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A study of the Cognitive Structure of Conflict over Disaster Mitigation Projects

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ABSTRACT

Projects for disaster mitigation such as reservoirs often change the natural and social environments of a region. If people have different opinions on such changes, these projects may cause conflicts. Participatory disaster mitigation requires a mechanism for managing such conflicts. To promote stakeholders involved in a conflict to a compromise, it is necessary to understand the structure of the conflict. This study focuses on the relationship between people's recognition about a conflict and final outcome of the conflict. First, a model involving players' game-making process is constructed, and it is shown that opinion-summarizing rules can affect the outcome of a conflict. Second, a survey of people's cognitive structure of a conflict was made, and the results show the possibility of polarization between people's recognition and game theoretic model.

1. INTRODUCTION

Projects for disaster mitigation, such as reservoirs, often change the natural and social environments of a region. When people have different opinions on such changes, projects may cause conflict. Participatory disaster mitigation requires a mechanism for managing such conflicts.

To get stakeholders involved in a conflict to compromise, it is necessary to understand the structure of that conflict. Game theory is often used for to analyze conflict. The non-cooperative game model consists of players (stakeholders involved in a conflict), strategies (actions which a player can take), and payoffs (players' numerical evaluations of the outcomes of conflict). In game theory, it is assumed that combination of players' strategies and an outcome have one-to-one correspondence. In an actual conflict, however, stakeholders may perceive the same conflict differently. Additionally, people's cognitive structures may differ from the standard game theoretic model, and inappropriate recognition may lead to an inefficient outcome. Conflict management needs to incorporate a process for sharing knowledge about a conflict.

This study focuses on the relationship between people's recognition of a conflict and the final outcome of that conflict. The study consists of two parts, model analysis and survey analysis. In the first part (Section **3**), a model involving players' game-making process is constructed. It shows that opinion summarizing rules can affect the outcome of a conflict. In the second part (Section **4**), a survey of people's cognitive structures of a conflict is made. Results show the possibility of polarization between people's recognition and game theoretic model.

2. GAME THEORY BASED CONFLICT MODELING

2.1 Non-Cooperative Strategic Form Game

Game theory is often used for modeling an interactive decision-making situation. Game theory is classified into cooperative and non-cooperative game, depending on whether a binding agreement exists. The non-cooperative strategic form game is defined hereafter.

Definition 2.1 (Myerson, 1991)

A strategic-form game is any Γ of the form

$$\Gamma = (N, (\Theta_i)_{i\in N}, (P_i)_{i\in N}) \tag{2.1}$$

Where N is a nonempty set and, for each i in N, Θ_i is a nonempty set and P_i a function from $\prod_{j\in N}\Theta_j$ into the set of real numbers $\mathbf{R}$.

N is a set of players who correspond to stakeholders in a conflict. Each player in N has the set of strategies Θ_i. $\Theta = \prod_{j\in N}\Theta_j$ is the set of strategy profile. For any strategy profile θ, the number $P_i(\theta)$ represents the payoff that player i can obtain if strategy profile c is realized.

Strategy profile θ^* is the Nash equilibrium if the following inequality is satisfied;

$$P_i(\theta^*) \geq P_i(\theta_i, \theta^*_{-i}), \forall i \in N, \forall \theta_i \in \Theta_i \tag{2.2}$$

$(\theta_i, \theta^*_{-i})$ is the strategy profile by which player i chooses strategy θ_i and the other players choose the same strategies with θ^*. The equilibrium of a game is usually interpreted as the outcome of a conflict.

KEY WORDS: Disaster Mitigation, Participatory Planning, Conflicts, Experimental Game

2.2 Players' Recognition on the Structure of a Game

As stated in **1**, the stakeholders in a conflict about disaster mitigation often have different recognition on the conflict. Examples of non-cooperative game models that describe behaviors of players who do not share the knowledge about the structure of a conflict are, incomplete information game of Harsanyi (1967, 1968) and learning model (ex. Fudenberg and Levine, 1998 and Young, 1998). In the incomplete information game, the probability distributions of elements of the game are common knowledge of the players. In contrast, in the learning model, expectations of other players' behavior are formed by repetitive plays of the same game. i.e., the learning model assumes that trial and error is permitted in the model. Additionally, as Oechssler and Schipper (2003) mentioned, players in the learning model learn about "How should we play?," but not about the structure of the game.

