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Confrontation Resolution Analysis of Pre-play Mechanism for Increasing Social Welfare

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ABSTRACT

The purpose of this paper is to investigate negotiation process among three players facing a non-cooperative game before they actually make final decisions in the framework of confrontation resolution analysis. We call such a negotiation process pre-play game. In this paper first of all, we propose a general framework for describing three-person pre-play game, by defining several types of action of the players. Next, we apply the framework to three-person Prisoner's Dilemma game with the option of "not playing the game". Finally, we argue how the social welfare solution (Cooperation, Cooperation, Cooperation) in the game is achieved depending on the types of the players and identify what player type is the strongest against invasion by different types. The findings obtained are not only insightful in an academic sense, but also provide useful suggestions for management of environmental problem practice.

Keywords: pre-play game, confrontation resolution, Prisoner's Dilemma game

1. INTRODUCTION

The purpose of this paper is to investigate negotiation process among three players facing a non-cooperative game before they actually make final decisions in the framework of confrontation resolution analysis (Fraser and Hipel [1]). In the real situations when three players face a non-cooperative game, it is quite natural for them to negotiate in advance (e.g. lobbying and behind-the scenes maneuvering) before their final decision-making. We focus on such a pre-play stage of decision making in a game situation and call it a pre-play game. If all the players follow perfect rational reasoning, then Nash equilibrium may simply provide resolutions. But, it is well known that for the case of Prisoner's Dilemma game, the only Nash equilibrium is (Defection, Defection, Defection) although there is a more desirable and Pareto optimal solution, i.e., (Cooperation, Cooperation, Cooperation). This implies that rationality does not always lead to a desirable situation in the sense of the social welfare. We are interested in the negotiation in the pre-play game that allows us to realize such a social welfare solution; we assume a social welfare solution satisfies Pareto optimal and fairness, that is mutual cooperation in the Prisoner's Dilemma game.

In the following sections, first ,we introduce some basic ideas of this paper, and clarify controvertial points in traditional confrontation resolution. Next, we try to extend the traditional confrontation resolution analysis to three-person game, to propose a general framework of three-person pre-play game and, then to define several types of the players. Thirdly, we will apply the framework to the three-person Prisoner's Dilemma game with the option of "not playing the game". Finally, we argue how the social welfare solution (Cooperation, Cooperation, Cooperation) in the game is achieved depending on the types of players and identify what player type is the strongest against invasion by different types.

Confrontation resolution analysis is originated from Meta-game theory (Howard [2]). It is based on the premise that his/her strategy corresponds to the opponent's; "if the opponent chooses strategy x, then I choose strategy y". Applying the framework to the two-person Prisoner's Dilemma game (Fraser and Hipel [1]), (Cooperation, Cooperation) and (Defection, Defection) are identified as equilibria. Since the result is consistent with intuition, we may think their method is insightful and interesting for describing the pre-play process for two-person games. However, it seems somewhat illogical if we assume that the pre-play process of two-person games is the same as that of three or more-person games. Indeed, if confrontation resolution analysis is directly applied to three or more-person game, there are unnatural parts in the definitions. It motivates us to try to improve confrontation resolution model.

Several researches on pre-play game have been conducted from the viewpoint of which outcome or payoff is achieved depending on the negotiation process. A typical model for such an analysis on pre-play game is Bargaining model (Rubinstein [3]). According to this model, equilibrium point depends on player's weight assigned to future payoff and payoff at the breakdown in negotiation. He then implies that the sub-game perfect equilibrium point corresponds to Nash bargaining solution under some condition if players' weight of future payoff is enough large. In this paper, we try to show outcomes of three-person pre-play game depend on announcement and change of strategies by the players.

To study realization mechanism of the cooperation solution, quite a lot of researches have been conducted in terms of repeated game where player is assumed to be able to identify opponent (Axelrod [4]). Some studies on realization of cooperation have been developed in terms of the game reduced to Prisoner's Dilemma game (Orberll and Dawes [5]). The traditional Prisoner's Dilemma game has no option other than choosing between cooperation and defection. Orberll and Dawes [5] claim that such a situation is very tough and propose Prisoner's Dilemma game accompanied with strategy of "not playing" besides the strategies of traditional game. Other researches show that it is highly possible that the cooperation can evolve in the context of the game where players are assumed to be not able to identify opponent (Imai [6], Cheon [7]).

In this paper, we try to extend Orberll and Dawes' idea to a three-person game.

2. THREE-PERSON PRE-PLAY GAME

In this section, we introduce some basic ideas of this paper, and clarify controvertial points in the traditional confrontation resolution. Then, we will extend the confrontation resolution to three-person game. Finally, we define three-person pre-play game.

The most basic ideas are concepts of stability, which are derived from the concept of unilateral improvement (UI) to negotiation at pre-play stage. UI is a fundamental idea of metagame theory and conflict resolution to deal with the pre-play process. In order to define the UI, we need several definitions first.

2. 1. Basic Definitions

Definition 1(Decision makers). We call the participants in conflict situation the decision makers or players. The set of n players is given by

$$N = \{1,2,3\cdots,i,\cdots,n\}$$

Definition 2(Options). A given player i possesses a set of available options defined by

$$\forall i \in N, O_i = \{O_{1i}, O_{2i}, \cdots O_{mi}\}$$

Definition 3(Strategy). Let $f_i(o_{ki})$ be a function mapping on an option to symbols 1(select) or 0(not select).

$$f_i(o_{ki}) = \begin{cases} 1 \\ 0 \end{cases}$$

Then a strategy is described as a vector composed of 1 or 0 to every i's option (e .g. $s_i = (001)$) Hence, if $|O_i| = m$,then $|S_i| = 2^m$.

