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Burden of Inspection Costs and Effectiveness of Environmental Regulations

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Burden of Inspection Costs and Effectiveness of Environmental Regulations[†]

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Abstract
Using a laboratory experimental approach, this study examines the effect of institutional changes in the responsibility for paying inspection costs for environmental regulations on the behavior of polluters and authorities. In particular, we compare two schemes: one is that authorities always bear the inspection cost and the other is that polluters bear the cost in a given situation. We find that polluters comply with regulations more frequently in the latter than the former scheme, while the inspection behavior of authorities does not change significantly. Moreover, the cost-bearing change in the scheme induces income redistribution between polluters and authorities (pollutees or society). In addition, we introduce uncertainty about the occurrence of environmental damage, and find that the frequency of inspection is greater in the latter than the former scheme. Because both inspection and compliance costs increase, total payoff may decrease by the partial shift of responsibility for inspection cost from authorities to polluters.

Keywords: Compliance, environmental regulation, inspection cost, laboratory experiment.
JEL Classifications: K32, Q52, Q58,

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1. Introduction

In the field of economics, the effectiveness of various kinds of environmental policies, such as regulations and taxes, has become an area of interest. Taxes are often considered to be preferable, because taxes can incentivize polluters to reduce their emissions and adopt environmentally friendly technology. However, in the real world, regulations are enforced in various industries and for various pollutants. One reason that environmental authorities adopt direct regulations rather than incentive schemes is that the former is more immediately effective than the latter. Punishment schemes for violation usually accompany regulations and, accordingly, polluters have to comply with regulations from the date of enforcement. Meanwhile, when polluters pay taxes, they can keep their status-quo production technologies and production quantities if they want to do so.

One important problem with environmental regulation and punishment schemes is that monitoring and inspection are imperfect. It is likely that the skills and technologies for monitoring and inspection are imperfect. Moreover, because these activities are costly, it is difficult for authorities to inspect all polluters for violation of regulations. To make matters worse, authorities might not have incentives to inspect polluters. The intuition is that inspections must be carried out after production activities. At that point, pollutants have been already emitted into the air and/or water. Moreover, even if authorities enforce punishment, fines and compensation are types of income redistribution between polluters and pollutees. Because inspection activities incur additional costs, it is meaningless for authorities to carry out the inspection if the objective of the authorities is social surplus maximization.

Many studies have been tackling this issue. Theoretically, for example, Harrington (1998) examined the inspection and compliance behavior in a repeated game setting, and demonstrated that even if the possibility of inspection is low firms may comply with environmental regulations when authorities classify firms into groups based on their behavior in the past. Several papers also investigated institutional issues. For example, Franckx (2002) examined the effect of ambient inspection when an authority cannot verify each firm's pollution emission with certainty. Frieson (2003) also considered a targeting scheme that save inspection costs and encourage compliance behavior. Moreover, many studies considered optimal policies including the choice of tax, standards, or emission permits and the introduction of self-reporting scheme in the presence of imperfect and costly inspection (Xepapadeas, 1991; Chen and Liu, 2009; Evans et al., 2009; Arguedas et al, 2010; Caffera and Chávez, 2011).[2]

Empirically, Helland (1998) examined the effect of inspection and violation in the past periods and economic conditions on the behavior of polluters and authorities in the present period. Because self-reporting schemes are also referred to, the analysis of Helland (1998) is closely related to this study in terms of the relationship between the past and present variables. Moreover, Dion (1998) examined the factors that influence the monitoring behavior of authorities. In terms of the function of regulations, Stafford (2003) investigated whether the US hazardous waste regulation works effectively. Moreover, Shimshack (2005) found that there is a reputational effect regarding enforcement of inspections. Several articles focused on punishment schemes. For example, Stafford (2002) investigated the effect of severity of punishment on compliance behavior. Faure and Svatikova (2012) and Blondiau et al. (2015) compare administrative penalty schemes with criminal schemes.[3]

As compared with theoretical and empirical studies, there are fewer experimental studies. Using a laboratory experimental approach, Cochard (2005) examined the effect of environmental policies (such as input based tax, ambient tax/subsidy, ambient tax, group fine)

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[2] Heyes (2000) reviewed and examined the issues regarding environmental regulations and compliance behavior theoretically. Moreover, Holler (1993) considered a game between a polluter and an inspector and examined the case in which the third player intervenes the game.

[3] Gray and Shimshack (2011) reviewed empirical studies regarding environmental regulations. Dasgupta et al. (2000) examined the relationship between the type of environmental policy on compliance behavior.

on compliance behavior. Except for ambient tax/subsidy, these policies are found to be effective. Moreover, Germani et al. (2017) introduced a realistic penalty scheme into a laboratory experimental design and showed that unpredictable inspection enforcement may induce compliance.[4]

Using a laboratory experimental approach, this study examines the effect of institutional changes in the responsibility for paying inspection costs on the behavior of polluters and authorities.

To achieve our goal, we first compare two schemes of inspection cost payments. In our experiment, each subject plays either the role of a polluter (a producer) or an authority (an inspector). There are two production methods for producers: clean (environmentally friendly) and dirty (environmentally unfriendly). Producers have to adopt the clean production method to comply with the environmental regulation. However, producers can choose a production method in reality differing from that they report to authorities. In other words, producers can report use of the clean method but actually use the dirty method. In the first cost payment scheme, the authority always bears the inspection cost. In the second scheme, a producer bears the inspection cost (i) when the producer uses the dirty method but reports the clean method and (ii) when an inspector carries out the inspection. Intuitively, producers have stronger incentive to comply with the environmental regulation in the latter than the former scheme, because it becomes more costly for them to make a false report.

Second, as noted above, social surplus maximizers might not have incentives to conduct inspection, punishment, and income redistribution because they are costly. Thus, we introduce

[4] Other experimental studies are also related to this study, although they did not focus on environmental regulations. For example, Kleven (2011) conducted a type of field experiment and observed tax evasion behavior and compared self-reporting income and third party reported income. Anderson and Stafford (2003) conducted a public goods game with a punishment scheme and examined the effect of severity of punishment on compliance behavior. Moreover, they found a positive relationship between punishment in the past and compliance in the present period. Moreover, Ambrus and Greiner (2012) conducted a public goods game and examined the effect of costly punishment on cooperative behavior.

an environmental authority whose objective is to maximize the sum of revenues from polluters, fines, and compensation for environmental damage, minus environmental damage and inspection costs. Because the producer surplus is not included in this objective function, fines and compensation are not mere distribution. Rather, they are positive factors for the environmental authority, because it can use the revenue to mitigate environmental damage and/or prevent future environmental damage. Many researchers have referred to the objective of authorities and/or society. For example, Rousseau (2009) enumerated three important possible objectives of regulators: social welfare maximization, deterrence maximization, and providing justice.[5] Social welfare maximization is an orthodox objective in the field of economics. Deterrence maximization is aimed at minimizing the possibility of violation. Providing justice is a more complicated objective than the first two, because there are various definitions of justice. Taking into consideration these objectives, the objective of the environmental authority in our study is located between welfare maximization and deterrence minimization.

Third, we investigate whether uncertainty about environmental damage influences the behavior of both polluters and authorities. In particular, we adopt an experimental design in which an authority cannot know with certainty whether an environmentally friendly or unfriendly polluter emits pollution when the authority does not carry out the inspection, although the authority can observe the occurrence of the pollution with certainty.

The main results are as follows. First, the partial shift of inspection cost payment from authorities to polluters induces compliant behavior of polluters. In addition, polluters choose their strategies based on the behavior of authorities in the past periods. In particular, the more frequently the authorities carry out inspection, the more likely it is that polluters comply with the environmental regulation. Second, the partial shift of inspection cost payment from

[5] Blondiau and Rousseau (2017) theoretically and empirically examined judge's objective functions.

authorities to polluters does not influence the frequency of carrying out inspections significantly. Rather, authorities choose their enforcement strategies based on the inspection cost and behavior of polluters in the past periods. As intuitively expected, the higher is the inspection cost, the less frequently authorities carry out inspections. In addition, the more frequently producers violate the environmental regulation in the past periods, the more likely it is that authorities carry out inspections. Third, the shift of responsibility for inspection cost from authorities to polluters causes income redistribution between polluters and authorities (or pollutees). Because polluters pay more compliance costs when there is a possibility of bearing the inspection cost than when authorities always bear the cost, and because the frequency of the occurrence of environmental damage decreases owing to the change in the cost allocation scheme, the payoff of polluters significantly decreases. However, total payoff (i.e., the sum of payoffs of polluters and authorities) increases only slightly and the difference between the two cost allocation schemes is not significant. Fourth, when uncertainty about environmental damage is introduced, not only the behavior of polluters but also that of authorities is influenced by the change in the inspection cost allocation scheme. In particular, the frequency of inspection is greater when there is a possibility that polluters bear the inspection cost than when authorities always bear the cost. Consequently, the change in the scheme increases both payments for compliance and inspection costs and, accordingly, decreases the total payoff on average.