Whereas Bayesian equilibrium in the incomplete information game is determined by the objective probability distributions of the elements of the game, for subjective equilibrium by Kalai and Lehrer (1995), players own subjective expectations on probability distributions of elements of a game, and decisions are made based on those expectations. If subjective and objective expectations accidentally are consistent, then subjective and objective equilibrium also are consistent. Even if expectations are not same, subjective and objective equilibrium can exist simultaneously without correct recognition of the structure of the game. From the viewpoint of experimental game, Oechssler and Schipper (2003) showed that players may not recognize the structure of a game even after repetitive play. They also showed that the player with wrong recognition may be able to behave the way as the player with correct recognition.

In conflicts on disaster mitigation, the structure of conflict varies depending on each case, and it is difficult to form expectation by repetitive play. In each conflict, players need to form game structure and share the recognition about it. In the following sections, the interactive decision making situations in which players do not share the knowledge on the structure of a conflict are analyzed. In section **3**, a model incorporating players' opinion summarizing process is described. When players need to reflect their supporters' preferences for their behaviors, they summarize the supporters' opinions in order to construct a game. In that case, differences of opinion-summarizing rules can affect the outcome of a conflict. Section **4** reports a survey of people's recognition of a conflict. The survey focuses on correspondence between the strategy profile and the outcome of conflict.

3. DECISION MODEL INVOLVING OPINION SUMMARIZING PROCESS

3.1 Modeling Agent Game

A model that describes a game in which players behave as the agents of supporters is shown. The relationship between players and supporters is diagrammed in **Fig. 3.1**. Supporters 1 and 2 have their own preferences for the outcomes of a conflict. The players as agents behave according to priority orders, which reflect supporters' preference orders indirectly. Supporter i's evaluation of outcome j is represented by the payoff p^i_j. Supporter i's payoff profile is;

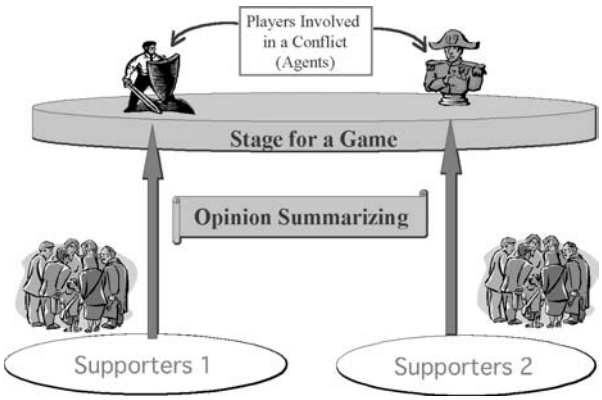

Fig. 3.1 Relationship between Players as Agents and Supporters

$$P^i = (p^i_1, p^i_2, ..., p^i_u) \tag{3.1}$$

The player summarizes supporter's opinions and derives a priority order. Player i's priority for outcome j is represented by π^i_j. Since π^i_j is determined by payoff profile p^i and outcome j, we can define the following function ϕ^i.

$$\pi^i_j = \phi^i(P^i, j) \tag{3.2}$$

Hereafter, ϕ^i is called the "opinion summarizing rule."

Players take actions to obtain the outcome that has the maximum π^i_j. Even if supporters' preferences are the same, π^i_j may differ, depending on the opinion summarizing rule.

3.2 Modeling a Conflict

In this section, the Graph Model for Conflict Resolution (GMCR) by Fang, *et al*. (1993) is employed to describe a conflict. Let $N = \{1,2,\ldots,n\}$ be the set of players and $K = \{k_1,k_2,\ldots,k_u\}$ the set of states of the conflict. In this paper, only two player conflicts ($N = \{1,2\}$) are discussed. Two-tuple $\{D_i\}(i=1,2)$ is defined as the set of directed graphs such that $D_i = (K,V_i)$. The set of arcs, V_i, denotes player i's possible move between states. Let $k_l k_m$ be the arc from state k_l to state k_m. $k_l k_m \in V_i$ implies that player i can move from state k_l to state k_m, unilaterally.

To formulate a conflict by the GMCR, payoff functions are also necessary to be defined. Payoff function P_i specifies the player i's preference order. If $P_i(k_l) > P_i(k_m)$, then player i prefers state k_l to state k_m. In the general definition of GMCR, the states can be preferred equally. However, in this paper, it is assumed that each pair of states is ordered strictly (i.e., there are no equally preferred states.)

The GMCR for a 2-player conflict is represented by 4-tuple $\{N,K,V,P\}$, in which

$N = \{1,2\}$, $K = \{k_1,k_2,\ldots,k_u\}$, $V = \{V_1,V_2\}$ and $P = \{P_i \mid i \in N\}$.