Definition 4(Outcomes). An outcome q is formed when each player selects a strategy.

$$s_{ki} \in S_i, q = (s_{a1}, s_{b2} \cdots, s_{ki}, \cdots, s_{tn})$$

The set Q of all theoretically possible outcomes is defined as the Cartesian product of all the players' strategy set

$$Q = S_1 \times S_2 \times \cdots \times S_n$$

In a given definition, a given player may have some options under his/her control that are mutually exclusive, and hence he/she can choose at most one of them at any one point in time. Accordingly, any outcome that contains a choice of more than one of these options is infeasible. When modeling and analyzing a game, we wish only to deal with feasible outcomes. Let the set of feasible outcomes be denoted by Q^*, where,

$$Q^* \subseteq Q$$

Definition 5(Individual preference function). Let $q \in Q^*$, $M^+{}_i(q)$ is the set of outcomes which are preferred by i to outcome q. And $M^-{}_i(q)$ is the set of outcomes which are not preferred by i to outcome q. Hence, individual preference function $M_i(q)$ is given by

$$M_i(q) = M_i^+(q) \cup M_i^-(q)$$

We say that a player has a unilateral improvements (UI) from a state of the game if he/she has an incentive to deviate from it unilaterally. We then can define the set of UIs of the player from the state.

Definition 6(unilateral improvements). Let s_i stand for strategy for a decision maker i, and s_{N-1} for a strategy for the decision makers other than i. An outcome q is formed by the strategy pair $q = (s_i, s_{N-i})$.

Let $m_i(q)$ that are accessible to decision maker i from outcome q by decision maker i changing his/her strategies and other decision maker $N-i$ remaining at a fixed strategy s_{N-i} be given by set

$$m_i(q) = \{(s'_i, s_{N-i}) | s'_i \in S_i - \{s_i\}\}$$

The $m^+{}_i(q)$ is called the set of unilateral movements by i from outcome q. An important subset of the unilateral movements is the set of unilateral improvements (UI), defined as

$$m_i^+(q) = m_i(q) \cap M_i^+(q)$$

The set of unilateral movements not preferred by player i to outcome q is given as

$$m_i^-(q) = m_i(q) \cap M_i^-(q)$$

Hence,

$$m_i(q) = m_i^+(q) \cup m_i^-(q)$$

Definition 6(Sanction). Let $q \in Q^*$. Outcome q is called a sanction by player j to i, if and only if

$$\exists p \in m^+{}_i(q), \left(m_j^+(p) \cap M_i^-(q) \neq \phi\right)$$

where, $j \neq i$.

Next, for a feasible outcome q in the game, we define four types of stability (See Fig.1).

1. Rational: We say outcome q is rational for i if and only if $m^+{}_i(q) = \phi$.
2. Sanctioned: We call q is sanctioned if for all UIs available to the particular player, credible actions can be taken by other players which lead to a less preferred outcome than outcome q.
3. Unstable: We say the outcome q is unstable for i if and only if
$$\exists p \in m^+{}_i(q), \exists j \in N, \left(m^+{}_j(p) \cap M^-{}_i(q) = \phi\right).$$
4. Stable by simultaneity: Let $S \subseteq N$ where $S = \{i \mid \text{the outcome } q \text{ is unstable for } i\}$
Let p be an outcome when all the players in S change their strategies simultaneously from the q. The outcome is stable by simultaneity if and only if $\exists i \in S, M^-{}_i(q) \neq \phi$.

Then, we define equilibrium as follows: an outcome is called equilibrium if and only if for every player the outcome is rational, sanctioned, or stable by simultaneity.

2. 2. Three-person Confrontation Resolution

Applying the method to the two-person Prisoner's Dilemma game (Fraser and Hipel [1]), (Cooperation, Cooperation) and (Defection, Defection) are identified as equilibria. The result is consistent with intuition for the cases of two-person dilemma game.

However, there seem somewhat illogical results for three- or more-person games. Let us consider the following examples (Refer to Fig. 2): In the case 1, when the first player takes UI p from outcome q, the second player's UI r is indeed a sanction for i. But, the sanction disappears by the third player's UI r'. That is, the first player has the incentive to deviate from q. But, according to original concept of confrontation resolution, the outcome q is sanction for i, that is, the player i doesn't change the strategy. In the case 2, we assume that player i thinks outcome q is as acceptable as outcome q'. When player i take UI p from q, other player j takes UI q' from p. In this case, we think player i doesn't have the incentive to deviate from q. In this case, the definition is not clear (See Def6, Fig2).