The structure of this paper is as follows. Section 2 provides the theoretical background, and Section 3 explains the basic experimental design. Section 4 reports and discusses the results of the experiment in the absence of uncertainty. Section 5 examines the case in the presence of uncertainty. Section 6 provides concluding remarks.

2. Background

In this section, we describe the background of the experimental design. The first subsection presents the theoretical background regarding the sub-game perfect equilibrium and the second subsection refers to a repeated-game setting and also describes the findings of laboratory and field experimental studies in the literature.

2.1 One-shot Game between a Firm and an Authority

Consider a game between one firm and one authority. The firm chooses either G or B production method in the presence of an environmental regulation set by the authority. If the firm wants to comply with the regulation, it has to choose G. On the contrary, the choice of B implies violation of the environmental regulation. For simplicity, we extract from the decision making on the production quantity and assume that the firm produces a certain fixed amount of products. The production costs for G and B is c_G and c_B, respectively. It is assumed that $c_G > c_B$.[6] Method B emits pollution into the air and/or water, while Method G does not emit any pollution. The environmental damage in monetary value is denoted by e_B, which is a type of social cost. Therefore, if there are no schemes and/or policies to shift the social cost to the private cost of the firm, the firm does not (need to) bear the environmental cost.

In addition, the firm reports its production method to the authority. The report itself does not incur any cost. The reported method can differ from the actual production method. On the one hand, the report is public information, which means that the authority can receive the report. On the other hand, the actual production method is private information, which implies that the authority cannot know with certainty whether the report is true. However, as explained below, the authority may inspect the actual production method. In such a case, the actual

[6] If $c_G \leq c_B$, the firm has no incentive to violate the regulation. Thus, there is no problem to be solved regarding environmental damage and policies. We exclude such a redundant situation by this assumption.

production method is assumed to be necessarily revealed.

If the firm chooses B as the actual production method and reports G, and if the false report is revealed, the firm has to pay a fine to the authority, the amount of which is denoted by F. The firm may also have to pay compensation for environmental damage, which implies that the scheme of environmental regulation and inspection may be able to shift the environmental cost from the society to the firm. If the firm chooses B and reports B, it necessarily has to pay compensation. However, if the firm chooses B and reports G, it has to pay compensation only when the authority carries out the inspection. The compensation value is assumed to be the same as the environmental cost.

The authority chooses whether to carry out the inspection, whose cost is denoted by C_M. Because the compensation and fine are income redistribution, whether they are present does not influence social welfare, including the environmental cost. Therefore, the authority has no incentive to carry out inspection if its objective is social welfare maximization and if it always bears the inspection cost. The reason is that the decision whether to inspect is made after the completion of production (and emissions, if there are any). Thus, we consider an environmental authority whose objective is explained below. In addition, we consider an additional scheme under which the firm bears the inspection cost in a given situation.

The objective function of the firm (π) is given by

$$\pi = \mathrm{R} - c_i - \sigma_B e_B - \sigma_F F - \sigma_M C_M, \qquad i = G, B,$$

where R denotes the sales revenue from production. $\sigma_B = 1$ when the firm pays compensation and $\sigma_B = 0$ when it does not. $\sigma_F = 1$ when the firm is fined and $\sigma_F = 0$ when it is not. $\sigma_M = 1$ when the firm bears the inspection cost and $\sigma_M = 0$ when it does not. Moreover, hereafter, we assume that $c_G = 0$ for simplicity.

The objective function of the authority (S) is given by

$$\mathrm{S} = \sigma_B e_B + \sigma_F F - \tau_B e_B - \tau_M C_M.$$

$\tau_B = 1$ when the firm chooses B as the actual production method and $\tau_B = 0$ when it chooses G as the real production method. $\tau_M = 1$ when the authority bears the inspection cost and $\tau_M = 0$ when it does not. Note that when the authority chooses to carry out the inspection, $\tau_M + \sigma_M = 1$ necessarily holds, and when the authority chooses not to carry out the inspection, $\tau_M = \sigma_M = 0$ necessarily holds.

We consider the following game structure. In the first stage, the firm chooses its actual production method and the content of the report, G or M. In the second stage, the authority chooses whether to carry out inspection. The game tree is shown in Figure 1. In the figure, for clarity, the choices of the firm are disaggregated into two stages: the choice of report and the choice of actual production method. In this sense, this game can be recaptured as follows. In the first stage, the firm chooses its report content. In the second stage, the firm and the authority simultaneously choose the actual production method and whether to carry out the inspection, respectively.

First, we consider the cost allocation scheme in which the authority always bears the inspection cost regardless of the choices of actual production method and report content. The payoffs for each combination of choices by both players are shown in Figure 1. From these payoffs, we can summarize the strategies regarding the sub-game perfect equilibrium. Suppose that the authority always bears the inspection cost. On the one hand, if $\mathrm{C_M - F \geq e_B}$, there is a unique sub-game perfect equilibrium in which the firm reports G and chooses B as the actual production method and the authority chooses not to carry out inspection. On the other hand, if $\mathrm{C_M - F < e_B}$, there might be two sub-game perfect equilibria. One is a pure-strategy equilibrium in which the producer reports B and chooses G as the actual production method and the authority chooses not to carry out inspection. The other is a mixed-strategy equilibrium in which the firm reports G with certainty, while it chooses probabilities of adopting both actual production methods. The authority also chooses probabilities of inspection and no inspection.

Second, we consider the cost allocation scheme in which the firm has to bear the inspection cost (i) when it reports G and chooses B as the actual production method and (ii) when the authority carries out the inspection. Like the previous allocation scheme, the authority bears the inspection cost for other situations. The change in the payoff corresponding to this change in cost allocation is indicated by bold-highlighted and red values in Figure 1. From these payoffs, we can summarize the strategies for the sub-game perfect equilibrium as follows. Suppose that the firm has to bear the inspection cost (i) when it reports G and chooses B as the actual production method and (ii) when the authority carries out the inspection. Then, there is a unique sub-game perfect equilibrium, which is a mixed-strategy equilibrium in which the firm reports G with certainty, while it chooses probabilities for both actual production methods. The authority also chooses probabilities of inspection and no inspection.

2.2 Conditional Behavior

In the real world, as pointed out by Harrington (1988), in spite that inspection and sanction probabilities are low, compliant behavior is observed and the probability of compliance seems to be relatively high. Harrington (1988) set up a repeated game and considered a scheme in which firms are categorized into two groups; that is, the group of well-behaved and ill-behaved.[7] Hereafter in this paper, the former and latter groups are referred to as GW and GI, respectively. Precisely, if a firm in GW violates the environmental regulation, it will be categorized into GI in the next period. And, if a firm in GI comply with the environmental regulation, it will be categorized into GW with a certain probability in the next period. Then, the authority sets inspection probabilities for firms of both groups and the probability that a compliant firm moves from GI to GW. Under this setting, the theory can explain the

[7] As noted in the introduction, Frieson (2003) also examined this type of scheme.

probabilities of inspections and compliance in the real world. The important point is that because the inspection probability for firms in GW is different from and lower than that for firms in GI, the inspection probability for each firm depends on the firm's behavior in the past periods. As described in the introduction, Helland (1998) empirically found that the behavior of firms (authorities) depend on the behavior of authorities (firms).

Conditional behavior is also often observed in the case of common-pool resource use. For example, using laboratory or field experimental approaches, many studies have found that there are conditional cooperators regarding the use of common pool resources and the contribution for public goods.[8] Resource users or contributors act cooperatively if their partners or community members act cooperatively. In this case, the behavior of these resource users is determined based on the behavior of other users in the past periods.

In this respect, similar situations may be observed for compliance with enforcement of environmental regulations. For example, firms may have strong incentive to comply with an environmental regulation when they do not observe inspections frequently, which may imply that firms perceive that authorities are cooperative, in past periods. In addition, authorities may have strong incentive to carry out inspections when they observe frequent violation by firms, which imply that firms are non—cooperative, in past periods.

