash equilibrium. Then, $N = \{s_1\}$ is a credible* *neologism* ($C(\{s_1\}) = \{s_1\}$) *if and only if*

$$k \leq \frac{2\left(3 - p_\Gamma^o\right)}{p_\Gamma^o\left(2 - p_\Gamma^o\right)}. \tag{36}$$

Subset $\{s_1\}$ *is a unique credible neologism* ($N = C(N)$) *such that* $s_1 \in N$.

Proof. Take a neologism $N = \{s_1\}$. It may be proved that

$$V(s, x^{\{s_1\}}, p_\Gamma^{\{s_1\}}) - V^{s_0}(s) = \begin{cases} -2 - kp_\Gamma^o & \text{if } s = s_0 \\ \frac{2\left(1-p_\Gamma^o\right)^2}{\left(2-p_\Gamma^o\right)^2} + k\frac{p_\Gamma^o\left(1-p_\Gamma^o\right)}{2-p_\Gamma^o} & \text{if } s = s_1 \\ -\frac{2\left(1-p_\Gamma^o\right)\left(3-p_\Gamma^o\right)}{\left(2-p_\Gamma^o\right)^2} + k\frac{p_\Gamma^o\left(1-p_\Gamma^o\right)}{2-p_\Gamma^o} & \text{if } s = s_2. \end{cases} \tag{37}$$

By (37), $V(s_1, x^{\{s_1\}}, p_\Gamma^{\{s_1\}}) > V^{s_0}(s_1)$. Thus, $s_1 \in C(\{s_1\})$. Moreover, by (36), $V(s_0, x^{\{s_1\}}, p_\Gamma^{\{s_1\}}) < V^{s_0}(s_0)$. Finally, $V(s_2, x^{\{s_1\}}, p_\Gamma^{\{s_1\}}) \leq V^{s_0}(s_2)$ if and only if (36) holds. Thus, the first part of the theorem holds. The second part is obvious. ■

It is possible to give credible neologism $\{s_1\} = C(\{s_1\})$ an interpretation similar to that on $\{s_2\} = C(\{s_2\})$, discussed above. Because it is not our main purpose to investigate the case in which the medium accident occurs, we do not explain in detail.

As is discussed above, Farrell's neologism proof equilibrium is defined as a perfect Bayesian Nash equilibrium that permits no credible neologism. For the s_0-revealing perfect Bayesian Nash equilibrium, all the neologisms other than $\{s_1\}$ and $\{s_2\}$ are trivial in that they give the same return to the government as in the perfect Bayesian Nash equilibrium. Thus, the neologism proof s_0-revealing equilibrium is the state in which neither $\{s_1\}$ nor $\{s_2\}$ are credible neologism. This can be guaranteed by Theorems 4 and 5.

Corollary 1 *Regardless of the value of* h, *the* s_0*revealing obscurantism (Fukushima partition),* $p_M^{s_0}$, *is a neologism-proof perfect Bayesian Nash equilibrium if and only if*

$$\frac{2\left(3 - p_\Gamma^o\right)}{p_\Gamma^o\left(2 - p_\Gamma^o\right)} \leq k \leq \frac{3 - 2p_\Gamma^o}{\left(1 - p_\Gamma^o\right)\left(2 - p_\Gamma^o\right)}. \tag{38}$$

Proof. The equilibrium is neologism-proof if and only if neither (33) nor (36) is satisfied. ■

In much the same way as proving Corollary 1, it is possible to characterizes the neologism-proof s_2-revealing equilibrium.

Theorem 6 *Regardless of the value of* h*, the* s_2*-revealing obscurantism,* $p_M^{s_2}$*, is a neologism-proof perfect Bayesian Nash equilibrium if and only if*

$$\frac{2(2p_\Gamma^o + 1)}{(1 - p_\Gamma^o)(1 + p_\Gamma^o)} < k \leq \frac{(2p_\Gamma^o + 1)^2}{p_\Gamma^o (1 + p_\Gamma^o)}. \tag{39}$$

As is noted above, in the no-information equilibrium, p_M^n, a message conveying $s' \in \{s_0, s_1, s_2\}$ is sent no matter which state of nature is realized. Therefore, there are six non-trivial neologisms, $\{s_i\}$ and $S \backslash \{s_i\}$, $i = 0, 1, 2$. By comparing the government's payoff from each of those neologism and that from staying with the no-information equilibrium, we obtain the following result.

Theorem 7 *Regardless of the value of* h*, the no-information obscurantism,* p_M^n*, is a neologism-proof perfect Bayesian Nash equilibrium if and only if*

$$k > \max \left\{ \frac{(3 - 2p_\Gamma^o)(1 + 2p_\Gamma^o)}{2(1 - p_\Gamma^o)}, \frac{(2p_\Gamma^o + 1)\left(7p_\Gamma^o + 3 + 2(p_\Gamma^o)^2\right)}{2p_\Gamma^o (p_\Gamma^o + 1)} \right\}. \tag{40}$$

Proof. See the Appendix for a proof. ■

In Figure 3, the lower boundaries of conditions (38), (39), and (40) are illustrated by curves N^0, N^2, and N^n, respectively. The s_0- and s_2-revealing neologism-proof equilibria, respectively, exist between curves E^0 and N^0 and curves E^2 and N^2.

As this shows, the condition for a neologism-proof equilibrium gives a lower bound for parameter k, capturing how important for the government the public's assessment on the government's capability is. In contrast, as is noted above, the condition for a perfect Bayesian Nash equilibrium gives an upper bound for the parameter, k. This difference arises because, in the model of this study, a neologism-proof equilibrium is concerned with the government's incentive to convey the truth to the public whereas a perfect Bayesian Nash equilibrium is concerned with the government's incentive to misinform the public. This explains that in order for the Fukushima partition to be supported as a neologism proof equilibrium, parameter k must be in a middle range.