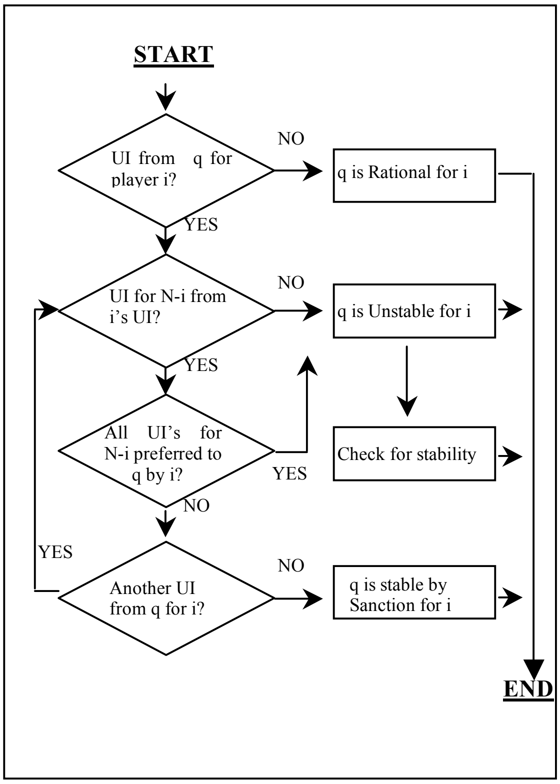

Fig1. Stability of State q for player i in the traditional Confrontation resolution analysis

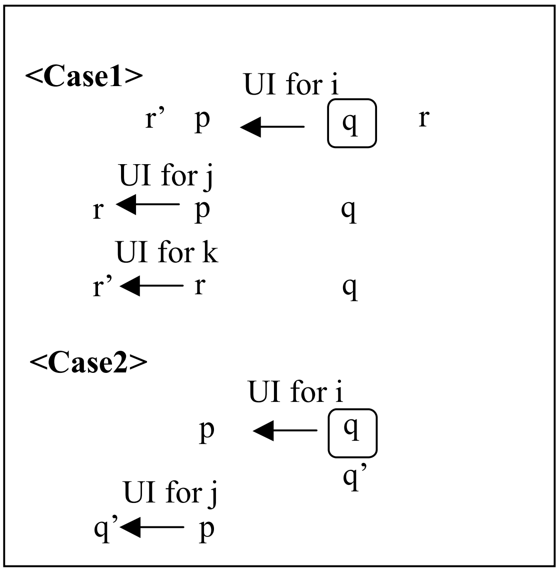

Fig2. Problems of the traditional Confrontation resolution analysis

To express these situations more clearly, we re-define several concepts of conventional confrontation resolution.
First of all, we introduce:

Definition 5(Individual preference function).
Let $q \in Q^*$. $M^+{}_i(q)$ is the set of outcomes which are preferred by i to outcome q, or are indifferent to outcome q.

Case2 has improved by this definition.

Next, we re-define four types of stability and action flowchart (See Fig3). According to original confrontation resolution, every player has one chance to take UI. In our new formulation, every player is assumed to have finite opportunities of UI, and to choose only the best UI. Suppose now the end of finite sequence of UI p_n is the UI from p_{n-1} for j. Let p_t be the UI from p_{t-1} for j. Hence,

$$q \xrightarrow[i]{} p \xrightarrow[k]{} p_2 \xrightarrow[l]{} \cdots p_t \xrightarrow[l]{} \cdots p_{n-1} \xrightarrow[j]{} p_n$$

where, $p_0 = q, p_1 = p$.

1. Rational: We say the outcome q is rational for i if and only if $m^+{}_i(q) = \phi$.
2. Unstable: The outcome q is called Unstable for i if and only if $\exists p \in m^+{}_i(q), \forall j \neq i, m^+{}_j(p) = \phi$ or
$\exists p \in m^+{}_i(q)$ *such that*
$$1)\forall t = \{2, \cdots, n-1\}, \exists j, m^+{}_j(p_{t-1}) \neq \phi$$
$$\textit{and} \quad 2)\exists j \neq i, m^+{}_j(p_{n-1}) \neq \phi, m^+{}_j(p_{n-1}) \cap M^-{}_i(q) = \phi$$
3. Cyclic: The outcome is called Cyclic if and only if the same outcome exists in infinite sequence of UI.
4. Sanctioned; Outcome q is called Sanctioned for i if and only if
$\exists p \in m^+{}_i(q)$ *such that*
$$1)\forall t = \{2, \cdots, n-1\}, \exists j, m^+{}_j(p_{t-1}) \neq \phi$$
$$\textit{and} \quad 2)\exists j \neq i, m^+{}_j(p_{n-1}) \neq \phi, m^+{}_j(p_{n-1}) \cap M^-{}_i(q) \neq \phi$$

Then, we define equilibrium: an outcome is called equilibrium if and only if for every player the outcome is rational, sanctioned, or cyclic.
By this reformulation we can overcome the problem caused in Case 1.