3. Experimental Design

Each experimental session involved four steps. Subjects filled out a questionnaire on risk preference and time preference in the first and second steps, respectively. They played a compliance-inspection game in the third step, and they filled out a follow-up questionnaire about their experience and strategy in the compliance-inspection game in the fourth step. We explain the details of each step below.

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[8] For example, see Rustagi et al. (2010) for the field experimental analysis and Duffy and Lafky (2016) and Röttgers (2016) for laboratory experiments among others.

3.1 Risk Preference

The questionnaire about risk preference consisted of 10 questions.[9] Subjects selected either Choice A or Choice B for each question. For example, the meaning of each choice for Question 1 is as follows. A lottery will be drawn after subjects finish answering questions: (i) 10 cards with a number from 1 through 10 on each card are placed in a bag; then (ii) the experiment's organizer or an assistant will blindly picks one card. When a subject has chosen Choice A, if card 1, 2, 3, or 4 is picked, the subject will receive JPY 400, while if card 4, 5, 6, 7, 8, 9, or 10 is picked, the subject will receive JPY 100. On the other hand, when a subject has chosen Choice B, if card 1 is picked, the subject will receive JPY 680, while if card 2, 3, 4, 5, 6, 7, 8, 9, or 10 is picked, the subject will receive JPY 50. Prizes for Choice B differ across questions. For all questions, Choice A is less risky than Choice B. Thus, the more risk averse a subject, the greater times the subject selects Choice A.

In the sessions, subjects were told that only 1 of 10 questions would be chosen for real payments although which question is for real payments would be determined by lottery after all of the four steps are finished.

3.2 Time Preference

The questionnaire about time preference consisted of 14 questions.[10] Subjects selected either Choice A or Choice B for each question, the meaning of which is as follows. On the one hand, when a subject selects Choice A, s/he receives a certain amount of money today. On the other hand, when a subject selects Choice B, s/he receives a certain amount of money at a certain point in the future. For example, in Question 1, when a subject selects Choice A, s/he receives JPY 3,000 today, whereas, when a subject selects Choice B, s/he receives JPY 4,000 after 1

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[9] See Figure 2 for details.
[10] See Table 1 for details.

month. The amounts of money and the point in the future differ across questions.

Different from the questionnaire on risk preference, the questionnaire on time preference is hypothetical. Thus, in the sessions, subjects were told that they would not receive real money from the questionnaire on time preference.

3.3 Compliance and Inspection Game

Two subjects were randomly paired at the beginning of the game. Neither subject knew the identity of his or her partner during and after the experiment. One of the pair acted as a producer and the other as an inspector.[11] These roles were fixed throughout the compliance-inspection game. As described below, pairs were fixed for the first 20 rounds. At the beginning of the 21st round, we reshuffled pairs and randomly paired subjects for another fixed period from the 21st to 45th rounds. Hereafter, we refer to the first 20 rounds as the first phase and the last 25 rounds as the second phase.

Each round of the game consisted of three stages. In the first stage, each producer selected production method 1 or 2 and message 1 or 2 within 15 seconds. Hereafter, for differentiation between production methods and messages, let P1 and P2 denote production methods, and M1 and M2 denote messages. The message chosen was conveyed to the producer's partner (inspector), while the real production method was private information for the producer. The producer could select a different message to the real production method. For example, s/he could choose P1 and M2.

The producer did not set production amounts; sales from production were 100 regardless of production method. When the producer chose P1, s/he had to pay a certain amount of production cost.[12] However, when the producer chose P2, s/he paid no production cost. P2

[11] In the experiment, we adopted more neutral words for representing the two roles: executant and surveillant.

[12] Because the production costs differ across treatments, we explain them in Subsection 3.5.

was assumed to cause environmental damage to the society around the production point, whose monetary value was 40, while P1 caused no environmental damage.

When the producer selected P1, s/he did not need to pay any compensation. However, when the producer selected P2 and M2, s/he had to pay compensation for the damage equivalent to 40. When the producer chose P2 and M1, compensation had to be paid depending on the presence of inspection. One the one hand, when the producer's partner chose to carry out the inspection, the producer had to pay compensation. In addition, in this case, the producer had to pay a fine equivalent to 10. The existence of a fine means that there was an environmental regulation governing the production method. Adoption of production method 1 implies compliance, while adoption of production method 2 implies violation. On the other hand, when the producer's partner chose not to inspect, s/he paid neither compensation nor a fine.

In the second stage, each inspector chose whether to carry out inspection or not within 10 seconds. When the inspector made the choices, s/he was aware of the message sent from her/his partner. However, s/he did not know the real production method. Inspection is costly, the amount of which depends on treatments. When the producer pays compensation and a fine, this becomes the revenue of the inspector.

The payment of the inspection cost is important for the purpose of this study. In the first phase, regardless of the choice of production method and message by producers, the inspection cost was always borne by inspectors when they conducted inspection. However, in the second phase, when a producer chose P2 and M1, and when the inspector chose to carry out inspection, the producer had to pay the inspection cost. When a producer chose P1 or a combination of P2 and M2, the inspector had to pay the inspection cost, like in the first phase.

In the third stage, the results were shown on the screen for 15 seconds. During this stage, subjects recorded the results on a piece of paper.

The producer's payoff for the first phase (the first 20 rounds) of this game is defined as

$$\boldsymbol{Sales\ \ - Production\ \ cost -\ \ Compensation\ \ - Fine.}$$

Thus, the payoff for each case is calculated as follows. When the producer chose P1, regardless of the messages or presence of inspection, her/his payoff was

$$\boldsymbol{Sales\ \ (100) - Production\ \ Cost\ \ .}$$

When the producer chose P2 and M1 and inspection was conducted, her/his payoff was

$$\boldsymbol{Sales\ \ (100) - Compensation\ \ (40) - Fine\ \ (10) = 50}.$$

When the producer chose P2 and M1 and inspection was not conducted, her/his payoff was

$$\boldsymbol{Sales\ \ (100)}.$$

When the producer chose P2 and M2, regardless of whether inspection was conducted, her/his payoff was

$$\boldsymbol{Sales\ \ (100) - Compensation\ \ (40) = 60.}$$

The inspector's payoff for the first phase (the first 20 rounds) of this game is defined as

$$\boldsymbol{100\ \ - Inspection\ \ cost - Environmental\ \ damage +\ \ Compensation + Fine.}$$

To avoid the occurrence of negative total payoff, we introduce positive fixed revenue (the first term in the definition of the inspector above). Thus, the payoff for each case is calculated as follows. When the partner chose P1, and the inspector chose to inspect, regardless of messages, her/his payoff was

$$\boldsymbol{100\ \ - Inspection\ \ cost.}$$

When the partner chose P1, and the inspector chose not to inspect, regardless of messages, her/his payoff equaled $\boldsymbol{100.}$ When the partner chose P2 and M1, and the inspector chose to inspect, her/his payoff was

$$\boldsymbol{100\ \ - Inspection\ \ cost - Environmental\ \ damage\ \ (40) +\ \ Compensation\ \ (40) + Fine(10).}$$

When the partner chose P2 and M1, and the inspector chose not to inspect, her/his payoff was

$$\mathbf{100}\ \boldsymbol{Environmental\ \ damage}\ \ (\mathbf{40}).$$

When the partner chose P2 and M2, and the inspector chose to inspect, her/his payoff was

$$\mathbf{100}\ \ \boldsymbol{-Inspection\ \ cost - Environmental\ \ damage}\ \ (\mathbf{40}) \\ +\ \boldsymbol{Compensation}\ \ (\mathbf{40}).$$

When the partner chose P2 and M2, and the inspector chose not to inspect, her/his payoff was

$$\mathbf{100}\ \boldsymbol{Environmental\ \ damage}\ \ (\mathbf{40})\ \ +\ \ \boldsymbol{Compensation}\ \ (\mathbf{40}).$$

The payoffs in the second phase were the same as those for the first phase when a producer chose P1 or a combination of P2 and M2. However, when a producer chose P2 and M1, the payoffs of both producers and inspectors differed in the first and second phases. As the inspection cost was borne by the producer in this case, we redefine the producer's payoff as

$$\boldsymbol{Sales\ \ - Production\ \ cost -\ \ Compensation\ \ - Fine - Inspection\ \ cost.}$$

However, because the production cost for P1 is zero, the payoff of a producer for this case is rewritten as

$$\boldsymbol{Sales}\ \ -\ \ \boldsymbol{Compensation}\ \ (\mathbf{40}) - \boldsymbol{Fine}\ \ (\mathbf{10}) - \boldsymbol{Inspection\ \ cost.}$$

The payoff of an inspector for this case is rewritten as

$$\mathbf{100}\ \ - \boldsymbol{Environmental\ \ damage}\ \ (\mathbf{40})\ \ +\ \ \boldsymbol{Compensation}\ \ (\mathbf{40}) + \boldsymbol{Fine}(\mathbf{10}).$$

3.4 Follow-up Questionnaire

After the compliance-inspection game, subjects answered a follow-up questionnaire that consisted of two simple questions. The first question asked subjects about the experience of participating in laboratory experiments, and the second question asked them about their adopted strategies. The latter was not a multiple-choice question and subjects could write any answers.