Here are other definitions used in GMCR.

a) State k's reachable list: $S_i(k)$ $(k \in K)$

$$kk' \in V_i \Leftrightarrow k' \in S_i(k) \tag{3.3}$$

b) State k's unilateral improvement (UI): $S^+_i(k)$

$$k' \in S_i(k) \text{ and } P_i(k') > P_i(k) \Leftrightarrow k' \in S^+_i(k) \tag{3.4}$$

By means of the GMCR, the conflict over reservoir project is

modeled. Player 1 is called the opposition group, player 2 the government. For simplicity, possible outcomes are limited to following the four states ($K=\{k_1,k_2,k_3,k_4\}$).

State 1 (k_1): Opposition escalates and the project is modified.

State 2 (k_2): Opposition escalates and the project is carried out as planned.

State 3 (k_3): The opposition group communicates with the government and the project is modified.

State 4 (k_4): The opposition group communicates with the government and the project is carried out as it planned.

Possible players' actions are "taking aggressive behavior" and "accepting dialogue with the government" for player 1, and "modifying the project" and "carrying out the project as planned" for player 2. The set of possible actions for player i is defined as A_i. The state where player 1 chooses $a_l^1 \in A_1$ and player 2 chooses $a_m^2 \in A_2$ is represented by $k(a_l^1, a_m^2)$. Players can change the state by varying their actions. Player 1 can change the state between k_1 and k_3 and between k_2 and k_4, whereas, player 2 can change the state between k_1 and k_2 and between k_3 and k_4. **Fig. 3.2** shows players' possible transitions.

In this study, the above four states are interpreted as the phases of the conflict, and the set of player's reactions in each state is defined as "stationary strategy." Player i's stationary strategy θ_i is formulated as follows.

$$\theta_i : k \to k', k' \in [S_i(k) \cup \{k\}] \tag{3.5}$$

Under stationary strategy, player's reaction at each state is determined in advance.

The set of player i's stationary strategies is defined as Θ_i. **Fig. 3.3** and **Fig. 3.4** show the feasible stationary strategies of players 1 and 2. The combination of players' stationary strategies, the strategy profile, is represented by θ.

The outcome of conflict under strategy profile θ is defined as follows.

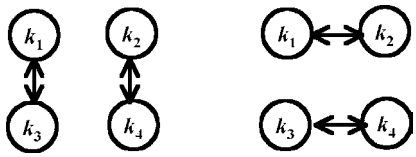

Fig. 3.2 D_1 (Left) and D_2 (Right)

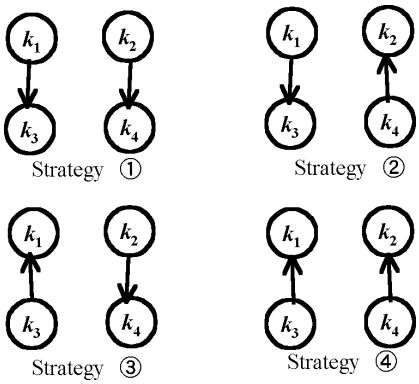

Fig. 3.3 Player 1's Stationary Strategies

Definition 3.1

Under strategy profile θ, state k that satisfies the following equation is called the outcome of conflict under θ and is represented by $O(\theta)$;

$$\theta_i(k) = k \quad \forall i \in N \tag{3.6}$$

Since each player has four stationary strategies (**Figs. 3.3** and **3.4**), the modeled conflict can be formulated as a strategic-form game with 16 strategy profiles. **Table 3.1** shows the relationships between the stationary strategies and outcomes. In the strategy profiles represented by "-", the outcome defined by (3.6) does not exist.

Players choose a stationary strategy that maximizes its own payoffs. Nash equilibrium can be formulated as it defined in ordinary strategic form game.

Definition 3.2

Strategy profile θ^* is Nash equilibrium if and only if the following relationship is satisfied for each player;

$$P_i(O(\theta^*)) \geq P_i(O(\theta_i, \theta_{-i}^*)) \quad \forall \theta_i \in \Theta_i \tag{3.7}$$

3.3 Opinion Summarizing Rules

In this paper, two types of opinion summarizing rules are supposed.