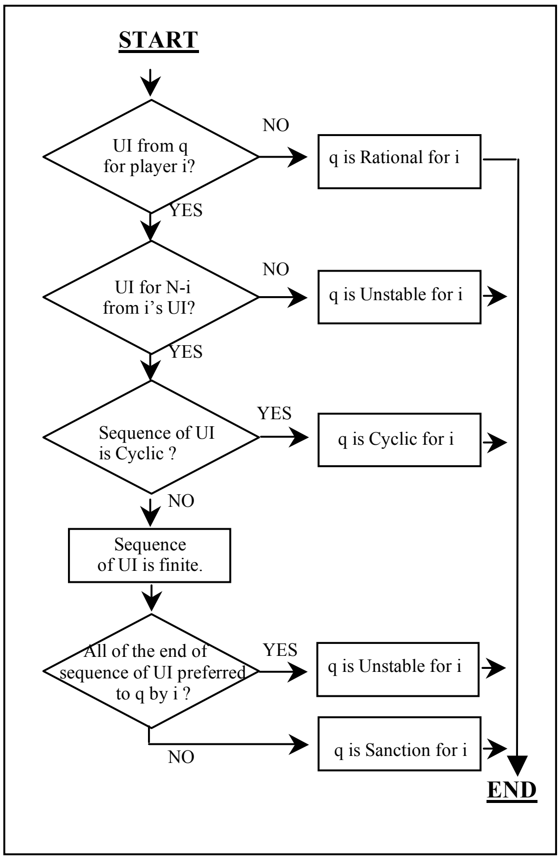

Fig3. Stability of State q for player i in n-person game

Now, we try to extend UI originally introduced in conflict resolution analysis to three-person game.
Then we can have:

Proposition. The confrontation resolution equilibrium always exists.

Proof.
We assume the confrontation resolution equilibrium doesn't exist. Hence, $\forall q, \exists i, m^+{}_i(q) \neq \phi$ by definition.
Let q^* be an unstable outcome for player i and $p \in m^+{}_i(q^*)$.
Let the end of finite sequence of UI p_n be the UI from p_{n-1} for j $(j \neq i)$ and p_t be the UI from p_{t-1} for j.
Hence

$$q^* \xrightarrow[i]{} p \xrightarrow[k]{} p_2 \xrightarrow[l]{} \cdots p_t \xrightarrow[l]{} \cdots p_{n-1} \xrightarrow[j]{} p_n$$

where, $p_0 = q^*, p_1 = p$.
1) We consider the case an UI from p doesn't exist. By definition, $\exists p \in m^+{}_i(q^*), \forall j \neq i, m^+{}_j(p) = \phi$. Clearly, q^* is rational for any player by definition. Hence, q^* is equilibrium. It is a contradiction.
On the other hand,

2) We consider the case an UI from p exists. By definition,

$\exists p \in m^{+}{}_{i}(q^{*})$ *such that*

$$1) \forall t = \{2, \cdots, n-1\}, \exists j, m^{+}{}_{j}(p_{t-1}) \neq \phi$$

$$\text{and} \quad 2) \exists j \neq i, m^{+}{}_{j}(p_{n-1}) \neq \phi, m^{+}{}_{j}(p_{n-1}) \cap M^{-}{}_{i}(q^{*}) = \phi$$

By definition, $m^{+}{}_{j}(p_{n-1}) \neq \phi, M^{+}{}_{i}(q^{*}) \cap M^{-}{}_{i}(q^{*}) = \phi$ and, let $p_n \in m^{+}{}_{j}(p_{n-1}) \cap M^{+}{}_{i}(q^{*})$, p_n is the rational outcome for j. Moreover, $N-j$ doesn't change strategy from p_n, that is, $m^{+}{}_{N-j}(p_n) = \phi$. p_n is the rational outcome for $N-j$. Hence, it is equilibrium. It is a contradiction.

QED

The player in confrontation resolution analysis we suggested is farsighted and rational. It is a type of action of players. In the real world, there are also many other types of players; those who consider they should cooperate for other player, those who consider they should fight back against the other players' defection, and so on. In the next section we will introduce several types of players to pre-play game.

2. 3. Pre-play game Model

We first illustrate pre-play game process (See Fig4). First, each player announces the strategy which he/she is willing to choose. Next, if he/she wants to change the strategy, he/she announces a new strategy to others in some fixed order. By iteration, the outcome from which no one wants to change the strategy is the final decision. In addition, when he/she goes around in circles, "negotiation needs to change (NC)" is the final decision. Next, we define player type by

*Definition 7(player type). P*layer type is defined by the pair (the rule of first announcement, the rule of changing the strategy).

For the case of three-person Prisoners Dilemma game, for example, they includes those who consider they should cooperate no matter what happens, those who consider they should fight back against the other players' defection, and so on. In this paper, we define representative six types of players (See Fig5).

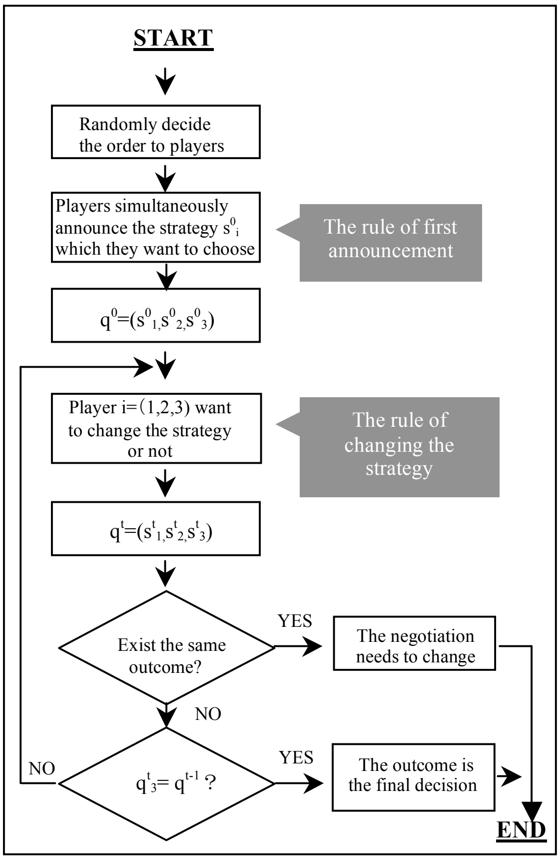

Fig4. Three-person pre-play game

3. APPLICATION TO THREE-PERSON PRISONER'S DILEMMA GAME WITH THE OPTION OF NOT PYAYING THE GAME

We now apply the pre-play game model to the three-person Prisoner's Dilemma game with the option of "not playing the game".