3.5 Treatments

We adopt three treatments for the experiment on the compliance-inspection game.[13] As noted in Subsection 3.3, there is one common feature for all treatments: When the producer of a pair chooses P2 and M1 and when the inspector of the pair chooses to carry out inspection, the inspection cost is borne by the inspector in the first phase and by the producer in the second phase. The main purpose of this study is to investigate the effect of changing responsibility for inspection cost payment, which is captured by the difference between the two phases.

The difference between the treatments is the amount of compliance and inspection costs. The former cost is the production cost that producers have to pay when they choose P1. In the LH treatment, the compliance cost is 15 and the inspection cost is 60. In the HH treatment, the compliance cost is 30 and the inspection cost is 60. Moreover, in the LL treatment, the corresponding values are 15 and 30, respectively.

In terms of the sub-game perfect equilibrium strategies, the LH and HH treatments are similar. In the first phase, producers choose P2 and M1 and inspectors choose not to carry out inspection. In this case, the dominant strategy for inspectors is no inspection. Taking into consideration the behavior of inspectors, producers choose to violate the environmental regulation, that is, they choose environmentally unfriendly production method, P2. On the other hand, in the second phase, if the producer of a pair chooses P2 and M1, the payoff for the inspector of the pair is larger when s/he chooses to carry out inspection than not to carry out. Thus, there is no dominant strategy for inspectors in the second phase. There is a mixed strategy equilibrium. The probability of compliance is 50/110 for both the LH and HH treatments, and the probabilities of inspection are 15/110 for the LH treatment and 30/110 for the HH treatment.

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[13] We also adopted an additional treatment with uncertainty (see Section 5 for details).

In the case of the LL treatment, there are two possible equilibria. One is the equilibrium in which producers choose P1 and M2 and inspectors choose no inspection. There is also a mixed-strategy equilibrium because there is no dominant strategy for an inspector when her/his partner chooses M1. However, there is dominant strategy for an inspector, no inspection, when her/his partner chooses M2. The expected payoff of a producer when s/he chooses M1 and the payoff of a producer when s/he chooses P1 and M2 are the same. Thus, when an inspector observes M2, s/he understands that her/his partner chooses P1 as the real production method. The equilibrium situation for the LL treatment in the second phase is similar to that for the other two treatments. The probability of compliance is 50/80 and the probability of inspection is 15/80.

3.6 Sessions and Procedure

We conducted four, two, and two sessions for the HL, HH, and LL treatments, respectively. There were 10 participants in each session, implying that there were five pairs in each session. The subjects were undergraduate students of Kwansei Gakuin University. See Table 2 for the details of the sessions. Although we did not exclude students from any specific departments, the participants were mainly students of the School of Economics. Other students were from the fields of business, law, and literature, among others, although their ratios were small. Each student participated in only one session. Each subject received JPY 1,000 as a fixed participation award. The payoff from the questionnaire on risk preference and from the compliance-inspection game (the payoff of the compliance-inspection game times 0.6) were added. Thus, on average, students were paid JPY 3074.59 based on their results.[14]

At the beginning of each session, the subjects signed a consent form after listening to general instructions. Then, they answered the questionnaire on risk preference. At the

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[14] The minimum, maximum, and standard deviation were 2,600, 3,800, and 190.331, respectively.

beginning of the compliance-inspection game, subjects read the instructions for about 10 minutes. Then, before starting the game, for a more precise understanding of the instructions, an instructor read them out aloud.

In the first stage of the compliance-inspection game, producers inputted 1 or 2 for both the production method and messages. Because both producers and inspectors listened to an instructor reading the instruction aloud, we adopted different numbers for inspectors to avoid confusion: inspectors inputted 3 when choosing to carry out an inspection and 4 when they did not.

In this study, we use technical terms specific to environmental economics. However, in the experiment, the subjects were shown more neutral terminology. We conducted the experiment using the University of Zurich's A-tree program (Fischbacher, 2007).

4. Methods and Results

4.1 Basic Results

We begin with the behavior of producers. Figure 3 shows the frequencies of the combinations of the production method and message in both phases. The result of the LH treatment (Figures 3 (a) and (b)) reveals that the ratio of the combination of P1 and M1 is larger and that of P2 and M1 is smaller in the second phase than in the first phase. This fact implies that the partial shift of inspection cost payment from the inspector to the producer induces the compliance behavior of producers. Because the violation and the creation of a false report become more costly in the second phase than in the first phase, the producers are considered to respond to an increase in the cost of violation rationally.

The change in the ratios of the frequencies is clearer for the HH treatment than for the LH treatment (Figures 3 (c) and (d)). Because the compliance cost is higher in the former than in the latter treatment, the incentive to violate the environmental regulation in the first phase is stronger in the former than the latter treatment. The difference in the incentive for violation is reflected in Figures 3 (a) and (c). The shift of the inspection cost when the producer chooses P2 and M1 clearly reduces the incentive for violating the environmental regulation.

When it comes to the LL treatment, the result is unclear: that is, the ratios of the frequency of violation in both phases do not seem to be different (Figures 3 (e) and (f)). The possible reasons are as follows. First, because the compliance cost is low, the incentive for violation is relatively weak even in the first phase. Second, because the inspection cost is low, the effect of the change in the cost allocation is also relatively small.

Let us now turn to the behavior of inspectors. Figures 4 (a), (b), and (c) show the results of the ratios of carrying out inspection for the LH, HH, and LL treatments, respectively. Contrary to the behavioral change of producers, there is no difference in the ratios between the first and second phases for all of the three treatments.

The results of the behavior of both producers and inspectors reveal that their choices are different from those in the sub-game perfect equilibrium. Producers are supposed to always choose P2 and M1 in the first phase for the LH and HH treatments if they follow the strategy in the sub-game perfect equilibrium. Although the direction of the change in the choices of producers is the same, the choices in particular in the first phase are clearly different from those in the sub-game perfect equilibrium. We investigate their behavior in more detail in the next subsection.

We verify the difference of the choices between the first and second phases by conducting Welch's t-test. The results are shown in Table 3. As noted above, the partial shift of the inspection cost payment induces an increase in the choice of P1 and M1 for the LH and HH treatments, while the change is not significant for the LL treatment. Moreover, with regard to the ratio of the frequency, the behavior of inspectors is not influenced by the change in the responsibility for bearing the inspection cost.

Finally, we focus on the effect of the change in the inspection cost allocation on payoffs of both producers and inspectors. According to Table 3, the payoffs of producers are significantly smaller in the first than second phase, while those of inspectors are significantly larger in the first than in second phase. This result is natural because compliance, which is the adoption of production method 1, is costly, and an increase in the frequency of compliance leads to a decrease in environmental damage. Meanwhile, it is interesting that the difference in the total payoff is not significant between the two phases. In fact, the average total payoff increases slightly after the change in the responsibility for paying inspection costs for all three treatments. However, the effect of an increase in the compliance cost payment neutralizes the effect of a decrease in the social cost payment (environmental damage). Nevertheless, it is clear that the institutional change in the inspection cost allocation leads to the income redistribution.

4.2 Investigation of Conditional Behavior

As described in the previous subsection, the strategies of producers and inspectors are different from those in the sub-game perfect equilibrium. Thus, we next examine if their choices depend on their own choices and/or their partners in the previous periods.