Another important condition for the Fukushima partition to be supported as a neologism-proof equilibrium is that the public's prior assessment on the government's capability, p_Γ^o, is sufficiently high. The higher the prior assessment, the lesser extent to which the public revises its assessment on the government's capability after realizing the government's preparation against the accident is sub-par.

That would increase the government's incentive to tell the truth in the case in which the accident scale is large.

As Figure 3 shows, only the Fukushima partition can be a unique neologism-proof equilibrium. The condition follows from (36) and (40).

Corollary 2 *Regardless of the value of* h, *the* s_0*-revealing obscurantism (Fukushima partition),* $p_M^{s_0}$, *is a unique neologism-proof perfect Bayesian Nash equilibrium if and only if*

$$\frac{\left(2p_\Gamma^o+1\right)^2}{p_\Gamma^o\left(1+p_\Gamma^o\right)} < k \leq \frac{\left(3-2p_\Gamma^o\right)\left(1+2p_\Gamma^o\right)}{2\left(1-p_\Gamma^o\right)}. \tag{41}$$

Corollary 2 implies that it might be an inevitable outcome in a game between the government and the public that the government failed to convey to the public the catastrophic state of the Fukushima accident during its early stage. That is, even if the government is capable of conveying the truth to the public, it might not wish to do so in order to protect the high assessment that the public has on the government's capability.

Remark 8 (Mixed Obscurantism) *As is noted in Section 2, our model has another unignorable class of equilibria, which may be called a mixed obscurantism. This equilibrium is defined as an equilibrium in which multiple posterior probability distributions on incident scale may be associated with a single incident scale, i.e., given* $s \in S$, *there are* $m' \in M(s;p_M)$ *and* $m'' \in M(s;p_M)$ *such that* $p_S(\cdot|m') \neq p_S(\cdot|m'')$. *From these updated probabilities, two responses* $(x(m'), p'_\Gamma(\gamma|m))$ *and* $(x(m''), p_\Gamma(\gamma|m''))$ *will emerge with the probabilities determined by* p_M. *We therefore call this type of equilibria a mixed information equilibrium.*[12]

The next proposition shows that this mixed information equilibrium cannot survive neologism-proof refinement.

Proposition 2 *An equilibrium of mixed obscurantism is not neologism-proof and is Pareto dominated by the coexisting pure-information equilibrium.*

[12] In Crawford and Sobel (1982)'s equilibrium, the probability with which a mixed information strategy is chosen is zero, because they deal with a continuous state space. (It occurs only at a threshold type.) Because this study deals with a finite state space, the probability with which a mixed information strategy is chosen becomes positive. For that reason, a mixed information equilibrium is unigonorable.

6 Fukushima Accident

As is shown above, this study identifies two exogenous parameters as important factors contributing to the bad information flows from the government to the public that were observed during the early stage of the Fukushima nuclear accident (see the Introduction for details). Those parameters are p_{Γ}^{o} and k, which, respectively, capture the public's prior assessment on the government's capability to handle various matters including the accident and the importance that the government attaches to the posterior assessment by the public, $p_{\Gamma}(\gamma|m)$. The above results, Theorem 4 and Corollaries 1 and 2, all show that *parameters* p_{Γ}^{o} *and* k *must be sufficiently large* if the government hides a catastrophic situation from the public. In order for the Fukushima partition to be supported as a perfect Bayesian Nash equilibrium, parameter k cannot be too large, as Theorem 1 shows. If, however, k is too large to support that equilibrium, a no-information equilibrium will emerge, given p_{Γ}^{o} is sufficiently large. In that respect, we may conclude that if p_{Γ}^{o} and k are sufficiently large, a catastrophic situation cannot be revealed.

There are various pieces of evidence supporting that p_{Γ}^{o} and k are large. Below, we will explain this.

We regard p_{Γ}^{o} as the parameter capturing the government's capability to handle general governmental matters. If that parameter is limited to the capability to handle potential nuclear accidents, important evidence supporting high p_{Γ}^{o} may be that, since the first reactor at the Fukushima plant was built, about sixty reactors have been built all over Japan. Second, according to Iwai and Shishido (2015, p. 177), the percentage of people who worries about the danger of nuclear power plants decreased from 68 percent in 1999 to 56 percent in 2009. According to them, "The reasons for feeling safe . . . included 40 percent of people saying Japan has a satisfactory history in nuclear power generation, 36 percent saying Japan's nuclear power generation is safe, 33 percent saying that they trust the government, . . ." Moreover, in 2009, 60 percent of people was in favor of increasing Japan's reliance on nuclear energy (see Iwai and Shishido, 2015, Figure 4). After the Fukushima accident, this public support quickly diminished.[13]

That parameter k may have been high during the accident may be supported

[13] The public's high assessment on the government capability itself may be attributable to an informational bias that existed long before the Fukushima accident. Recently, it has been reported that in 2007 and 2009, the IAEA informed TEPCO, the operator of the Fukushima plant, and the government that "a magnitude-8.3 earthquake off the coast of Fukushima could lead to tsunami of around 15 meters, . . . , inundating the buildings." The IAEA further reports that TEPCO, as well as the government, failed to take a necessary measure against such a tsunami (Kyodo News, May 25, 2015; see also Muccury (*Guardian*, June 11, 2015)). At the time of the accident, the public was unaware of these facts and generally under the impression that both the government and TEPCO were skillfully managing the power plant. This may be explained by modifying our model.

by different investigations that took place after the Fukushima accident. According to the Intermediate Report (2011, p. 261) by Investigation Committee on the Accident at the Fukushima Nuclear Power Stations of Tokyo Electric Power Company, the government did not disclose vital information in fear of "creating unnecessary confusions" among public. The Independent Investigation Committee attributes this fear to what it calls "elite panic." The Chairman of the Committee, Koiichi Kitazawa, explains that elite panic occurred during the accident in which "various layers of the governments, fearful of inciting panic among the general public, refuses to pass on critical pieces of information[;]" see Kitazawa (2012). In our model, this phenomenon may be interpreted as a sudden increase in k in the face of the catastrophic accident.