3. 1. Model of Three-person Prisoner's Dilemma game with the option of not playing the game

Orberll and Dawes [5] conducted experiments and showed that when individuals are free to accept or reject play in Prisoner's Dilemma game, social aggregate welfare increases. This finding is only appliable to two-person Prisoner's Dilemma game with the payoff structure $t > r > 0 > p > s$, and not necessarily to other possible structures. t is temptation from unilateral defection, r is the payoff from mutual cooperation, p is the payoff mutual defection, and s is the payoff to a prisoner who denies any in the crime when the other defection.
Since Cheon formulates more clearly the idea of Orberll and Dawes in mathematical terms, in this paper, we extend Cheon's model to three-person game.

PLAYER NAME	THE RULE OF FIRST ANNOUNCE	THE RULE OF CHANGE THE STRATEGY
1.Selfish (SE)	•The strategy is conducive to the best self-pleasing outcome	•Unilateral Improvement（UI) from the adjacent outcome UI or not ···· ····
2.Shortsighted Rational (SR)	•If Nash equilibrium exists, the strategy leads to it. •If not,max-min strategy.	•Unilateral Improvement（UI） from the adjacent outcome, considering the UI from his/her UI for next player. UI or not next 1-person ···· ····
3.Farsighted Rational (FR)	•The best self-pleasing strategy in the Confrontation Resolution equilibrium	•Unilateral Improvement（UI） from the adjacent outcome, considering the UI from his/her UI for every player. UI or not N-2-person ···· ····
4.Unselfish (US)	•The player randomly chooses player j among N-i players. •The strategy is conducive to the best outcome for j.	•The strategy is conducive to the best outcome for j. •If there are several strategies for him/her, he/she chooses the best strategy for himself/herself in these.
5.make out punish forever (PF)	•The strategy leads to Pareto and fairness solution (i.e. cooperation).	•The strategy always punish to the player who doesn't choose cooperation. •If there are several strategies for him/her, he/she chooses the best strategy for himself/herself in these.
6.make out punish opponent's action (PA)	•The strategy leads to Pareto and fairness solution (i.e. cooperation).	•The strategy always punish to the player who doesn't choose cooperation at t=1. •The strategy punish to the nearest player who take UI not preferred for him/her at t≠1. If there are several strategies for him/her, he/she chooses the best strategy for himself/herself in these.

Fig5. Types of players in the pre-play game

In our game, if a player chooses N (nothing), his/her payoff is always 0; C (cooperation) earns payoff b. When he/she meets other C-players, his/her payoff get reduced by ε. When he/she meets other D-players, a large amount of payoff R is taken away; D (defection) needs to consume d. He/She can get payoff R from other C-players. When he/she meets other players who choose C and D, he/she cooperates against D-player, that is, D-players get payoff $2\delta R$ and divide it equally between them. Hence, we have

$$N \quad 0 \qquad (6)$$

$$C \quad \begin{cases} b & ifNN \quad (3) \\ b-\varepsilon & ifNC,CN \quad (4) \\ b-2\varepsilon & ifCC \quad (5) \\ b-R & ifND,DN \quad (9) \\ b-2\delta R & ifDD \quad (10) \\ b-\varepsilon-1/2R & ifND,DN \quad (8) \end{cases}$$

$$D \quad \begin{cases} -d & ifNN \quad (7) \\ R-d & ifNC,CN \quad (1) \\ R-d & ifCC \quad (1) \\ -d & ifND,DN \quad (7) \\ -d & ifDD \quad (7) \\ \delta R-d & ifND,DN \quad (2) \end{cases}$$

where since we have $b,R,d,\varepsilon > 0, 0 < \delta < 1, R > b, \varepsilon < (\delta - 1/2)R$.

The player's preference ordering is represented by the figure in round bracket.

In confrontation resolution analysis, 0-1 matrix is helpful to conduct analysis (See Table1). In the table, each outcome is assigned a letter name. Table 1 displays the preferences of player 1; the most preferred outcomes are listed on the left while the least preferred ones are on the right. The player is indifferent among the outcomes in square bracket. According to the definition, for example, an option for player i is N or C or D, a strategy for i is (100) or (010) and so on. The preferences of other players can be described in the same way.