First, focusing on the behavior of producers, we estimate the following equation:

$$\begin{aligned}\boldsymbol{Violation_{j,t,g}} &= \boldsymbol{c} + \boldsymbol{\beta_1} \cdot \boldsymbol{risk_j} + \boldsymbol{\beta_2} \cdot \boldsymbol{time_j} + \boldsymbol{\beta_3} \cdot \boldsymbol{half} + \boldsymbol{\beta_4} \cdot \boldsymbol{icost_{t,g}} \\ &\quad + \boldsymbol{\beta_5} \cdot \boldsymbol{ccost_{t,g}} + \boldsymbol{\beta_6} \cdot \boldsymbol{method4_{j,t,g}} + \boldsymbol{\beta_7} \cdot \boldsymbol{enforcement4_{k,t,g}} \\ &\quad + \boldsymbol{\beta_8} \cdot \boldsymbol{lagfine_{j,t,g}} + \boldsymbol{\varepsilon}\end{aligned}$$

where subscripts *j, k, t,* and *g* denote index for individual producer, individual inspector, rounds, and sessions, respectively. The dependent variable is a dummy variable that takes 1 when a producer chooses P2 and 0 when a producer chooses P1. We adopt a panel probit estimation for the analysis.

We adopt eight independent variables. $risk_j$ is the degree of risk aversion of subject *j*. As explained in Subsection 3.1, the more risk averse a subject, the more times the subject selects Choice A. Moreover, the questionnaire is designed so that each subject switch her/his answer only once from Choice A to Choice B. However, some subjects switched more than once not only from Choice A to Choice B but also from Choice B to Choice A. This time, we adopt the first switching point as representing the degree of risk averting, and this variable is the number of times Choice A is made before the first switching point. $time_j$ represents the time preference of subject j. This time, we use eight questions (Q7–Q14), and we observe no multiple switching of choices. This variable is the number of times Choice A is made; the larger this variable is, the more myopic the subject is. *half* is a dummy variable that takes 1 for the rounds in the second phase and 0 for the rounds in the first phase. The coefficient of this variable is expected to be negative because the institutional change in the inspection cost allocation when choosing P2 and M1 increase the cost of violating and making a false report for producers. $icost_{t,g}$ and $ccost_{t,g}$ are the inspection cost and compliance cost, respectively, in round *t*. The coefficient of $icost_{t,g}$ may be negative, because an increase in the inspection cost increases the cost of violation for producers in the second phase. Moreover, the coefficient of $ccost_{t,g}$ is expected to be positive, because an increase in the compliance cost increases the incentive of producers to violate the regulation. $method4_{j,t,g}$ is the average number of times that subject j chooses P2 in the past 4 periods from *t-4* through *t-1*. $enforcement4_{k,t,g}$ is the average number times that the partner of subject j chooses to carry out inspection in the past 4 periods. This variable is considered to represent the attitude of the partner toward enforcement of the environmental regulation. Thus, the coefficient of this variable is expected to be negative. $lagfine_{j,t,g}$ is a dummy variable that takes 1 if subject j was fined in the previous period and 0 if subject j was not. The coefficient of this variable may be positive or negative. On the one hand, if producers consider that their partners carry out inspection with certain probabilities, the coefficient can be positive. On the other hand, the experience of being fined may have a similar effect to the effect of $enforcement4_{j,t,g}$. In such a case, the coefficient is negative.

The results are shown in Table 4. As verified by the t-test, producers are more likely to comply with the regulation in the second than first phase. In addition, we obtain an interesting result about their responses to the behavior of their partners in past periods. The coefficient of $enforcement4_{j,t,g}$ is negative, as expected, which implies that producers revise their beliefs on the attitude of their partners toward enforcing the environmental regulation. Meanwhile, the coefficient of $lagfine_{j,t,g}$ is positive. Producers may not expect their partners to carry out the inspection when the partners did so successfully with punishment in the previous period. In summary, it is clear that producers determine their choice of production method and message based on their partners' behavior in past periods.

Second, focusing on the behavior of inspectors, we estimate the following equation:

$$\boldsymbol{Enforcement_{k,t,g} = c + \beta_1 \cdot risk_k + \beta_2 \cdot time_k + \beta_3 \cdot half + \beta_4 \cdot icost_{t,g}}$$
$$\boldsymbol{+\ \beta_5 \cdot ccost_{t,g} + \beta_6 \cdot method4_{j,t,g} + \varepsilon}$$

The dependent variable is a dummy variable that takes 1 when an inspector chooses to carry out the inspection and 0 when not. Similar to the analysis for producers, we adopt a panel probit estimation for the analysis.

The signs of the coefficients of the two independent variables are expected to be different from those for the producers' estimation equation. The coefficient of *half* is considered positive because the change in the responsibility for paying the inspection cost reduces the inspectors' expected inspection cost. The coefficient of $method4_{j,t,g}$ is expected to be positive if inspectors revise their belief according to the behavior of their partners in the past periods. The larger is this variable, the more likely it is that their partners violate the environmental regulation. Therefore, inspectors are likely to choose to carry out inspection more frequently.

The results are shown in Table 5. $icost_{t,g}$ and $method4_{j,t,g}$ influence the decision making of inspectors to carry out the inspection significantly. The signs of these two variables are the same as expected. The important point is that inspectors as well as producers respond to the behavior of their partners' behavior in the past periods.

5. Uncertainty on Environmental Damage

As mentioned in the introduction, there are several difficulties for authorities to carry out inspections perfectly regarding environmental regulations. We have so far focused on the incentive of authorities, because they are often reluctant to carry out costly inspections. In this section, we introduce one additional difficulty, which is uncertainty. In particular, we consider uncertainty about verification of the source of pollution by assuming there is a possibility of occurrence of environmental damage with not only environmental unfriendly but also environmentally friendly production method. When an authority observes environmental degradation, it cannot verify whether the degradation is caused by a producer that adopt environmentally friendly or unfriendly production method unless it carries out the inspection.

The basic design of the treatment with uncertainty, which we hereafter refer to as the ULH treatment, is the same as those in the other treatments. The compliance and inspection costs are the same as the LH treatment: the former cost is 15, and the latter cost is 60. Uncertainty is introduced as follows. On the one hand, when a producer chooses P1, the probability of the occurrence of environmental damage is 0.2. On the other hand, when a producer chooses P2, the probability of the occurrence of environmental damage is 0.8. If an inspector carries out the inspection, s/he can verify the actual production method with certainty. However, if an inspector does not carry out the inspection, s/he cannot verify the actual production method with certainty. Even in the result showing screen, they can know only the occurrence of environmental damage.

The compensation and fine schemes are as follows. On the one hand, when an inspector carries out the inspection, a producer has to make compensation based on its actual production method and the occurrence of environmental damage. If the producer chooses P2 and environmental damage arises, it has to make compensation. In addition, regardless of the occurrence of environmental damage, if a producer chooses P2 and M1 and if an inspector carries out the inspection, the producer is fined. On the other hand, when an inspector does not carry out the inspection, a producer has to make compensation based on its report and the occurrence of environmental damage. Regardless of the actual production method, if the producer chooses M2 and if environmental damage is observed, the producer has to make compensation.

Similar to the LH and HH treatments, there is a unique sub-game perfect equilibrium in the first phase: a producer chooses P2 and M1, and an inspector chooses not to carry out the inspection. Moreover, there is a unique sub-game perfect equilibrium in the second phase: both a producer and an inspector adopt mixed strategies.

The choices of both producers and inspectors in the two phases are shown in Figure 5, and the result of the Welch's t-test are shown in Table 6. Similar to the case in the absence of uncertainty, the behavior of producers changes from the first to the second phase. The partial shift of inspection cost payment reduces the incentive of producers to adopt environmentally unfriendly production method. However, although the frequencies in both phases differ significantly, the graph indicates that relatively large number of producers stick to the combination of P2 and M1 even in the second phase. Uncertainty is considered to give rise to this situation in the second phase. The possible reason is as follows. As explained below, the frequency of inspection is lower in the ULH than in the other treatments. Observing this situation, producers have incentive to increase their payoff by making a false report.

When we observe the behavior of inspectors, there are two clear differences between the choices in the absence and presence of uncertainty (see also Figure 4). First, the frequencies of inspections in both phases are likely to be lower in the presence than in the absence of uncertainty. There are two possible reasons: one is that the probability of the occurrence of environmental damage is lower in the ULH than the other three treatments when producers adopt the environmentally unfriendly production method (P2). Thus, an authority may carry out inspections less frequently with than without uncertainty. The other is that even when producers choose P2 and are inspected, they may not have to make compensation because environmental damage may not be generated. Thus, authorities may perceive that inspections are not effective very much when uncertainty is present in terms of revenue gains. Second, the frequency of inspection increases after the change in the responsibility for the inspection cost payment from inspectors to producers. The result of t-test also indicates this change in inspectors' behavior.

