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Decision makers' attitude analysis

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ABSTRACT

The relative preferences for each decision maker (DM) over all feasible states are one of the most important information when modeling and analyzing a conflict. As DMs' preferences are usually the subjective judgments of DMs, DMs' attitudes may have significant influence on DMs' preferences as well as the outcome of the conflict. Specifically, DMs' preferences and state transitions can be changed when DMs hold positive, negative or neutral attitudes towards themselves and/or others. Thus, the resolution or equilibrium of a conflict may be different under different attitudes. When carrying outan attitude analysis, firstly, a specified dispute is studied without considering DMs' attitudes; secondly, the attitude analysis under the framework of Graph Model for Conflict Resolution is executed. As demonstrated by the study of a water resource controversy, attitude analysis methodology can be readily applied to real-world conflict to gain an enhanced strategic understanding when DMs' attitudes are not discrete.

KEYWORDS

Conflict analysis; Relative preferences; Decision makers; Attitude analysis.

INTRODUCTION

Conflicts arise in diverse contexts of human interaction. The Graph Model for Conflict Resolution (GMCR)[1,2] has been demonstrated to be a comprehensive and flexible methodology for systematically studying conflicts. It needs only decision makers' (DMs)relative preference information. Since relative preferences for each DM over all feasible states are one of the most important inputs to the modeling step of the graph model, many scholars have extended the basic GMCR framework through studying DMs' preferences. For instance, uncertain preference[3,4] was introduced into GMCR to analyze the strategic effects of preference uncertainty. As DMs' preferences are usually the subjective judgments of DMs, DMs' attitudes may have significant influence on DMs' preferences as well as the outcome of the conflict. Inohara et al.[5, 6] formally introduced DMs' attitudes analysis methodology under the framework of GMCR. Walker et al.[7] extended the attitude analysis approach to analyzeconflicts with coalition members. In fact, attitudes can be seen as an effective way of understanding how a DM will behave when he or she must take into account other DMs' preferences as well as his or her own preferences.

The objective of this research is to clearly demonstrate the direct connection between DMs' attitudes and their overall preferences through investigating a water reservoir capacity conflict. In Section 2, the structure of GMCR and formal definitions of attitudes with respect to various kinds of stability concepts, are introduced. Next, in Section 3, the attitude analysis methodology is illustrated using an application of attitudes to a water reservoir capacity conflict. Finally, in Section 4, appropriate conclusions are drawn and direction for future work is given.

GMCR AND ATTITUDE ANALYSIS METHOD

The framework of GMCR

A graph model for a strategic conflict with crisp preference information is generally represented as $G = \langle N, S, D, \{\succ_i, \backsim_i\}_{i\in N}\rangle$, where$N = \{1, 2, \dots, i, \dots, n-1, n\}$ is a set of DMs, $S = \{s_1, \dots, s_k, \dots, s_t, \dots, s_v, s_w\}$ indicates a set of feasible states, $D = \langle S, \{A_i\}_{i\in N}\rangle$ represents a set of directed graphs with node set S and oriented arcs $A_i \subseteq S \times S$. A crisp preference describes a DM's relative preference for one state over another, which is expressed in terms of a pair of binary relations "is (strictly) preferred to," $\succ$, and "is indifferent to," $\backsim$. Therefore, $\{\succ_i, \backsim_i\}_{i\in N}$ or $\{\succsim_i\}_{i\in N}$represents a set of preference relationships on S for each DM i.

Employing the graph model methodology to analyze a strategic conflict usually comprises two steps: first, conflict modeling, or specifying a graph with all the above-mentioned elements, and second, conducting stability analysis on the graph using stability concepts. Various types of movements among statesand solution concepts for analyzing conflicts are defined as follows.

Definition 1 (reachable list)

For $i \in N$ and state $s_k \in S$, DM i's reachable list from state s_k is the set $\{s_t \in S | (s_k, s_t) \in A_i\}$, denoted by $R_i(s_k) \subset S$.

Definition 2 (unilateral improvement (UI) list for a DM)

For $i \in N$ and state $s_k \in S$,DM i's UI list from state s_k is the set $\{s_t \in R_i(s_k) |\ s_t \succ_i s_k\}$, denoted by $R_i^+(s_k) \subset S$.