Table 1. Preference vector of player 1

outcome	[o	f	l]	[r	x]	b	[e	k]	n	[a	d	g	j	N	p	s	v	y]	[c	I	u	A]	[q	w]	[h	t]	z
1																											
N	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
C	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
D	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0
2																											
N	0	0	1	0	0	1	0	1	0	1	0	0	1	0	0	1	0	0	1	0	1	0	0	0	0	1	0
C	1	1	0	0	1	0	1	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0
D	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0	1	1	0	1	0	1
3																											
N	0	1	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0
C	1	0	1	1	0	0	0	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0
D	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	0	1	0	1	1

3. 2. Simulations

We conducted simulations for 367 cases. Table 2 shows an example. In the case, there are two selfish players and a farsighted rational player. We assume that each player doesn't change his/her rule for changing strategies depended on the type of other players. The outcome from players' first announcement is (Defection, Defection, Cooperation). Each player considers whether he/she changes the strategy or not from the stage of $q^1{}_1$. In the stage of $q^2{}_3$, for example, player 3 doesn't change the strategy because if he/she changes Defection from Nothing, the next player 1 changes Defection from Nothing, and the player 2 change Nothing from Cooperation. It finally derives the outcome (Defection, Nothing, Defection), which is not preferred to (Nothing, Cooperation, Nothing) by player 3.
In the stage of $q^5{}_1$, the outcome has already existed in the stage of $q^2{}_1$ for the player 1. Therefore, we conclude that the final decision is "the negotiation needs to change" at 5th term.

Table2. Case (SE,SE,FR) in the pre-play game

1.TYPE OF PLAYERS

player1	SE
palyer2	SE
player3	FR

2.FIRST ANNOUNCEMENT

	N	C	D
player1 $s^0{}_1$	0	0	1
player2 $s^0{}_2$	0	0	1
player3 $s^0{}_3$	0	1	0

outcome $q^0=(s^0{}_1, s^0{}_2, s^0{}_3)$	r=(001,001,010)

3.CHANGE OF STRATEGY

$q^1{}_1$	r=(001,001,010)	
$q^1{}_2$	r=(001,001,010)	
$q^1{}_3$	I=(001,001,100)	
$q^2{}_1$	g=(100,001,100)	
$q^2{}_2$	d=(100,010,100)	
$q^2{}_3$	d=(100,010,100)	
$q^3{}_1$	f=(001,010,100)	
$q^3{}_2$	c=(001,100,100)	
$q^3{}_3$	c=(001,100,100)	
$q^4{}_1$	b=(010,100,100)	
$q^4{}_2$	h=(010,001,010)	
$q^4{}_3$	h=(010,001,010)	
$q^5{}_1$	g=(100,001,100)	
$q^5{}_2$	d=(100,010,100)	
$q^5{}_3$	d=(100,010,100)	

4.FINAL DECISION

t-term	5th term
outcome	negotiation needs to change

3. 3. Discusion on Simulation Results

In order to define what society is better, we first introduce concept of increase of the social welfare. According to Orberll and Dawes, the social welfare increases with the number of cooperate-cooperate relationship. By their definition, in the two-person Prisoner's Dilemma game the order of outcomes in terms of social welfare is $CC > CD, DC > DD$.
Similarly we assume the social welfare increases if the number of players in the society who choose Defection decreases and if the number of cooperators increases. Moreover, if the social welfare solution satisfies Pareto optimal and fairness, it is better. Then, the social welfare solution in the three-person Prisoner's Dilemma game is (Cooperation, Cooperation, Cooperation).

(1) Effect of Pre-play game
According to the simulation results, we have to confess that the social welfare doesn't increase depending on pre-play, as shown by Table 3.

Table3. Total result in the pre-play game
(367 cases)

NUMBER OF COOPERATORS	3	2	1	TOTAL
FIRST ANOUCEMENT	125	75	21	221
FINAL DECESION	27	79	45	151

(2) Social welfare of the Society
Next, we examine difference between the cases where all the player are of the same type and the cases where different types of players exist.

1.The society consisting only of the SE can be debated till the end of time. Any action of the player doesn't bring increase of the social welfare in SE-society. Particularly, SE creates the society where defectors exist against invasion by type of the non-thougtfull players like the US and PA. Moreover, the results of analysis does not depend on the order of anoucement of players in pre-play. Relatively, it takes a long time to get ditermined on the negotiation (See Table 4).
2.The society consisting only of the SR is unconcerned with others; no one plays the game. SR creates the society where defectors exist against invasion by any type of players. Moreover, the results of analysis depends on the order of anoucement of players in pre-play (See Table 5).
3. The society consisting only of the FR is the best society. FR creates the society where defectors don't exist against invasion by US, PF, or PA. But, FR creates the society where defectors exist against invasion by SE, SR. (See Table 6).
4. The society consisting only of the US is a good society. US creates the society where defectors don't exist against invasion by FR, PF, or PA. But, the US-society is fragile against invasion by SE. Also, it is possibly fragile against invasion by SR. Relatively, the negotiation get ditermined first. When the favors to others by US is placed a disproportion, US-society is rubust against invasion by FR, PF, or PA. On the other hand, when these are placed a proportion and the first US acts on the final player's behalf, the US-society is rubust against invasion by SR, FR, PF, or PA (See Table 7).
5. The society consisting only of the PF or PA is also the best society. They are maintainable against invasion by FR, US. But, It is fragile against invasion by SE, SR (See Tables 8,9).

Based on the observations above, we can find that there is society where the players choose Defection when there are SE, SR, and it implies that the social welfare does not increase owing to pre-play game.

(3) Realization of social welfare solution

Now we discuss how to realize society without defectors when there are SE,SR. First, in the situation, FR, PF, or PA can realize the society without defectors when they are between SE and SR. In other words, it is important that there are those who are thougtful or have moral sense among the non-thougtfull people like SE, SR. This leads to preventing bad synergy effect-mutual defection- on SE,SR (See Fig6-1).