The changes in the payoffs are also interesting. Similar to the case in the absence of uncertainty, the payoffs of producers decrease form the first to the second phase on average. This change takes place because of an increase in the payment of the compliance cost. However, the payoffs of inspectors do not increase by the scheme change when uncertainty is present. Although the frequency of compliance by producers increases, the inspection cost payment increases. The former is a positive effect, and the latter is a negative effect in terms of the objective of inspectors. Both effects are considered to cancel out each other. Consequently, the total payoff decreases by the change in the responsibility for the inspection cost payment.

6. Conclusion

Using a laboratory experimental approach, this study examined the effect of institutional change of the way of payment of inspection costs on the behavior of polluters and authorities.

We found that regardless of the existence of uncertainty, the way of bearing the inspection cost influences the behavior of polluters. However, the degree of the influence may be smaller in the presence than in the absence of uncertainty. Contrary to the behavior of producers, the behavior of inspectors does not change significantly when uncertainty is absent, while the frequency of inspections is smaller when uncertainty is present than when it is absent.

The way of inspection cost payment also influences the payoffs of producers and inspectors and, accordingly, the total payoff. In terms of violation deterrence, it is clear that the partial shift of inspection cost payment works effectively because compliance behavior is induced. However, it does not necessarily mean welfare increase. This result implies that even if a certain institutional change works effectively for one objective, it may not be desirable in terms of other objectives. We added an additional evidence that the authority and the society should take into consideration their objectives when designing environmental regulations and punishment schemes.

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Table 1. Choice List on Time Preference

	<u>**Choice A**</u>	<u>**Choice B**</u>
Q1	JPY 3,000 today	JPY 4,000 one month later
Q2	JPY 3,000 today	JPY 5,000 one month later
Q3	JPY 3,000 today	JPY 6,000 one month later
Q4	JPY 3,000 today	JPY 4,000 seven month later
Q5	JPY 3,000 today	JPY 5,000 seven month later
Q6	JPY 3,000 today	JPY 6,000 seven month later
Q7	JPY 4,000 today	JPY 4,000 two weeks later
Q8	JPY 4,000 today	JPY 4,040 two weeks later
Q9	JPY 4,000 today	JPY 4,080 two weeks later
Q10	JPY 4,000 today	JPY 4,200 two weeks later
Q11	JPY 4,000 today	JPY 4,400 two weeks later
Q12	JPY 4,000 today	JPY 5,600 two weeks later
Q13	JPY 4,000 today	JPY 6,800 two weeks later
Q14	JPY 4,000 today	JPY 8,000 two weeks later

Table 2. Session List

Session ID	Date	Treatment	Number of Subjects
1	Dec 19, 2018	LH	10
2	Dec 19, 2018	LH	10
3	Dec 20, 2018	LH	10
4	Dec 20, 2018	HH	10
5	Dec 20, 2018	HH	10
6	Dec 21, 2018	LL	10
7	Dec 21, 2018	LL	10
8	Dec 21, 2018	LH	10
9	Jan 9, 2019	ULH	8
10	Jan 9, 2019	ULH	10
11	Jan 9, 2019	ULH	8

Table 3. The result of T-test

Treatment	Variable	T-Value (One-sided)
Ucost60_Ccost15	Compliance	3.469***
	Inspection	0.659
	Payoff Producer	-3.983***
	Payoff Authority	4.880***
	Payoff Total	0.814
Ucost60_Ccost30	Compliance	6.690***
	Inspection	-0.137
	Payoff Producer	-3.370***
	Payoff Authority	4.192***
	Payoff Total	1.269
Ucost30_Ccost15	Compliance	0.503
	Inspection	-0.338
	Payoff Producer	-1.700**
	Payoff Authority	2.650***
	Payoff Total	0.581

Notes: Positive t-value for compliance/inspection means that frequency is larger in the second term (R21-45) than the first term (R1-20). Positive t-value for payoffs means that the average is larger in the second term (R21-45) than in the first term (R1-20).

*Significant at 10% level, **Significant at 5 %, ***Significant at 1% level.

Table 4. Estimation Result for Producers

Dependent Variable	Method 2 (Violation)	Method 2 (Violation)	Method 2 (Violation)
risk	-0.021	-0.025	-0.025
	(0.030)	(0.030)	(0.030)
time	-0.023	-0.022	-0.023
	(0.037)	(0.037)	(0.038)
half	-0.378***	-0.410***	-0.412***
	(0.062)	(0.073)	(0.073)
i-cost	0.002	-0.004	-0.004
	(0.005)	(0.005)	(0.005)
c-cost	0.002	-0.002	-0.001
	(0.011)	(0.011)	(0.011)
method4		0.354**	0.209
		(0.149)	(0.158)
enforcement4		-0.714***	-0.817***
		(0.140)	(0.145)
lagfine			0.311***
			(0.110)
cons	0.026	0.142	0.327
	(0.381)	(0.458)	(0.468)
Observations	1800	1480	1480
ρ	0.112	0.105	0.110
Log Likelihood	-1150.195	-928.229	-924.229
LR chi2	38.23	79.50	87.50
Chibar2	60.43	25.78	27.18

Note: *Significant at 10% level, **Significant at 5 %, ***Significant at 1% level.
Values in parentheses are standard errors.

Table 5. Estimation Result for Inspectors

Dependent Variable	Enforcement	Enforcement
risk	-0.003	-0.010
	(0.018)	(0.019)
time	-0.010	-0.019
	(0.022)	(0.023)
half	0.012	0.091
	(0.063)	(0.073)
i-cost	-0.018***	-0.019***
	(0.004)	(0.003)
c-cost	0.009	0.006
	(0.007)	(0.007)
method4		0.839***
		(0.130)
cons	0.322	-0.701**
	(0.248)	(0.307)
Observations	1800	1480
ρ	0.039	0.026
Log Likelihood	-1099.327	-889.553
LR chi2	18.25	56.87
Chibar2	10.43	3.51

Note: *Significant at 10% level, **Significant at 5 %, ***Significant at 1% level.

Values in parentheses are standard errors.

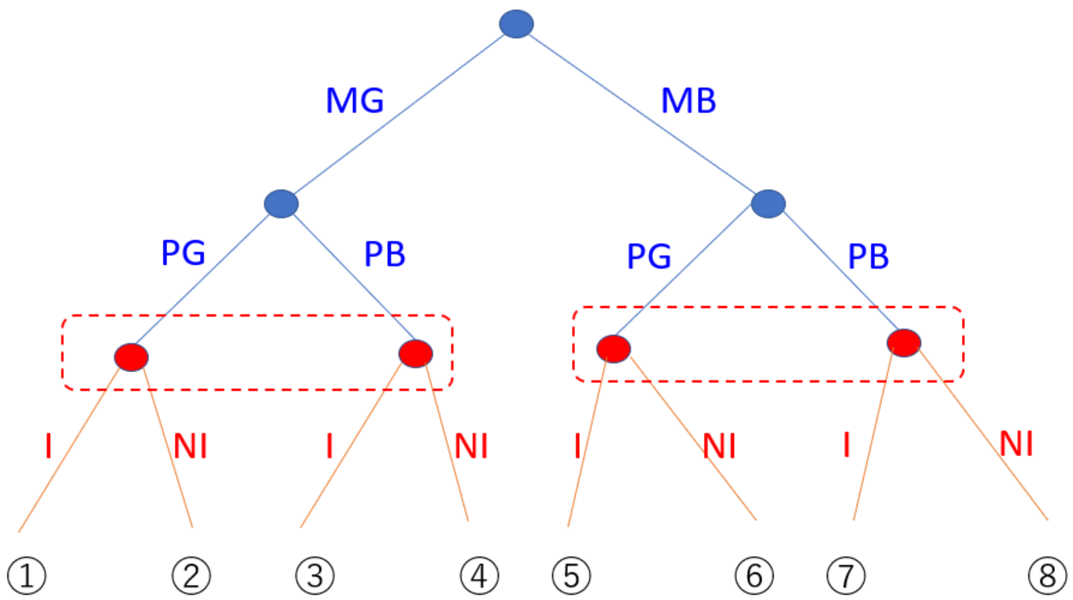
Table 6. The result of t-test (Uncertainty)

Treatment	Variable	T-Value (One-sided)
Uncertain (U60_C15)	Compliance	1.934**
	Inspection	2.183**
	Payoff Producer	-4.827***
	Payoff Authority	-0.051
	Payoff Total	-4.043***

Notes: Positive t-value for compliance/inspection means that frequency is larger in the second term (R21-45) than the first term (R1-20). Positive t-value for payoffs means that the average is larger in the second term (R21-45) than in the first term (R1-20).