Definition 3 (Reachable list of a coalition)

For $H \subseteq N$ and $s_k \in S$, the reachable list of coalition H from state s_k is defined inductively as the set $R_H(s_k)$ that satisfies the two conditions: (i) if $i \in H$ and $s_t \in R_i(s_k)$, then $s_t \in R_H(s_k)$, and (ii) if $i \in H$ and $s_t \in R_H(s_k)$ and $s_w \in R_i(s_t)$, then $s_w \in R_H(s_k)$.

Definition 4 (Unilateral improvement list of a coalition)

For $H \subseteq N$ and $s_k \in S$, the strictly unilateral improvement list of H from state s_k is defined inductively as the set $R_H^+(s_k)$ that satisfies the two conditions: (i) if $i \in H$ and $s_t \in R_i^+(s_k)$, then $s_t \in R_H^+(s_k)$, and (ii) if $i \in H$ and $s_t \in R_H^+(s_k)$ and $s_w \in R_i^+(s_t)$, then $s_w \in R_H^+(s_k)$.

Definition 5 (Set of less or equally preferred states)

For $i \in N$ and state $s_k \in S$, the set of all states that are less preferred or equally preferredtostate$s_k$byDM$i$is$\phi_i^{\simeq}(s_k) = \{s_t \in S | s_k \succsim_i s_t\}$.

Definition 6 (Nash stability (Nash))

For $i \in N$, state $s_k \in S$ is Nash stable for DM i, denoted by $s_k \in S_i^{Nash}$, if and only if $R_i^+(s_k) = \phi$.

Definition 7 (General metarationality (GMR))

For $i \in N$, state $s_k \in S$ is general metarational for DM i, denoted by $s_k \in S_i^{GMR}$, if and only iffor all$s_t \in R_i^+(s_k)$, $R_{N\setminus i}(s_t) \cap \phi_i^{\simeq}(s_k) \neq \phi$.

Definition 8 (Symmetric metarationality (SMR))

For $i \in N$, state $s_k \in S$ is symmetric metarational for DM i, denoted by $s_k \in S_i^{SMR}$, if and only iffor all$s_t \in R_i^+(s_k)$, there exists $s_v \in R_{N\setminus i}(s_t) \cap \phi_i^{\simeq}(s_k)$ such that $s_w \in \phi_i^{\simeq}(s_k)$ for all $s_w \in R_i(s_v)$.

Definition 9 (Sequential stability (SEQ))

For $i \in N$, state $s_k \in S$ is sequentially stable for DM i, denoted by $s_k \in S_i^{SEQ}$, if and only iffor all$s_t \in R_i^+(s_k)$, $R_{N\setminus\{i\}}^+(s_t) \cap \phi_i^{\simeq}(s_k) \neq \phi$.

Attitudes under GMCR

Following the framework in [25], three types of attitudes, positive, negative, and neutral attitudes, are considered in this paper. Moreover, the positive, negative, and neutral attitudes of a DM toward others derive "altruistic", "sadistic", and "apathetic" behaviors, respectively, and those toward her/himself derive "selfish", "masochistic", and "selfless" behaviors, respectively. TABLE 1 shows these assumptions on the relationships between attitudes and DMs' behavior.

TABLE 1 : Relationships between attitudes and behaviors

Types	Attitudes	
	Toward others	**Toward her/himself**
Positive	altruistic	selfish
Negative	sadistic	masochistic
Neutral	apathetic	selfless

Developed in[5] and further explained in[6], the attitudes analysis within the framework of GMCR allows DMs or conflict analysts to determine the impact on a conflict outcome that may arise when a DM takes other DMs' preferences into account. The following definition provides a formal structure for this concept.

Definition 10 (Attitudes)

For $i \in N$, the attitude of DM i is $e_i = (e_{ij})_{j\in N}$, where $e_{ij} \in \{+, 0, -\}$ for $j \in N$. $e_{ij}$is named the attitude of DM i to DM j.

A list $e = (e_i)_{i\in N}$ of attitudes e_i of DM i for each $i \in N$, is said to be totally positive, if and only if $e_{ij} = +$ for all $i, j \in N$ (see Figure 1). Similarly, $e = (e_i)_{i\in N}$ is said to be totally negative, if and only if $e_{ij} = -$ for all $i, j \in N$ (see Figure 2). $e = (e_i)_{i\in N}$is said to be discrete, if and only if $e_{ij} = +$ for all $i \in N$ and $e_{ij} = +$ for all $i, j \in N$ such that $i \neq j$ (see Figure 3), and is said to be totally neutral, if and only if $e_{ij} = 0$ for all $i, j \in N$ (see Figure 4).