Broadly speaking, parameters k and h are intended to capture the importance that the government and the public, respectively, attach to the public's assessment on the general capability of the government. As is discussed above, our results depend only on the value of k (on the government side) but not on that of h (on the public side). If, as is stressed by the Independent Committee, elite panic is triggered by the accident, and if the government was "fearful of inciting panic among the general public, it may be attributable to the government's fear of losing the public's trust in handling the accident. In our model, this may be captured by a sudden increase in the importance for the government of the public trust (or assessment on the government's capability), k, as soon as the government realized that the accident was in a catastrophic state. This may explain the withholding of vital information during the early stage of the Fukushima accident.

7 Various Obscurantisms

While we build our model to capture the Fukushima nuclear accident, there are many other real-world incidents to which our model may fits; a recent, and very important, incident is the cover-up of attacks on scores of young women in Cologne, Germany, which we have already discussed. In what follows, we will discuss several more of such incidents. It is possible to interpret them as a result of the interaction between idiosyncratic information on the information sender's capability and non-idiosyncratic information on particular circumstances, which would bring about a particular reaction of the receiver.

7.1 Benghazi

On September 11, 2012, the U.S. consulate in Benghazi, Lybia, was attacked, and four people including the U.S. ambassador were killed. Initially, the government said that the assault was spontaneous and grew out of a protest against the controversial video. It turned out, however, that the assault was by an organized terrorist group. Since then, this discrepancy in explanation has been criticized as showing the failure of providing proper security for diplomats. It is generally held that it is hard for the government property to prepare against spontaneous attacks. In contrast, it is part of the government's responsibility to prepare against organized terrorist attacks.

Like the Fukushima incident, this incidence can be captured in our model. For this purpose, think of $\omega = 1$ and $\omega = 2$ as the states in which the attack was spontaneous and planned, respectively. Moreover, $\gamma = 0$ and $\gamma = 1$ are the states in which the government is unprepared and prepared, respectively, against attacks. These events, ω and γ, are independently distributed; the state of nature is $\theta = (\omega, \gamma)$. The government's competency is considered to be high ($s = s_0 = 0$) if the attack is spontaneous and if the government is prepared ($\theta = (\omega, \gamma) = (1, 1)$, in which case $s = \omega - \gamma = 0$) and low ($s = s_2 = 2$) if the attack is planned and if the government is unprepared ($\theta = (2, 0)$, in which case $s = \omega - \gamma = 2$). Otherwise, the government's competency is medium; $s = s_1 = 1$ if $\theta = (1, 0)$, $(2, 1)$. The payoff of people (or of those related to governmental activities in abroad) depends on the competence of the government, s, and its own preparation against emergency, x, and is captured by $D(s, x)$. People develops their own trust in government, which is captured by p^o_Γ. The government's payoff is $V = -D(s, x) + kp_\Gamma$.

At this stage, it is still difficult to determine which type of obscurant equilibrium may be suitable as a description. Some argue that the government knew that it was a planned attack from the beginning, which is unclear. Whether or not the announcement that the government initially made reveal any information is unclear either. What we know for sure at this moment seems that if, in fact, the government knew $s_2 = 2$ (i.e., the incident was planned at the same time that the government is unprepared), the equilibrium was neither worst-scenario revealing nor non-obscurant fully revealing.

7.2 IRS Cover-up

Another incident of obscurantism is the alleged cover up of harassments against political opponents whose application for tax-exempt status the U.S. Internal Revenue Service (IRS) held up for many months. An IRS official in charge of tax exemption resigned in 2013 after disclosures that the official's division targeted the opposition party (Tea Party and other groups) before the 2012 national election. The emails of the official, which would have provided important evidence, has been lost by a clash of the official's hard disk drive in 2011. Opposition party critics argue the hard disk drive clash looks like a cover-up.

This typical cover-up case as well can be described by our model. For this purpose, think of $\omega = 1$ and $\omega = 2$ as the states in which the harassment that took place was mild and bad, respectively. Moreover, $\gamma = 0$ and $\gamma = 1$ are the states in which the hard disk is intentionally destroyed and incidentally broken, respectively. The state of nature is $\theta = (\omega, \gamma)$. The government's performance is considered to be acceptable ($s = s_0 = 0$) if the harassment is mild and if the hard disk is accidentally broken ($\theta = (\omega, \gamma) = (1, 1)$) and intolerable ($s = s_2 = 2$) if the harassment is bad and if the hard disk was intentionally destroyed ($\theta = (2, 0)$). Otherwise, the government's competency is medium; $s = s_1 = 1$ if $\theta = (1, 0)$, $(2, 1)$.