(a) Outcome-Based Opinion Summarizing

$$\phi^i(P^i, j) = p_j^i \tag{3.8}$$

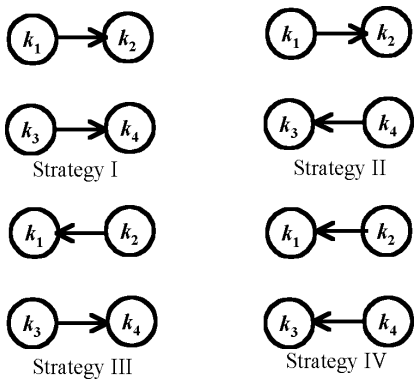

Fig. 3.4 Player 2's Stationary Strategies

Table 3.1 Relationship between Stationary Strategies and Outcomes

		Player 2			
		I	II	III	IV
Player 1	①	4	3	4	3
	②	2	2,3	—	3
	③	4	—	1,4	1
	④	2	2	1	1

(b) Action-Based Opinion Summarizing

Under the outcome-based opinion-summarizing rule, players ask supporters to reveal the payoff for each outcome (i.e., players say "Please let me know your payoffs for outcomes."). As a result, $\pi^i_j = p^i_j$ is satisfied for each player i and outcome j.

In contrast, players under the action-based opinion-summarizing rule ask supporters to reveal differences in the desirability of each action (Players ask supporters, "Which action do you prefer?"). Supporter i's difference of desirability for player l's actions 1 and 2 is defined as σ^i_l. When $\sigma^i_l > 0$, supporter i hopes that player l will choose action 1 rather than action 2. Player i determines behavior based on the revealed (σ^i_1, σ^i_2).

The Opinion-summarizing rule must satisfy the following conditions.

(1) Consistency with supporter's preference

$$P^i_1 > P^i_3 \text{ and } P^i_2 > P^i_4 \Rightarrow \sigma^i_1 > 0 \tag{3.9}$$

$$P^i_1 < P^i_3 \text{ and } P^i_2 < P^i_4 \Rightarrow \sigma^i_1 < 0 \tag{3.10}$$

$$P^i_1 > P^i_2 \text{ and } P^i_3 > P^i_4 \Rightarrow \sigma^i_2 > 0 \tag{3.11}$$

$$P^i_1 < P^i_2 \text{ and } P^i_3 < P^i_4 \Rightarrow \sigma^i_2 < 0 \tag{3.12}$$

(2) Consistency with revealed information

$$\sigma^i_1 > 0 \Rightarrow \pi^i_1 > \pi^i_3 \text{ and } \pi^i_2 > \pi^i_4 \tag{3.13}$$

$$\sigma^i_1 < 0 \Rightarrow \pi^i_1 < \pi^i_3 \text{ and } \pi^i_2 < \pi^i_4 \tag{3.14}$$

$$\sigma^i_2 > 0 \Rightarrow \pi^i_1 > \pi^i_2 \text{ and } \pi^i_3 > \pi^i_4 \tag{3.15}$$

$$\sigma^i_2 < 0 \Rightarrow \pi^i_1 < \pi^i_2 \text{ and } \pi^i_3 < \pi^i_4 \tag{3.16}$$

Consistency with supporter's preference means that if the supporter prefers outcomes lead from one player's action dominantly, supporter reveals that the action is more desirable. Consistency with revealed information means that player gives priority to the action which is desirable for the player's supporter. From conditions (1) and (2), the following property can be derived.

Priority of the supporter's dominant action

$$P^i_1 > P^i_3 \text{ and } P^i_2 > P^i_4 \Rightarrow \pi^i_1 > \pi^i_3 \text{ and } \pi^i_2 > \pi^i_4 \tag{3.17}$$

$$P^i_1 < P^i_3 \text{ and } P^i_2 < P^i_4 \Rightarrow \pi^i_1 < \pi^i_3 \text{ and } \pi^i_2 < \pi^i_4 \tag{3.18}$$

$$P^i_1 > P^i_2 \text{ and } P^i_3 > P^i_4 \Rightarrow \pi^i_1 > \pi^i_2 \text{ and } \pi^i_3 > \pi^i_4 \tag{3.19}$$

$$P^i_1 < P^i_2 \text{ and } P^i_3 < P^i_4 \Rightarrow \pi^i_1 < \pi^i_2 \text{ and } \pi^i_3 < \pi^i_4 \tag{3.20}$$

Obviously, outcome-based opinion-summarizing rule satisfies the priority of the supporter's dominant action. Note that equations (3.17) – (3.20) are not necessary and sufficient conditions. The action is dominant in player's priority, the action is not necessarily dominant in supporter's preference order.