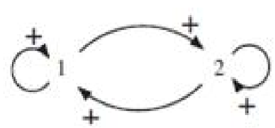

Figure 1 : Totally positive attitudes for DM1 and DM2

Figure 2 : Totally negative attitudes for DM1 and DM2

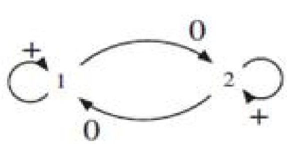

Figure 3 : Discrete attitudes for DM1 and DM2

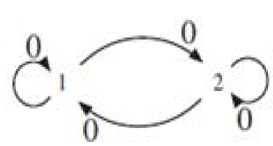

Figure 4 : Totally neutral attitudes for DM1 and DM2

Definition 11 (devoting preference (DP) on S)

For $i, j \in N$, the devoting preference of DM i to DM j, denoted by DP_{ij}, is defined as for $s_k, s_t \in S$, $s_k \mathrm{DP}_{ij} s_t$ if and only if $s_k \gtrsim_j s_t$.

Definition 12 (aggressive preference (AP) on S)

For $i, j \in N$, the aggressive preference of DM i to DM j, denoted by AP_{ij}, is defined as for $s_k, s_t \in S$, $s_k \mathrm{AP}_{ij} s_t$ if and only if $s_t \gtrsim_j s_k$.

Definition 13 (relational preference (RP) on S)

For $i, j \in N$, the relational preference $\mathrm{RP(e)}_{ij}$ of DM i to DM j at e is defined as follows:

$$\mathrm{RP(e)}_{ij} = \begin{cases} \mathrm{DP}_{ij} \; if \; e_{ij} = + \\ \mathrm{AP}_{ij} \; if \; e_{ij} = - \\ I_{ij} \; if \; e_{ij} = 0 \end{cases}$$

whereI_{ij} denotes that DM i is indifferent with respect to DM j's preference and, hence, $s_k I_{ij} s_t$ means that DM i's preferences between state s_k and s_t is not influenced by DM j's preference. Here, the types of preferences are matched with the three different attitudes. If DM i has a positive or negative attitude towards DM j, DM i will have a devoting or aggressive preference with respect to DM j, respectively. Thus, a DM behaves according to his or her attitudes.

Definition 14 (totally relational preference (TRP) on S)

The totally relational preference of DM i at e, denoted by $TRP(e)_i$, is defined as for $s_k, s_t \in S$,$s_k TRP(e)_i s_t$ if and only if $s_k \mathrm{RP}(e)_{ij} s_t$ for all $j \in N$.

A state satisfies a total relational preference for the situation in which it is a relational preference for DM i according to the attitudes of DM i towards all of the DMs in the conflict. Thus, if a state s_k is a relational preference by DM i to state s_t with respect to himself and DM j, and there are only the two DMs in the conflict, then state s_k is a total relational preference by DM i relative to state s_t.

Definition 15 (Totally Relational Reply (TRR) List)

The totally relational reply list of DM i at e from $s_k \in S$ is defined as the set $\{s_t \in R_i(s_k) \cup \{s\} | s_k TRP(e)_i s_t\}$, denoted by $TRR(e)_i(s_k)$.

Definition 16 (totally relational reply list of coalition)

The totally relational reply list of coalition $H \subseteq N$ at e from $s_k \in S$ is defined inductively, under the restriction in which a DM can only move once at a time, as the set $TRR(e)_H(s_k)$ that satisfies the next two conditions: (i) if $i \in H$ and $s_t \in TRR(e)_i(s_k)$, then $s_t \in TRR(e)_H(s_k)$, and (ii) if $i \in H$ and $s_t \in TRR(e)_H(s_k)$ and $s_w \in TRR(e)_H(s_t)$, then $s_w \in TRR(e)_H(s_k)$.

Definition 17 (relational less preferred or equally preferred states)

For $i \in H$ and $s_k, s_t \in S$, the set of all states that are relationally less preferred or equally preferred to state s_k by DM i (under attitude e) is $R\phi^{\simeq}(e)_i s_k = \{s_t \in S | s_t = s_k \; or \; NE(s_t TRP(e)_i s_k)\}$, where NE denotes "not".