7.3 Faulty Car-Airbag Cover-up

In 2013, a man was killed in a suburban Los Angeles parking lot by the airbag that deployed explosively in his 2002 car. *New York Times* reports that the police initially treated the case as a homicide because of the nature of him injuries and later realized that the man was killed by a metal portion of the airbag inflator.[14]

Prompted by previous accidents, in 2004, the manufacturer of the airbag suspected tested its airbag design and found that the steel inflaters in two of the airbags cracked during the tests, which could lead to rupture. According to *New York Times*, "[t]he result was so startling that engineers began designing possible fixes in preparation for a recall, [a] former employee said." The manufacturer, however, decided to ignore the test result and secretly disposed the tested airbags. According to Detroit News, "Defective Takata air bags are linked to least eight deaths worldwide and more than 100 injuries. Takata in May declared air bag inflators defective in 33.8 million vehicles produced by 11 automakers, sparking the largest U.S. auto recall in history."[15]

Although this incident is not concerned with the relationship between a government and people but between a private firm and its customers (actual and potential), the underlying structure may relate to the interaction between idiosyncratic information, concerning the manufacturers' general reputation, and non-idiosyncratic information, concerning the safety of airbags.

There have been many similar incidents of cover-ups in various markets, which is an important issue characterizing the quality of a particular market (Yano, 2009). This study shows that an informational bias in such a phenomenon may be attributable to idiosyncratic information.

[14] See Tabuchi (New York Times, Nov 6, 2014).

[15] See D. Shepardson (Detroit News, August 20, 2015).

8 Concluding Remarks

This study has demonstrated that in the face of a catastrophic state like the Fukushima accident, the government may hide the true state of nature from the public even if the government is concerned purely with the public's welfare. Such a bias may be attributable to the existence of idiosyncratic information; we say that information of the public is idiosyncratic if it does not influence the public's action but only its payoff. (It is non-idiosyncratic if it influences the public's action as well.) If idiosyncratic and non-idiosyncratic prior information are correlated, the government's message can jointly affect idiosyncratic and non-idiosyncratic posterior information of the public. If, therefore, the government shares the same payoff function with the public, its payoff is affected by the choice of a message. Therefore, the government's messaging rule is affected by the importance of the idiosyncratic information held by the public (captured by parameter k in our study). This opens the possibility that the government places an information bias.

In our model, an information bias depends on how strongly the government's payoff is influenced by the idiosyncratic (posterior) information held by the public, k. In contrast, the bias does not depend on how strongly the public's payoff is affected by it, h. This is because the public's action is independent of idiosyncratic information.

A calm rational man would not cry over a bucket of milk spilled over the field, which would be of no use. In a similar sense the calmness and rationality of a government and a public can be captured by the importance that the government and the public place on the public's interpretation of idiosyncratic information, which does not affect the public's action; a perfectly calm rational government and public would place no importance on idiosyncratic information.

Many observers argue that the government lost the ability to make calm decisions by facing the catastrophic state of the accident. Some calls this elite panic. According to our result, elite panic is attributable to the fact that the government lost its calmness, i.e., that k increased suddenly. If elite panic in this sense occurs, our result shows, a truth may not be conveyed in the face of a catastrophic accident. Similar panic is not caused by the public (or a sudden increase in h), because an equilibrium does not depend on the importance that the public attaches to the idiosyncratic information held by the public.

9 Appendix: Proofs

Proof of Lemma 1. Take two messages m_0 and m_1 that are sent on-equilibrium ($\sum \Pr[\theta] p_M(m_0|\theta) > 0$ and $\sum \Pr[\theta] p_M(m_1|\theta) > 0$) that induce different action-evaluation pairs from the public. Without loss of generality, assume that $x(m_1) >$

$x(m_0)$. First observe that from $V_{12} > 0$, if

$$V(s, x(m_1), p_\Gamma(1|m_1)) \geq V(s, x(m_0), p_\Gamma(1|m_0))$$

for some s, then

$$V(s', x(m_1), p_\Gamma(1|m_1)) > V(s', x(m_0), p_\Gamma(1|m_0))$$

for all $s' > s$.

From this, for all $\theta_0 \in \Theta(s)$, $\theta_1 \in \Theta(s')$ such that $s' > s$, if $p_M(m_1|\theta_1) > 0$ and $p_M(m_1|\theta_1) > 0$, then it must hold that $p_M(m_1|\theta_0) = 0$, and if $p_M(m_1|\theta_0) > 0$ and $p_M(m_1|\theta_0) > 0$, then it must hold that $p_M(m_0|\theta_1) = 0$. Then from the fact that m_0 and m_1 induce different action-evaluation pairs, those imply that $p_S(s_2|m_0) = 0$ and $p_S(s_0|m_1) = 0$. Moreover, because $x(m_1) > x(m_0)$, it must hold that $E[s|m_1] > E[s|m_0]$, and hence $\min\{p_S(s_2|m_1), p_S(s_0|m_0)\} > 0$.

On the other hand, from (5), we have $\Pr(\gamma = 1|s) > \Pr(\gamma = 1|s')$. From those, it follows that

$$\begin{aligned}
p_\Gamma(1|m_0) &= \frac{\sum_{\theta\in\{\theta|\theta=(\omega,1)\}} p_M(m_0|\theta)\Pr[\theta]}{\sum_{\theta\in\Theta} p_M(m_0|\theta)\Pr[\theta]} \\
&= \frac{\sum_{s\in S}\sum_{\theta\in\{\theta|\theta=(\omega,1)\}} p_M(m_0|\theta)\Pr(\theta|s)\Pr[s]}{\sum_{\theta\in\Theta} p_M(m_0|\theta)\Pr[\theta]} \\
&= \sum_{s\in S} \frac{\sum_{\theta\in\{\theta|\theta=(\omega,1)\}} p_M(m_0|\theta)}{\sum_{\theta\in\Theta} p_M(m|\theta)} \cdot \frac{\Pr[s]\sum_{\theta\in\Theta} p_M(m|\theta)\Pr(\theta|s)}{\sum_{\theta\in\Theta} p_M(m_0|\theta)\Pr[\theta]} \\
&= \sum_{s\in S}\Pr(\gamma = 1|s)\cdot p_S(s|m_0) > \sum_{s\in S}\Pr(\gamma = 1|s)\cdot p_S(s|m_1) = p_\Gamma(1|m_1).
\end{aligned}$$

■

Lemma 2 is a direct consequence of Lemma 1.