In the following part, action-based opinion-summarizing rule that satisfies the priority of supporter's dominant action is formulated. Supporter is assumed to determine σ^k_l according to the following equations.

$$\sigma^1_1 = (P^1_1 - P^1_3)\beta + (P^1_2 - P^1_4)(1-\beta) \tag{3.21}$$

$$\sigma^1_2 = (P^1_1 - P^1_2)\alpha + (P^1_3 - P^1_4)(1-\alpha) \tag{3.22}$$

$$\sigma^2_1 = (P^2_1 - P^2_3)\beta + (P^2_2 - P^2_4)(1-\beta) \tag{3.23}$$

$$\sigma^2_2 = (P^2_1 - P^2_2)\alpha + (P^2_3 - P^2_4)(1-\alpha) \tag{3.24}$$

Here, $0 \le \alpha \le 1$ and $0 \le \beta \le 1$. $\alpha(1-\alpha)$ and $\beta(1-\beta)$ respectively are interpreted as subjective probabilities for player 1's strategies and player 2's strategies. A player determines the priority π^i_j, based on the revealed σ^i_l by the following equations.

$$\pi^i_1 = \sigma^i_1 + \sigma^i_2,\ \pi^i_2 = \sigma^i_1 - \sigma^i_2,\ \pi^i_3 = -\sigma^i_1 + \sigma^i_2,\ \pi^i_4 = -\sigma^i_1 - \sigma^i_2 \tag{3.25}$$

By equations (3.21) – (3.25), the action-based opinion-summarizing rule is,

$$\begin{aligned}
\phi^i(P^i,1) &= (\alpha+\beta)p^i_1 + (-\alpha-\beta+1)p^i_2 + (-\alpha-\beta+1)p^i_3 + (\alpha+\beta-2)p^i_4 \\
\phi^i(P^i,2) &= (-\alpha+\beta)p^i_1 + (\alpha-\beta+1)p^i_2 + (\alpha-\beta-1)p^i_3 + (-\alpha+\beta)p^i_4 \\
\phi^i(P^i,3) &= (\alpha-\beta)p^i_1 + (-\alpha+\beta-1)p^i_2 + (-\alpha+\beta+1)p^i_3 + (\alpha-\beta)p^i_4 \\
\phi^i(P^i,4) &= (-\alpha-\beta)p^i_1 + (\alpha+\beta-1)p^i_2 + (\alpha+\beta-1)p^i_3 + (-\alpha-\beta+2)p^i_4
\end{aligned} \tag{3.26}$$

Table 3.2 Relationship between σ^i_l and Outcomes

	$\sigma^2_2>0, \sigma^2_1>\sigma^2_2$ $\sigma^2_1+\sigma^2_2>0$	$\sigma^2_2>0, \sigma^2_1<\sigma^2_2$ $\sigma^2_1+\sigma^2_2>0$	$\sigma^2_2>0, \sigma^2_1<\sigma^2_2$ $\sigma^2_1+\sigma^2_2<0$	$\sigma^2_2<0, \sigma^2_1<\sigma^2_2$ $\sigma^2_1+\sigma^2_2<0$	$\sigma^2_2<0, \sigma^2_1>\sigma^2_2$ $\sigma^2_1+\sigma^2_2<0$	$\sigma^2_2<0, \sigma^2_1>\sigma^2_2$ $\sigma^2_1+\sigma^2_2>0$
$\sigma^1_1>0, \sigma^1_1>\sigma^1_2$ $\sigma^1_1+\sigma^1_2>0$	k_1, k_2	k_1	k_1	k_2	k_2	k_1, k_2
$\sigma^1_1>0, \sigma^1_1<\sigma^1_2$ $\sigma^1_1+\sigma^1_2>0$	k_1, k_2, k_3	k_1, k_3	k_1, k_3	k_2	k_2	k_1, k_2
$\sigma^1_1<0, \sigma^1_1<\sigma^1_2$ $\sigma^1_1+\sigma^1_2>0$	k_1, k_3	k_1, k_3	k_1, k_3, k_4	k_3, k_4	k_4	k_4
$\sigma^1_1<0, \sigma^1_1<\sigma^1_2$ $\sigma^1_1+\sigma^1_2<0$	k_3	k_3	k_3, k_4	k_3, k_4	k_4	k_4
$\sigma^1_1<0, \sigma^1_1>\sigma^1_2$ $\sigma^1_1+\sigma^1_2<0$	k_3	k_3	k_3, k_4	k_2, k_3, k_4	k_2, k_4	k_2, k_4
$\sigma^1_1>0, \sigma^1_1>\sigma^1_2$ $\sigma^1_1+\sigma^1_2<0$	k_1, k_2	k_1	k_1	k_2, k_4	k_2, k_4	k_1, k_2, k_4

The action-based opinion-summarizing rule formulated in equation (3.26) satisfies the priority of the supporter's dominant action.