Table4.The result of SE

PLAYER1	PLAYER2	PLAYER3	TERN (OUTCOME) PUNISH OPPONENT
SE	SE	SE	6(NC)
SR	SE	SE	4(NC)
SE	SR	SE	4(NC)
SE	SE	SR	4(NC)
FR	SE	SE	4(NC)
SE	FR	SE	4(NC)
SE	SE	FR	5(NC)
USfor2	SE	SE	1(C,D,D)
SE	USfor1	SE	1(D,C,D)
SE	SE	USfor1	1(D,D,C)
USfor3	SE	SE	1(C,D,D)
SE	USfor3	SE	1(D,C,D)
SE	SE	USfor2	1(D,D,C)
PA	SE	SE	4(NC)2/4(NC)3
SE	PA	SE	4(NC)1/4(NC)3
SE	SE	PA	5(NC)1/5(NC)2
PF	SE	SE	5(D,N,N)2/3(D,N,N)3
SE	PF	SE	4(N,D,N)1/5(N,D,N)3
SE	SE	PF	6(N,N,D) 1/4(N,N,D)2

Table5.The result of SR

PLAYER1	PLAYER2	PLAYER3	TERN (OUTCOME) PUNISH OPPONENT
SR	SR	SR	4(NC)
SE	SR	SR	2(N,D,N)
SR	SE	SR	3(N,N,D)
SR	SR	SE	3(D,N,N)
FR	SR	SR	2(N,D,N)
SR	FR	SR	3(N,N,D)
SR	SR	FR	2(D,N,N)
USfor2	SR	SR	2(C,D,N)
SR	USfor1	SR	2(N,C,D)
SR	SR	USfor1	1(D,N,C)
USfor3	SR	SR	2(C,D,N)
SR	USfor3	SR	2(D,C,D)
SR	SR	USfor2	1(D,N,C)
PA	SR	SR	2(N,D,N)2/2(N,D,N)3
SR	PA	SR	3(N,N,D)1/3(N,N,D)3
SR	SR	PA	2(D,N,N,)1/1(D,N,C)2
PF	SR	SR	2(N,D,N)2/2(N,D,N)3
SR	PF	SR	2(N,C,D)1/3(N,N,D)3
SR	SR	PF	2(D,N,N)1/1(D,N,C)

Table6.The result of FR

PLAYER1	PLAYER2	PLAYER3	TERN (OUTCOME) PUNISH OPPONENT
FR	FR	FR	1(C,C,C)
SE	FR	FR	2(N,D,N)
FR	SE	FR	3(N,C,N)
FR	FR	SE	2(D,N,N)
SR	FR	FR	2(N,D,N)
FR	SR	FR	3(N,N,D)
FR	FR	SR	3(D,N,N)
USfor2	FR	FR	1(N,C,C)
FR	USfor1	FR	2(C,N,C)
FR	FR	USfor1	2(C,C,N)
USfor3	FR	FR	1(N,C,C)
FR	USfor3	FR	2(C,N,C)
FR	FR	USfor2	2(C,C,N)
PA	FR	FR	1(C,C,C)
FR	PA	FR	1(C,C,C)
FR	FR	PA	1(C,C,C)
PF	FR	FR	1(C,C,C)
FR	PF	FR	1(C,C,C)
FR	FR	PF	1(C,C,C)