Proof of Proposition 1 and 2. We call the government with accident scale s government type s. We first prove that in any equilibrium, there are at most three different vectors (x^i, p_Γ^i), $i = 0, 1, 2$, such that $(x(m), p_\Gamma(1|m)) = ((x^i, p_\Gamma^i))$ for any $m \in \cup_{s'} M(s'; p_M)$. In order to obtain a contradiction, suppose that there are $n > 3$ number of on-equilibrium messages $m_1, .., m_n$, that induce different actions $x_1, .., x_n$, respectively. Let M_j be the set of messages that induce x_j, and without loss of generality, assume that $x_j < x_i$, for $j < i$. From Lemma 1, type 0 government sends a message from M_1 with probability one. Suppose that type 2 government does not send a message from M_1. Then, messages from M_1 are sent only by the type 1 government and thus it reveals the true scale of accident.

Moreover, messages from M_2 are sent only by type 2 government, which implies that those messages reveal government type and induces x_2. Then, from Lemma 1, no type of government prefers to send a message from m_j with $j > 2$, which is a contradiction. Now suppose that type 2 government sends a message from M_1 with a strictly positive probability, which implies that type 2 government at least weakly prefers messages from M_1 over those of M_j with $j > 1$. Then type 2 government strictly prefers messages from M_1 over those of M_j with $j > 2$. Therefore, all messages from M_j with $j > 1$ are sent only by type 2 government and hence induce x_2, which is a contradiction. This proves that there are only three different messages sent on equilibrium, from which Proposition 2 follows.

Now we prove Proposition 2. In the following, for expositional simplicity, we assume that not more than three massages are sent on-equilibrium. This is without loss of generality, because given what we have shown, if there is an equilibrium that has more than three on-equilibrium messages, we can find an outcome equivalent equilibrium that has not more than three on-equilibrium messages. For simplicity, we only prove the proposition for the equilibrium such that p_M depends only on s, i.e., $p_M(m|\theta) = p_M(m|\theta')$ if $\theta \in \Theta(s)$ and $\theta' \in \Theta(s)$ for some s, and denote the messaging rule by $p_M(m|s)$. Similar proof applies for the other cases as well.

First, think of an mixed obscurantism such that $p_M(m_0|0) = 1,\ p_M(m_0|1) > 0,\ p_M(m_1|1) > 0,\ \sum_{j=0,1} p_M(m_j|1) = 1$, and $p_M(m_2|2) = 1$ for $m_0,\ m_1$, and $m_2 \in M$. Then from (9), (10), and (11),

$$x(m_0) = \frac{p_M(m_0|1)}{p^o_\Gamma + p_M(m_0|1)},\ x(m_1) = 1, \text{ and } x(m_2) = 2$$

and

$$p_\Gamma(1|m_0) = \frac{p^o_\Gamma + p^o_\Gamma p_M(m_0|1)}{p^o_\Gamma + p_M(m_0|1)},\ p_\Gamma(1|m_1) = p^o_\Gamma, \text{ and } p^o_\Gamma(1|m_2) = 0.$$

In order for $p_M(\cdot|1)$ being optimal, it must hold that $D(1, x(m_0)) - D(1, x(m_1)) = k(p_\Gamma(1|m_0) - p_\Gamma(1|m_1))$. From this, $p_M(m_0|1) = \frac{2p^o_\Gamma - p^o_\Gamma k(1-p^o_\Gamma)}{k(1-p^o_\Gamma)}$ follows and hence in order for $p_M(m_0|1) > 0$ to hold, it must hold that $k < \frac{2}{1-p^o_\Gamma}$. Similarly, in order for $p_M(\cdot|2)$ being optimal, it must hold that $k < \frac{2}{p^o_\Gamma}$. Therefore, from Theorem 3, fully revealing equilibrium also exists under such parameter values.

It is also proved in a similar manner that if there exists a mixed obscurantism such that $p_M(m_0|0) = 1,\ p_M(m_1|1) > 0,\ p_M(m_1|2) > 0,\ p_M(m_2|2) > 0$, and $\sum_{j=1,2} p_M(m_j|2) = 1$ for $m_0,\ m_1$, and $m_2 \in M$, there also exists a fully revealing equilibrium. This completes the proof of Proposition 2. ■

Proof of Theorem 7. We prove that the two conditions

$$k > \frac{(3 - 2p^o_\Gamma)(1 + 2p^o_\Gamma)}{2(1 - p^o_\Gamma)} \tag{42}$$

and

$$k > \frac{(2p_\Gamma^o + 1)\left(7p_T^o + 3 + 2\left(p_\Gamma^o\right)^2\right)}{2p_\Gamma^o\left(p_\Gamma^o + 1\right)} \tag{43}$$

are necessary and sufficient for a babbling equilibrium to be neologism proof.

Sufficiency: Take a babbling equilibrium. Then the equilibrium payoff is given as follows.

$$V^*(s) = -D(s, \frac{3 - 2p_\Gamma^o}{2}) + kp_\Gamma^o.$$

There are six neologisms to consider, $N = \{0\}$, $\{1\}$, $\{2\}$, $\{0, 1\}$, $\{1, 2\}$, and $\{0, 2\}$.