*Significant at 10% level, **Significant at 5 %, ***Significant at 1% level.

Figure 1. Game Tree and Payoffs



MG: Report of method G (environmentally friendly method).
MB: Report of method B (environmentally unfriendly method).
PG: Choice of G as the actual production method.
PB: Choice of B as the actual production method.
I: Choice of inspection.
NI: Choice of no inspection.

	Polluter's Payoff	Authority's Payoff
①	R $- \; c_G,$	$- \; C_M$
②	R $- \; c_G$	0
③	**R** $\boldsymbol{- \; c_B - e_B - F}$ (**R** $\boldsymbol{- \; c_B - e_B - F - C_M}$)	$\boldsymbol{F - \; C_M}$ ($\boldsymbol{F}$)
④	R $- \; c_B$	$-e_B$
⑤	R $- \; c_G$	$- \; C_M$
⑥	R $- \; c_G$	0
⑦	R $- \; c_B - \; e_B$	$- \; C_M$
⑧	R $- \; c_B - e_B$	0

* The payoffs written in bold-faced type and black are those only for the case in which the authority always bears the inspection cost. The payoffs written in bold-faced type and red are those only for the case in which the polluter bears the inspection cost under a certain condition.

Figure 2 The List of Questions for Risk Preference

	Choice A		Choice B	
	Card	Prize	Card	Prize
1	①、②、③	JPY 400	①	JPY 680
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
2	①、②、③	JPY 400	①	JPY 750
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
3	①、②、③	JPY 400	①	JPY 830
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
4	①、②、③	JPY 400	①	JPY 930
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
5	①、②、③	JPY 400	①	JPY 1060
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
6	①、②、③	JPY 400	①	JPY 1250
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
7	①、②、③	JPY 400	①	JPY 1500
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
8	①、②、③	JPY 400	①	JPY 1850
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
9	①、②、③	JPY 400	①	JPY 2200
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

	Choice A		Choice B	
	Card	Prize	Card	Prize
10	①、②、③	JPY 400	①	JPY 3000
	④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 100	②、③、④、⑤、⑥、⑦、⑧、⑨、⑩	JPY 50

Figure 3. Choices of Producers (Frequencies)

Figure 4(a). LH, Phase 1

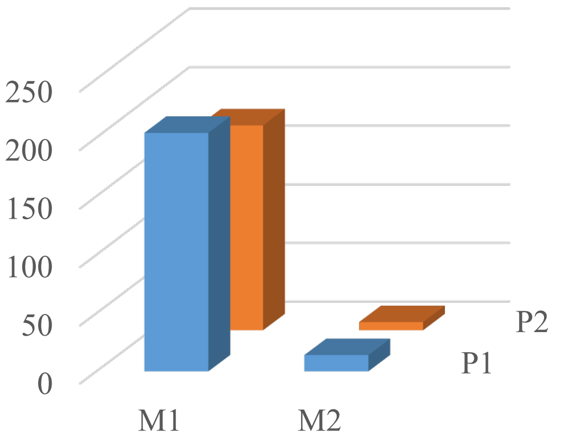


Figure 4(b). LH, Phase 2

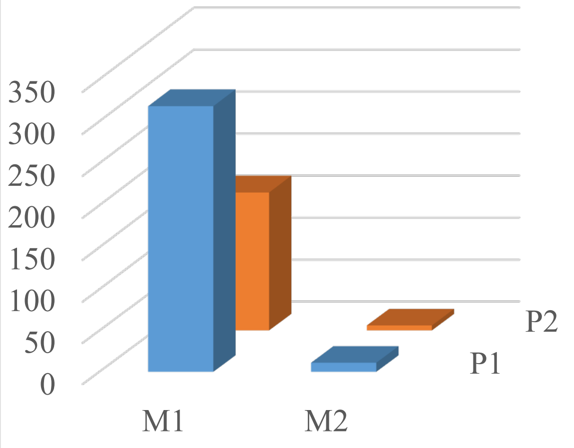


Figure 4(c) HH, Phase 1

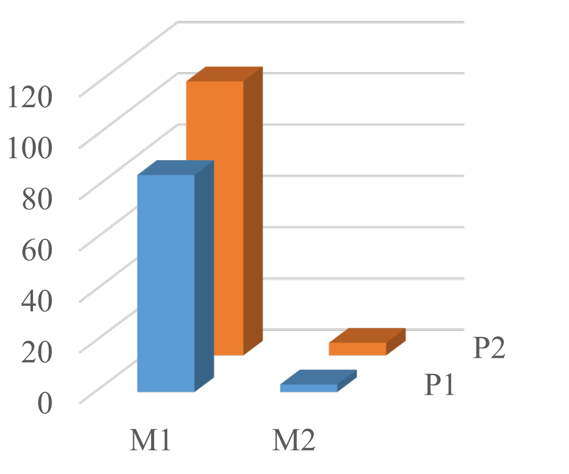


Figure 4(d). HH, Phase 2

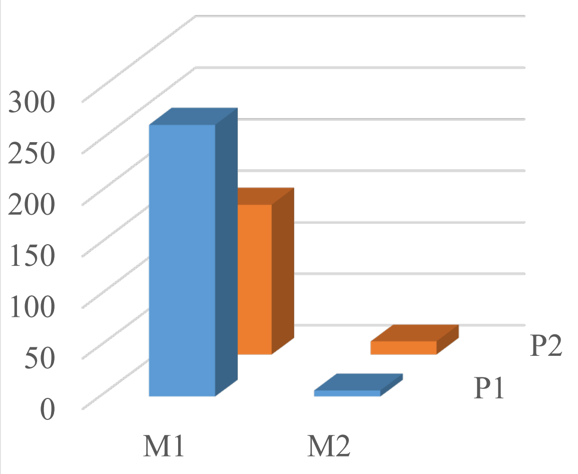


Figure 4(e). LL, Phase 1

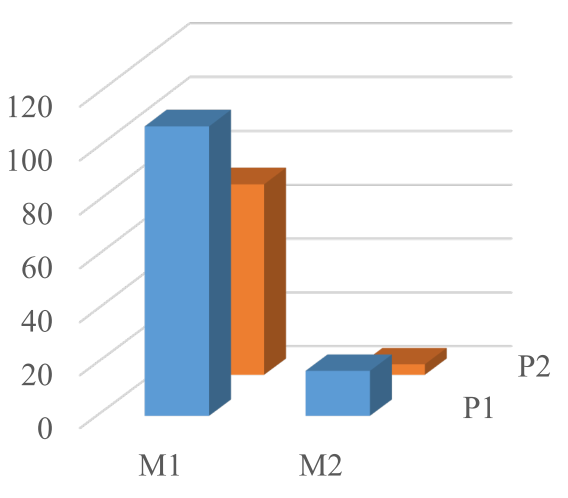


Figure 4(f). LL, Phase 2

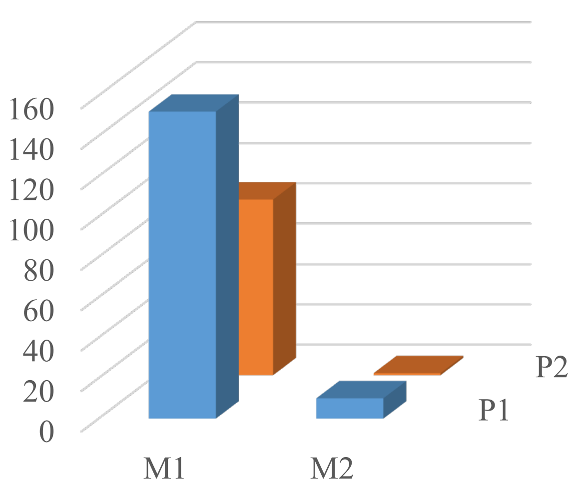


Figure 4. Choices of Inspectors (Ratios)