3.4 Nash Equilibrium in Agent Game

The equilibrium under the two opinion-summarizing rules defined in **3.2** is compared in the case defined as follows.

$$\text{Supporters 1: } P_3^1 > P_1^1 > P_2^1 > P_4^1$$

$$\text{Supporters 2: } P_4^2 > P_3^2 > P_2^2 > P_1^2 \quad (3.27)$$

Whereas supporters of the government prefer that project is carried out as planned ($P_4^2 > P_3^2$, $P_2^2 > P_1^2$), supporters of the opposition group prefer that the project is modified ($P_1^1 > P_2^1$, $P_3^1 > P_4^1$). If the project is modified, supporters of the opposition group prefer dialogue with the government ($P_3^1 > P_1^1$). However, if the project is carried out as it planned, they prefer escalating the conflict.

In the preference of the supporters of governments, the states where the opposition group accepts dialogue are dominant to the states where the opposition group is for escalating a conflict ($P_3^2 > P_1^2$, $P_4^2 > P_2^2$). This implies that the priority of the supporters of government is for dialogue with the opposition group.

When the outcome-based opinion-summarizing rule is employed, Nash equilibrium strategy profiles are ② − IV and ④ − I. Consequently, from **Table 3.2**, the realized outcomes are the states 2 (Opposition escalates and project is carried out as it planned) or 3 (Opposition group communicates with government and project is modified). Equation (3.26) shows that the state 3 is dominant to the state 2.

When action-based opinion-summarizing rule is employed, $\sigma_1^1 \leqslant 0$ $\sigma_2^1 > 0$, $\sigma_1^2 < 0$ and $\sigma_2^2 < 0$ are derived from (3.26). From **Table 3.2**, state 2 may be unique outcome of the conflict, i.e., only the Pareto inferior outcome can be realized.

4. SURVEY OF THE COGNITIVE STRUCTURE OF A CONFLICT

4.1 Survey

In section **3**, a model including opinion-summarizing rules was constructed. It showed that the result of conflict might change depending on the rules. In actual conflicts, opinion-summarizing rules are based on people's recognition of the structure of conflict. Here, a questionnaire is used to survey people's cognitive structures of conflicts over disaster mitigation projects. First, a respondent was instructed on the background of a hypothetical conflict over a reservoir project. For simplification, only two players, government and opposition group, are assumed. The government plans and proceeds with the reservoir project. In contrast, the opposition group is concerned about damage to natural environment and opposes the project. Both the government and opposition group have plural action choices. Although the conflict is hypothetical, similar situations occur in a real world.

Given instructions on the conflict, the respondent is asked to choose i) actions which he or she recognizes as being possible to take on the conflict, and ii) outcomes which he or she recognizes as being possible to be realized. If people's cognitive structure of a conflict is similar to game theoretic model, the choices in i) and ii) should be consistent.

We formulated an instruction to explain this hypothetical conflict. Respondents were asked to read the instruction and answer the following questions:

Q1: From your subjective viewpoint, choose the set of possible actions of the opposition group from the following three actions. (Choose more than one action.)

A. Taking aggressive behavior
B. Asking for a referendum
C. Communicating with the government

Q2: From your subjective viewpoint, choose the set of possible actions of the government from the following three actions. (Choose more than one action.)

A. Communicating with the opposition group
B. Suspension of the project
C. No communication and proceeding with the project

Q3: From the set of possible actions specified in **Q1** and **Q2**, choose one action as the most desirable action.

Q4: From your objective viewpoint, choose the set of possible outcomes of a conflict from the following nine outcomes. (The number of choices is not limited.)

- The opposition group takes aggressive behavior, and the government tries to communicate with the group (AA).
- The opposition group takes aggressive behavior, and the government suspends the project (AB).
- The opposition group takes aggressive behavior, but the government does not try to communicate with the group and proceeds with the project (AC).
- The opposition group asks for a referendum, and the government tries to communicate with the group (BA).
- The opposition group asks for a referendum, and the government suspends the project (BB).
- The opposition group asks for a referendum, but the government does not try to communicate with the group and proceeds with the project (BC).
- The opposition group tries to communicate with the government, and the government tries to communicate with the group (CA).
- The opposition group tries to communicate with the government, and the government suspends the project (CB).
- The opposition group tries to communicate with the government, but the government does not try to communicate with the group and proceeds with the project (CC).