Table7.The result of US

PLAYER1	PLAYER2	PLAYER3	TERN (FINAL DECESION) PUNISH OPPONENT
USfor2	USfor1	USfor1	2(N,C,C)
USfor2	USfor3	USfor1	2(N,N,C)
USfor2	USfor1	USfor2	2(N,C,N)
USfor2	USfor3	USfor2	2(N,N,C)
USfor3	USfor1	USfor1	2(N,C,C)
USfor3	USfor3	USfor1	2(N,N,C)
USfor3	USfor1	USfor2	2(N,C,N)
USfor3	USfor3	USfor2	2(N,N,C)
SE	USfor1	USfor1	1(D,C,C)
SE	USfor1	USfor2	1(D,C,C)
SE	USfor3	USfor1	1(D,C,C)
SE	USfor3	USfor2	1(D,C,C)
USfor2	SE	USfor1	1(C,D,C)
USfor2	SE	USfor2	1(C,C,D)
USfor3	SE	USfor1	1(C,D,C)
USfor3	SE	USfor2	1(C,D,C)
USfor2	USfor1	SE	1(C,C,D)
USfor2	USfor3	SE	1(C,C,D)
USfor3	USfor1	SE	1(C,C,D)
USfor3	USfor3	SE	1(C,C,D)
SR	USfor1	USfor1	1(D,C,C)
SR	USfor1	USfor2	2(C,N,C)
SR	USfor3	USfor1	1(D,C,C)
SR	USfor3	USfor2	1(D,C,C)
USfor2	SR	USfor1	1(C,D,C)
USfor2	SR	USfor2	1(C,C,D)
USfor3	SR	USfor1	1(N,N,C)
USfor3	SR	USfor2	1(N,N,C)
USfor2	USfor1	SR	2(C,C,D)
USfor2	USfor3	SR	2(C,C,D)
USfor3	USfor1	SR	2(C,N,N)
USfor3	USfor3	SR	2(C,C,D)
FR	USfor1	USfor1	2(C,N,N)
FR	USfor1	USfor2	2(C,N,C)
FR	USfor3	USfor1	2(C,N,N)
FR	USfor3	USfor2	2(C,N,C)
USfor2	FR	USfor1	1(N,C,C)
USfor2	FR	USfor2	2(C,C,N)
USfor3	FR	USfor1	1(N,C,C)
USfor3	FR	USfor2	2(N,C,N)
USfor2	USfor1	FR	1(N,C,C)
USfor2	USfor3	FR	2(N,N,C)
USfor3	USfor1	FR	1(N,C,C)
USfor3	USfor3	FR	2(N,N,C)
PA	USfor1	USfor1	2(C,N,N)
PA	USfor1	USfor2	2(C,N,C)
PA	USfor3	USfor1	2(C,N,N)
PA	USfor3	USfor2	2(C,N,C)
USfor2	PA	USfor2	1(N,C,C)
USfor2	PA	USfor1	1(N,C,C)
USfor3	PA	USfor2	2(N,C,N)
USfor3	PA	USfor1	1(N,C,C)
USfor2	USfor1	PA	1(N,C,C)
USfor2	USfor3	PA	2(N,N,C)
USfor3	USfor1	PA	1(N,C,C)
USfor3	USfor3	PA	2(N,N,C)
PF	USfor1	USfor1	2(C,N,N)
PF	USfor1	USfor2	2(C,N,C)
PF	USfor3	USfor1	2(C,N,N)
PF	USfor3	USfor2	2(C,N,C)
USfor2	PF	USfor1	1(N,C,C)
USfor2	PF	USfor2	1(N,C,C)
USfor3	PF	USfor1	1(N,C,C)
USfor3	PF	USfor2	2(N,C,N)
USfor2	USfor1	PF	1(N,C,C)
USfor2	USfor3	PF	2(N,N,C)
USfor3	USfor1	PF	1(N,C,C)
USfor3	USfor3	PF	2(N,N,C)

Table8.The result of PF

PLAYER1	PLAYER2	PLAYER3	TERN (OUTCOME) PUNISH OPPONENT
PF	PF	PF	1(C,C,C)
SE	PF	PF	2(N,D,N)
PF	SE	PF	3(D,N,N)
PF	PF	SE	2(D,N,N)
SR	PF	PF	2(N,D,N)
PF	SR	PF	3(N,N,D)
PF	PF	SR	2(D,N,N)
FR	PF	PF	1(C,C,C)
PF	FR	PF	1(C,C,C)
PF	PF	FR	1(C,C,C)
USfor2	PF	PF	1(N,C,C)
PF	USfor1	PF	2(C,N,C)
PF	PF	USfor1	2(C,C,N)
USfor3	PF	PF	1(N,C,C)
PF	USfor3	PF	2(C,N,C)
PF	PF	USfor2	2(C,C,N)
PA	PF	PF	1(C,C,C)
PF	PA	PF	1(C,C,C)
PF	PF	PA	1(C,C,C)

Table9.The result of PA

PLAYER1	PLAYER2	PLAYER3	TERN (OUTCOME) PUNISH OPPONENT
PA	PA	PA	1(C,C,C)
SE	PA	PA	2(N,D,N)
PA	SE	PA	3(D,N,N)
PA	PA	SE	2(D,N,N)
SR	PA	PA	2(N,D,N)
PA	SR	PA	3(N,N,D)
PA	PA	SR	2(D,N,N)
FR	PA	PA	1(C,C,C)
PA	FR	PA	1(C,C,C)
PA	PA	FR	1(C,C,C)
USfor2	PA	PA	1(N,C,C)
PA	USfor1	PA	2(C,N,C)
PA	PA	USfor1	2(C,C,N)
USfor3	PA	PA	1(N,C,C)
PA	USfor3	PA	2(C,N,C)
PA	PA	USfor2	2(C,C,N)
PF	PA	PA	1(C,C,C)
PA	PF	PA	1(C,C,C)
PA	PA	PF	1(C,C,C)

Second, the society without defectors is realized when FR is the first player, FR or PA is the third player, and SE is between them. In other words, when the leader is thoughtful and the last prevents action of non-thougtfull person, then it realizes. (See Fig6-2).

Finally, the society without defectors is realized in the case where the favors to others are placed a proportion and the first US acts on the final player's behalf when there is SR. In other words, we can see that there is a certain degree of thougtfulness of rationality to realize good society when there is the favor to others (See Fig6-3).

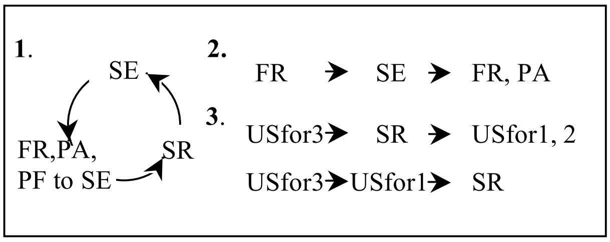

Fig6. Type of the society without defector

4. CONCLUSION AND FUTURE RESEARCH

In this paper we investigated a role of pre-play game. We found the society where only FR, PA, or PF exist achieves the social welfare solution. Moreover, it is equally strong against invasion by different types of action, while it is fragile against invasion by SE, SR player. One of the most important findings of this study is that some unique types of society are maintainable.

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