We first check if $N = \{0\}$ is a credible neologism. Since $(x^N, p_\Gamma^N) = (0, 1)$, the incentive for the government to send neologism N in state s is given by

$$V(s, x^N, p_\Gamma^N) - V^*(s) = \begin{cases} \frac{\left(3-2p_\Gamma^o\right)^2}{2} + k\left(1 - p_\Gamma^o\right) & \text{if } s = 0 \\ -\frac{\left(1+2p_\Gamma^o\right)\left(3-2p_\Gamma^o\right)}{2} + k\left(1 - p_\Gamma^o\right) & \text{if } s = 1 \\ -\frac{\left(5+2p_\Gamma^o\right)\left(3-2p_\Gamma^o\right)}{2} + k\left(1 - p_\Gamma^o\right) & \text{if } s = 2. \end{cases}$$

This shows that $s = 0 \in C(N)$. Moreover, $V(2, x^N, p_\Gamma^N) - V^*(2) < V(1, x^N, p_\Gamma^N) - V^*(1)$. Thus, $N = \{0\}$ is not a credible neologism if and only if $V(1, x^N, p_\Gamma^N) - V^*(1) > 0$, which is rewritten as (42). Hence it is not a credible neologism.

Next take neologism $N = \{0, 1\}$. Note that, given $N = \{0, 1\}$,

$$(x^N, p_\Gamma^N) = (\frac{1}{p_\Gamma^o + 1}, \frac{2p_\Gamma^o}{p_\Gamma^o + 1}).$$

The incentive for the government to send neologism $N = \{0, 1\}$ is characterized by

$$V(s, x^N, p_\Gamma^N) - V^*(s) = \begin{cases} \frac{\left(1+p_\Gamma^o-2p_\Gamma^o\right)}{2\left(p_\Gamma^o+1\right)^2} + k\left(\frac{p_\Gamma^o\left(1-p_\Gamma^o\right)}{p_\Gamma^o+1}\right) & \text{if } s = 0 \\ -\frac{\left(1+p_\Gamma^o-2p_\Gamma^o\right)\left(5+p_\Gamma^o-2p_\Gamma^o\right)}{2\left(p_\Gamma^o+1\right)^2} + k\left(\frac{p_\Gamma^o\left(1-p_\Gamma^o\right)}{p_\Gamma^o+1}\right) & \text{if } s = 1 \\ -\frac{\left(1+p_\Gamma^o-2p_\Gamma^o\right)\left(3+7p_\Gamma^o+2p_\Gamma^o\right)}{2} + k\left(\frac{p_\Gamma^o\left(1-p_\Gamma^o\right)}{p_\Gamma^o+1}\right) & \text{if } s = 2. \end{cases}$$

As a result, $N = \{0, 1\}$ is not a credible neologism if the bottom expression becomes strictly positive $2 \in C(N)$ or the middle expression becomes negative $1 \notin C(N)$, which is written as

$$k > \frac{(2p_\Gamma^o + 1)\left(7p_\Gamma^o + 3 + 2\left(p_\Gamma^o\right)^2\right)}{2p_\Gamma^o\left(p_\Gamma^o + 1\right)} \text{ and } k < \frac{(2p_\Gamma^o + 1)\left(5 + p_\Gamma^o - 2p_\Gamma^o\right)}{2p_\Gamma^o\left(p_\Gamma^o + 1\right)},$$

respectively. Hence $N = \{0, 1\}$ is not a credible neologism.

Next take neologism $N=\{1\}$. If it is credible, it must hold that $0\notin P(\{1\})$, $1\in P(\{1\})$, and $2\notin P(\{1\})$. However, those are rewritten as $p_\Gamma^o\geq\frac{1}{2}$, $p_\Gamma^o\neq\frac{1}{2}$, and $p_\Gamma^o\leq\frac{1}{2}$, respectively. Apparently, those are incompatible and hence neologism $N=\{1\}$ is not credible.

To see that $N=\{2\}$ is not a credible neologism, it can be computed that $2\notin P(\{2\})$ if

$$k\geq\frac{(1+2p_\Gamma^o)^2}{2p_\Gamma^o}.$$

Because the right hand side is smaller than $\frac{(2p_\Gamma^o+1)(7p_\Gamma^o+3+2p_\Gamma^o)}{2p_\Gamma^o(p_\Gamma^o+1)}$, it is not a credible neologism under (43).

To see that $N=\{0,2\}$ is not a credible neologism, observe that if it is, we must have

$$D(s,E[s|s\in\{0,2\}])-D\left(s,\frac{3-2p_\Gamma^o}{2}\right)<k\left(\Pr[\gamma=1|s\in\{0,2\}]-p_\Gamma^o\right)$$

for $s=0,\ 2$, and

$$D(1,E[s|s\in\{0,2\}])-D\left(1,\frac{3-2p_\Gamma^o}{2}\right)\geq k\left(\Pr[\gamma=1|s\in\{0,2\}]-p_\Gamma^o\right).$$

However, it can be computed that those are incompatible with each other.

Finally, to see that $\{1,2\}$ is not a credible neologism, we must have

$$D(1,E[s|s\in\{1,2\}])-D\left(1,\frac{3-2p_\Gamma^o}{2}\right)<k\left(\Pr[\gamma=1|s\in\{1,2\}]-p_\Gamma^o\right),$$

which is computed as $k<\frac{(3-2p_\Gamma^o)\left(-4+7p_\Gamma^o-2(p_\Gamma^o)^2\right)}{2p_\Gamma^o(2-p_\Gamma^o)(1-p_\Gamma^o)}$. However, the right hand side is smaller than $\left\{\frac{(3-2p_\Gamma^o)(1+2p_\Gamma^o)}{2(1-p_\Gamma^o)},\frac{1+2p_\Gamma^o}{2p_\Gamma^o}\right\}$ for all p_Γ^o. Hence $\{1,2\}$ cannot be a credible neologism.