Two characters in parentheses in **Q4** represent actions that lead a conflict to the corresponding outcome. In the actual questionnaire, these characters are not shown, and the order of outcomes in **Q4** is randomized.

As the purpose of this survey was to detect the general properties of cognitive structure of a conflict, the respondent was not necessarily a stakeholder involved in a specific conflict. There were 139 respondents, 99 university students and 40 engineers. Note that all the students belonged to the department of civil engineering, and most of the engineers were civil ones.

Table 4.1 shows the relationship between the set of players' possible actions and the corresponding outcomes. As defined in **2**, the combination of players' actions is the "strategy profile." Shaded areas in **Table 4.1** represent the strategy profiles when the opposition group chooses actions A and B as possible and the government actions B and C. If the respondent chooses outcomes outside of the shaded areas or does not choose outcomes included in

Table 4.1 Relationship between the Set of Players' Possible Actions and Corresponding Outcomes

		Q2: Government		
		Action A	Action B	Action C
Q1: Opposition Group	Action A	Outcome AA	Outcome AB	Outcome AC
	Action B	Outcome BA	Outcome BB	Outcome BC
	Action C	Outcome CA	Outcome CB	Outcome CC

those areas, it signifies that respondent's cognitive structure is polarized from non-cooperative game model.

4.2 Survey Result

A statistical test on ratios was carried out to detect people's cognitive structures. The population ratios of the two sets are defined as π_1 and π_2. The null hypothesis is $\pi_1=\pi_2(=p)$. The sample ratios of two samples from the two sets are defined as $\hat{p}_1$ and $\hat{p}_2$(Sample sizes are n_1 and n_2). Statistic Z is formulated as follows.

$$Z=\left|\frac{\hat{p}_1-\hat{p}_2}{\sqrt{p(1-p)(\frac{1}{n_1}+\frac{1}{n_2})}}\right|, p=\frac{n_1\hat{p}_1+n_2\hat{p}_2}{n_1+n_2} \tag{4.1}$$

When the sample size is large enough, Z follows normal distribution. If Z is larger than the threshold, the null hypothesis is rejected and π_1 and π_2 differ statistically. Results of three statistical tests are given below.

Test I: Difference between choices of strategy profiles and outcomes

In this test, sample ratios $\hat{p}_1$ and $\hat{p}_2$ were defined as follows.

$$\hat{p}_1=\frac{SUM3}{SUM1}, \hat{p}_2=\frac{SUM2-SUM3}{N-SUM1} \tag{4.2}$$

*SUM*1: The number of respondents who chose the corresponding strategy profile derived from **Q1** and **Q2**.

*SUM*2: The number of respondents who chose the corresponding outcome in **Q4**.

*SUM*3: The number of respondents who chose the corresponding strategy profile derived from **Q1** and **Q2**, and chose the corresponding outcome in **Q4**.

N: Total number of respondents

$\hat{p}_1$ is the ratio of the respondents who chose the corresponding strategy profile and outcome simultaneously, and $\hat{p}_2$ the ratio of respondents who chose the corresponding outcome out of those who did not choose the corresponding strategy profile. When the difference between $\hat{p}_1$ and $\hat{p}_2$ is significant, the choice of outcomes depends on the choice of strategy profiles. This means that the strategy profile and outcome are related to the respondent's cognitive structure of a conflict and that non-cooperative game model is appropriate to describe that conflict. If, however, the difference between $\hat{p}_1$ and $\hat{p}_2$ is not significant, polarization between recognitions of strategy profiles and outcomes exists.

Table 4.2 shows the results of Test I. The significance level α is 0.05. In some outcomes, such as AC and BC, the difference between $\hat{p}_1$ and $\hat{p}_2$ is not significant. This result shows that people's cognitive structure of a conflict is polarized in at least for some outcomes.

Table 4.2 Results of Test I

Outcome	AA	AB	AC	BA	BB	BC	CA	CB	CC
Z	1.56	2.13*	0.40	1.33	2.49*	1.49	2.86*	1.98*	2.13*

*: 5% significant (null hypothesis is rejected)

Test II: Consistency between the Subjective and Objective Recognitions of Actions

Possible reasons for the polarization seen in Test I are as follows.

1. Having heard or seen about conflicts over reservoir projects, respondents may already have knowledge about the structure of such conflicts. This prior knowledge might affect their answers.
2. Respondents may have answered differently from the subjective (**Q1** and **Q2**) and objective (**Q4**) viewpoint.