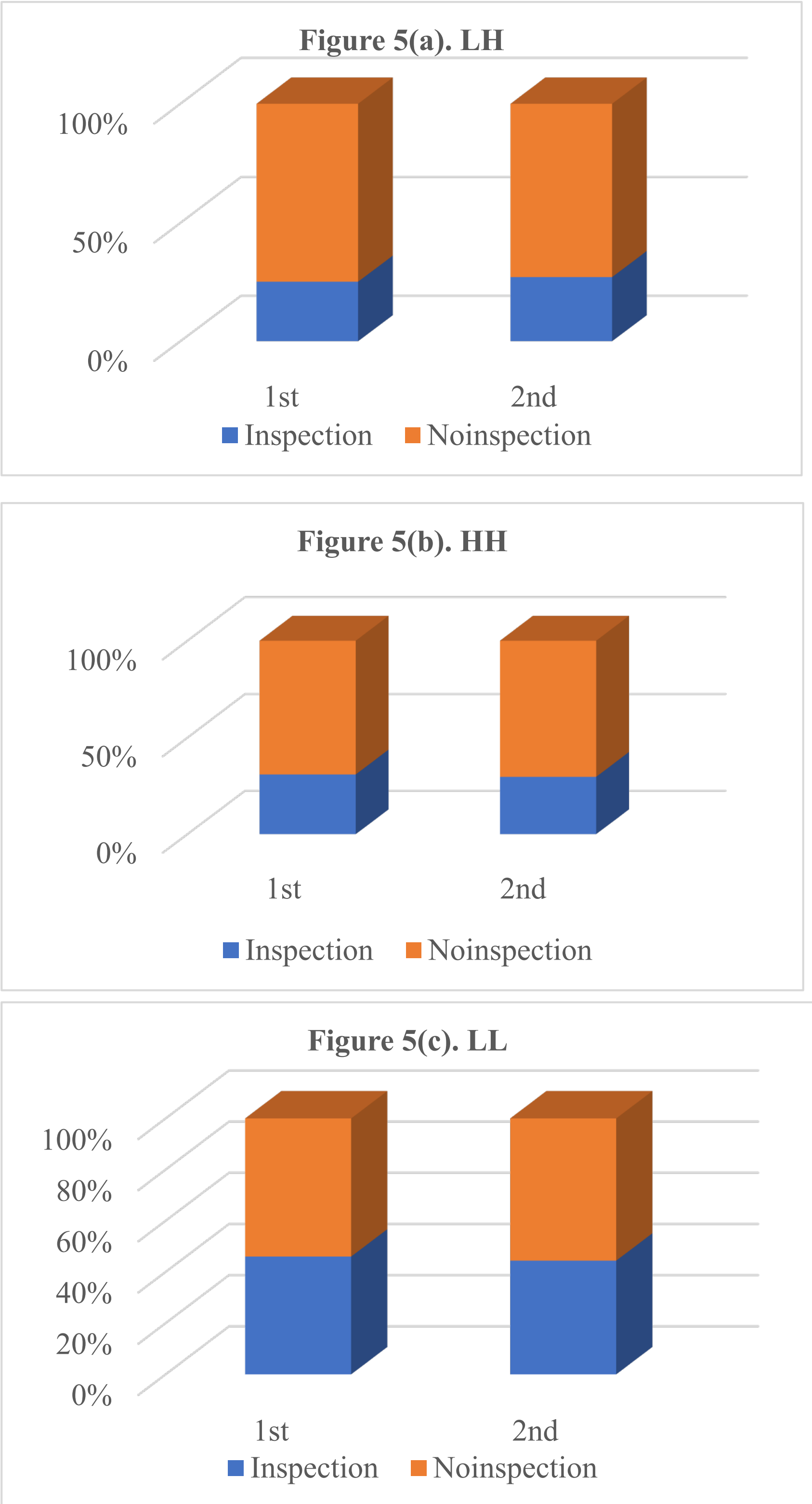


Figure 5. Choices of Producers and Inspectors in ULH Treatment

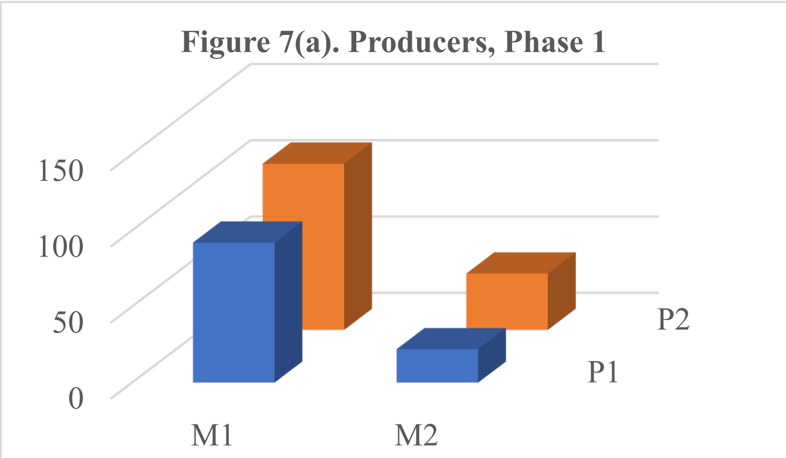


Figure 7(a). Producers, Phase 1

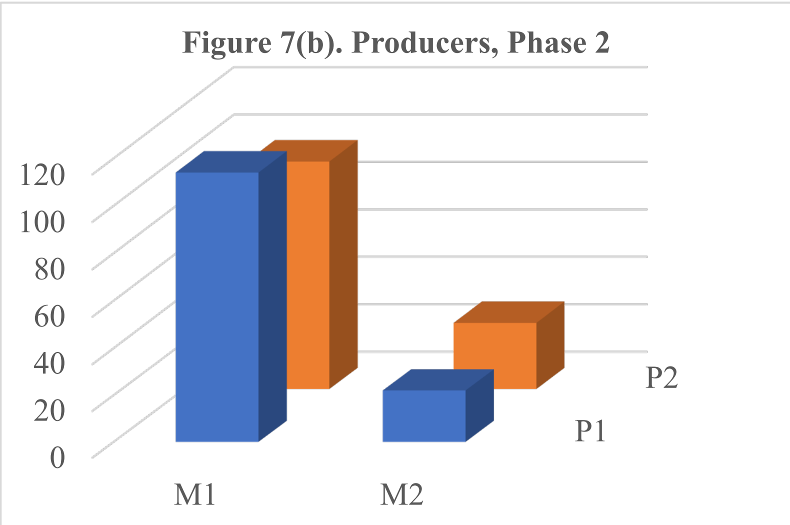


Figure 7(b). Producers, Phase 2

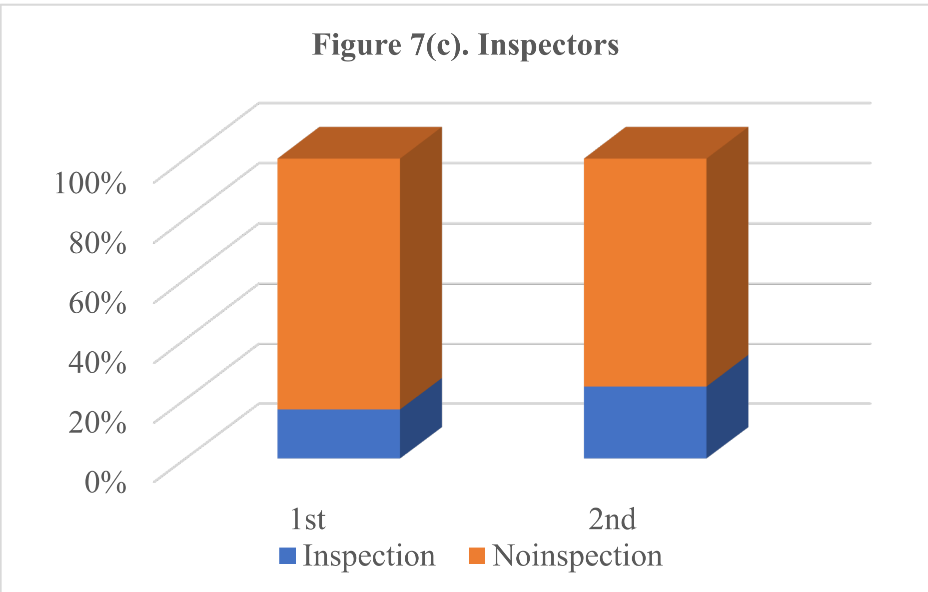


Figure 7(c). Inspectors