Necessity: We have already seen that (42) is necessary. Hence suppose that (43) is violated, which implies $2\notin P(\{0,1\})$. Because we obviously have $0\in P(\{0,1\})$, if neologism $N=\{0,1\}$ is not credible, we must have $1\notin P(\{0,1\})$, which is computed as $k\leq\frac{(2p_\Gamma^o+1)(3p_\Gamma^o-1+2p_\Gamma^o)}{2p_\Gamma^o(p_\Gamma^o+1)}$. Because the right hand side is smaller than $\max\left\{\frac{(3-2p_\Gamma^o)(1+2p_\Gamma^o)}{2(1-p_\Gamma^o)},\frac{(1+2p_\Gamma^o)^2}{2p_\Gamma^o}\right\}$ and we have (42), this implies that $k<\frac{(1+2p_\Gamma^o)^2}{2p_\Gamma^o}$. However, this implies that $N=\{2\}$ becomes a credible neologism.

The second statement can be proved in much the same way as Theorem 5 and hence omitted. *Q.E.D.* ■

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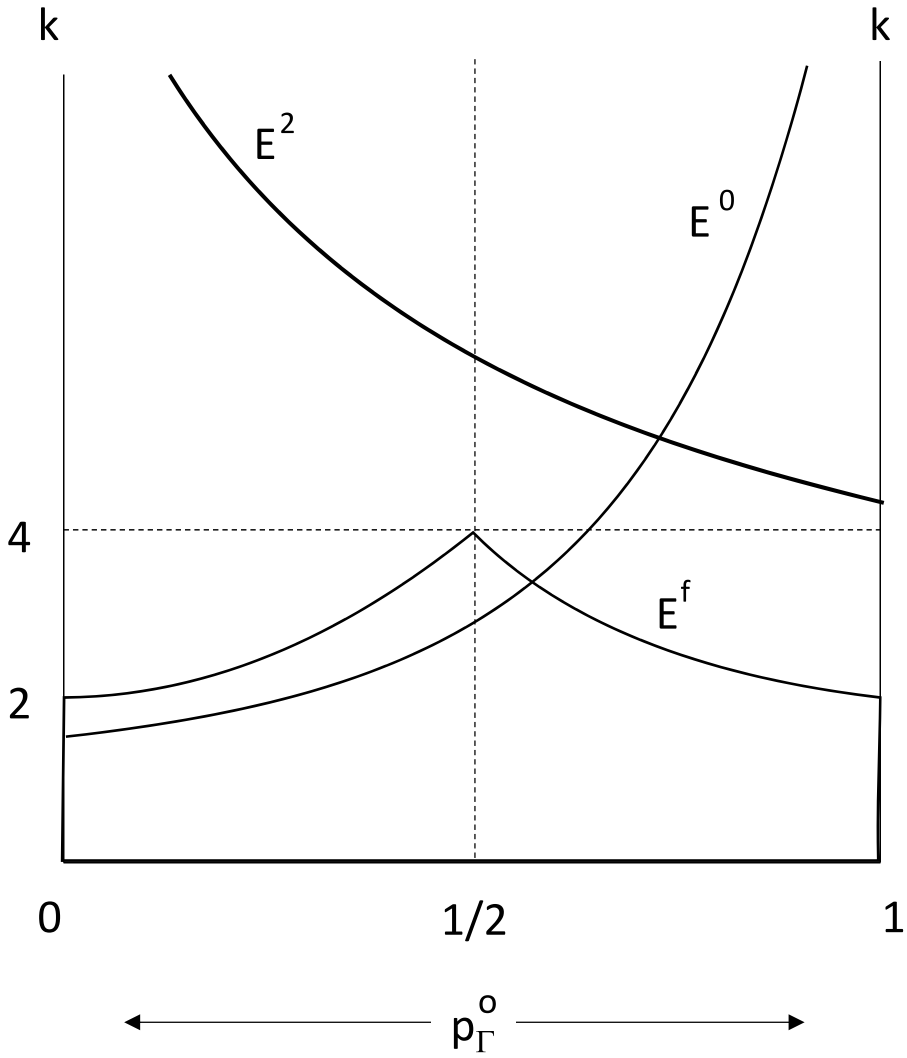