Test II was done to examine the second reason. First, the objective recognition of actions was defined. If a respondent chose at least one outcome caused by an action in **Q4**, it was judged that the respondent recognized the existence of the corresponding action objectively. In Test II, objective and subjective recognition of actions derived from **Q1** and **Q2** are compared.

The sample ratios, $\hat{p}_1$ and $\hat{p}_2$, are defined as follows.

$$\hat{p}_1=\frac{SUM6}{SUM4}, \hat{p}_2=\frac{SUM5-SUM6}{N-SUM4} \tag{4.3}$$

*SUM*4: The number of respondents who chose the corresponding action *a* in **Q1** or **Q2**.

*SUM*5: The number of respondents who chose at least one outcome caused by the action *a* in **Q4**.

*SUM*6: The number of respondents who chose the corresponding action *a* in **Q1** or **Q2** and at least one outcome caused by the action *a* in **Q4**.

$\hat{p}_1$ is the ratio of respondents recognizing action *a* objectively to those recognizing *a* subjectively, and $\hat{p}_2$ is the ratio of respondents recognizing action *a* objectively to those not recognizing a subjectively. When the difference between $\hat{p}_1$ and $\hat{p}_2$ is significant, subjective and objective recognitions of the action *a* are consistent.

Table 4.3 gives the results of Test II. In the opposition group's actions (**Q1**), polarization between subjective and objective recognition was relatively significant. This is partly because the survey respondents consisted of people familiar with public works projects.

Test III: Difference between choices of objective strategy profiles and outcomes

The sample ratios $\hat{p}_1$ and $\hat{p}_2$ are defined as follows.

$$\hat{p}_1=\frac{SUM8}{SUM7}, \hat{p}_2=\frac{SUM2-SUM8}{SUM5-SUM7} \tag{4.4}$$

*SUM*7: The number of respondents who chose at least one outcome caused by the opposition group's action *a* and the government's action *a*' in **Q2**.

*SUM*8: The number of respondents who chose at least one out-

Table 4.3 Results of Test II

	Q1: Opposition Group			Q2: Government		
	A	**B**	**C**	**A**	**B**	**C**
Z	3.04*	1.08	1.27	2.78*	2.55*	1.63

Table 4.4 Results of Test III

Outcome	**AA**	**AB**	**AC**	**BA**	**BB**	**BC**	**CA**	**CB**	**CC**
Z	-0.21	1.79	-0.44	1.59	2.38*	1.43	2.02*	2.00*	2.59*

come caused by the opposition group's action *a*, the government's action *a*' in **Q2**, and the corresponding outcome in **Q4**.

As in Test I, the purpose of Test III was to confirm differences between recognition of actions and outcomes. Based on results of Test II, choices of the opposition group's action in **Q1** were replaced by the objective recognition of actions derived from **Q4**. When the difference between $\hat{p}_1$ and $\hat{p}_2$ is significant, the strategy profile based on subjective recognition of opposition group's actions and outcome are related in respondent's cognitive structure of a conflict.

Table 4.4 shows the results of Test III. Comparison with **Table 4.1** shows that the differences between $\hat{p}_1$ and $\hat{p}_2$ are not necessarily increased. That is, polarization between recognition of strategy profile and outcome is not decreased by removing the difference between the subjective and objective recognition of action. Polarization may be due to respondents' knowledge of conflicts in the past, or their ability to estimate results from context.

4.3 Interpretation of Survey Results

Results of the statistical test show that polarization exists for some questions between recognition of actions and outcomes, whereas recognitions have consistency in other. This suggests that there were people who had prior knowledge of a similar type of conflict. Such knowledge is supposed to affect people's cognitive structure of a conflict.

In some cases, prior knowledge is useful for understanding a situation. For example, people may be able to find equilibrium of a conflict without examining the interaction of decisions. However, such knowledge may sometimes prevent them from behaving strategically. In the case of the conflict over a reservoir project, the opposition group may hope for dialogue with the governmental agency. If, however, government's knowledge suggests that opposition group prefers aggressive actions, government may not try to talk with opposition group, and the possibility of compromise is lost.

5. CONCLUSION

In this study, people's recognition about a conflict was analyzed. First, a model involving players' game-making process was constructed. Next, a survey of people's cognitive structure on a conflict was made. Results of both suggested that the cognitive structure of a conflict may affect outcome of the conflict.

In participatory planning, the importance of a coordinator is often emphasized. One role of a coordinator is to create the "stage" for discussion. This role can be interpreted as promoting communication between stakeholders. Our findings indicate the importance of such communication in order to achieve a better outcome.

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