Figure 1: Perfect Bayesian Nash Equilibria

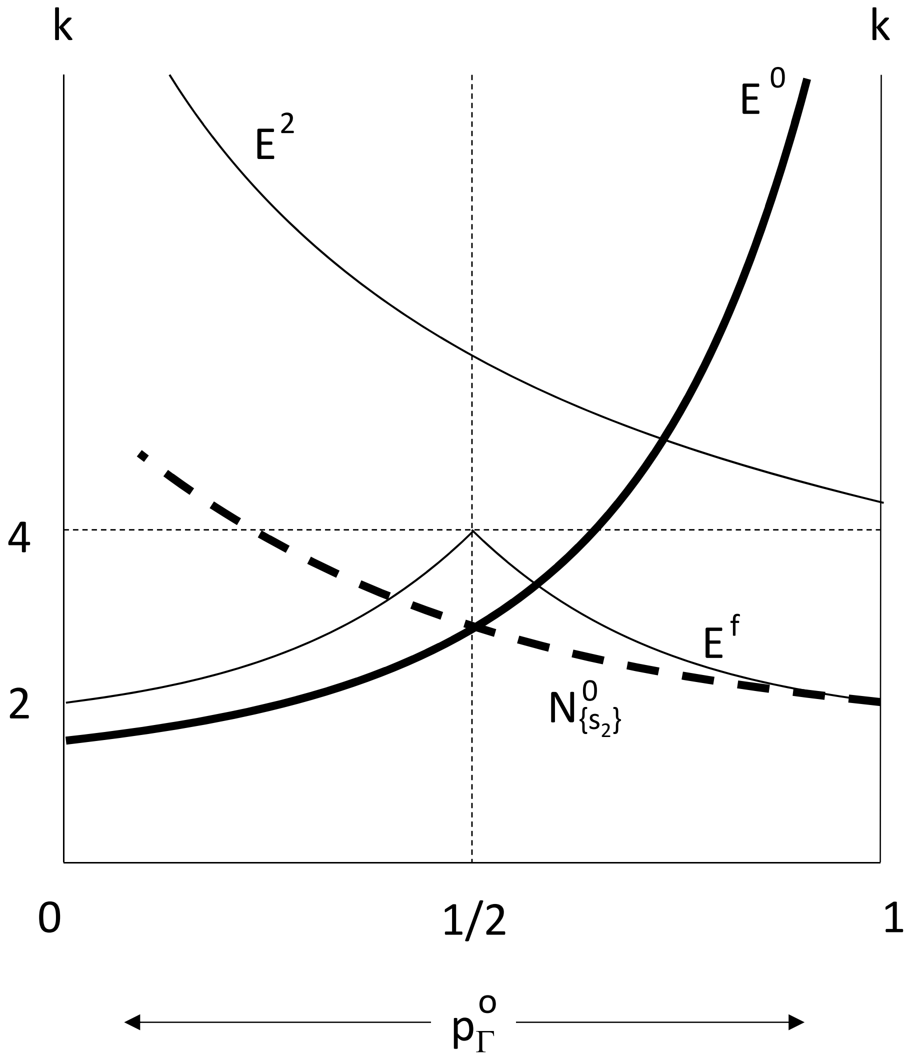

Figure 2: Truth Untold in the Fukushima Accident

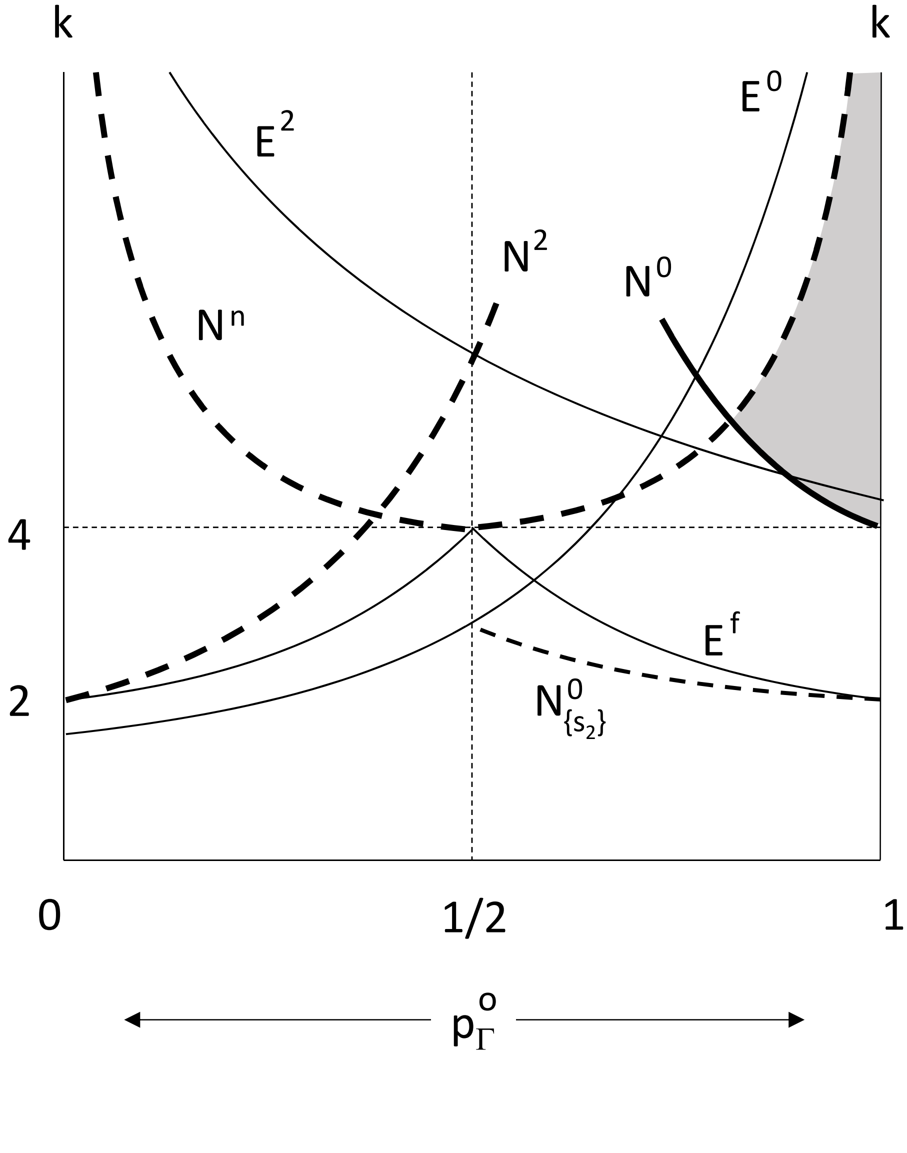

Figure 3: Neologism-proof Fukushima Equilibrium