Relational stability concepts

Employing the above definitionswhich lay out the framework of relational moves and preferences, relational solution concepts when attitudes are taken into account can now be defined as follows.

Definition 18 (relational nash stability (RNash))

For $i \in N$, state $s_k \in S$ is relational Nash stable at e for DM i, denoted by $s_k \in S_i^{RNash(e)}$, if and only if $TRR(e)_i(s_k) = \{s_k\}$.

Definition 19 (Relational general metarationality (RGMR))

For $i \in N$, state $s_k \in S$ is relational general metarationality at e for DM i, denoted by $s_k \in S_i^{RGMR(e)}$, if and only if for all $s_t \in TRR(e)_i(s_k) \backslash \{s_k\}$, $R_{N\backslash\{i\}}(s_t) \cap R\phi^{\simeq}(e)_i s_k \neq \phi$.

Definition 20 (Relational symmetric metarationality (RSMR))

For $i \in N$, state $s_k \in S$ is relational symmetric metarationality at e for DM i, denoted by $s_k \in S_i^{RSMR(e)}$, if and only if for all $s_t \in TRR(e)_i(s_k) \backslash \{s_k\}$, there exists $s_v \in R_{N\backslash\{i\}}(s_t) \cap R\phi^{\simeq}(e)_i s_k$, such that $s_w \in R\phi^{\simeq}(e)_i s_k$ for all $s_w \in R_i(s_v)$.

Definition 21 (Relational sequential stability (RSEQ))

For $i \in N$, state $s_k \in S$ is relational general metarationality at e for DM i, denoted by $s_k \in S_i^{RGMR(e)}$, if and only if for all $s_t \in TRR(e)_i(s_k) \backslash \{s_k\}$, $TRR(e)_{N\backslash\{i\}}(s_t) \cap R\phi^{\simeq}(e)_i s_k \neq \phi$.

APPLICATIONTOA WATERRESOURCE CONFLICT

The construction of large multi-purpose reservoirs usually involve many parties, and those parties often have dispute on the capacity of reservoir, because each party has his/her own proposal or strategy which is beneficial for himself/herself but is not always favored by other parties. This kind of conservations can be properly modeled and analyzed using GMCR to calculate or predict the resolution which might be accepted by all parties.

The conflict about the capacity of a large reservoir was studied using F-H methodology in[8]. A reservoir going to be constructed will lead to many kinds of benefits such as power generation, flood control, shipping and so on. But it also needs investment, and the upstream area might bare flood losses. The upstream and the downstream of the reservoir is province A and province B, respectively. Province A prefers to set a small flood control capacity for the reservoir to reduce flood damage, while province B is willing to set a large flood control capacity in order to get more benefits like flood control benefit. Thus, there is a dispute between province A and province B.GMCR method is employed to analyze the conflict in this paper. GMCR is developed based on F-H conflict analysis method, but it is much more mature, intuitive, and convenient than F-H method.

Conflict modeling

(1) Decision Makers and Options. Two DMs are involved in the conflict: province A (DM_1) and province B (DM_2). Province A possesses two options: A_1—Build the reservoir and leave no more than 1 billion m^3 of flood control capacity; A_2—Built the reservoir and set up 2 billion m^3 of flood control capacity without any economic compensation on temporary flooding. Province B holds three courses of action: B_1—Build the reservoir and set not less than 2 billion m^3 of flood control capacity through increasing the investment to give province A certain amount of compensation; B_2—Reinforce the embankments; B_3—Set up flood detention zone.

(2) Feasible States. From a logical point of view, the conflict between two DMs, with a total of five options will produce $2^5 = 32$ states. However, some states are infeasible in reality. For instance, province A can not choose two options at the same time; province B will at least select one option in order to control flood. Finally, ten feasible states remain after all infeasible ones being removed, as shown in TABLE 2. The left column in the TABLE lists the two DMs while the second column contains the options controlled by each DM. Each of the ten columns on the right hand side in TABLE 2represents a feasible state, or option combination: "Y" means the option is selected by the DM controlling it; and "N" indicates that it is not taken. All option combinations not shown are infeasible. In state s_1, for example, DM 1 has selected option A_2, and DM 2 has taken option B_1.

TABLE 2 : DMs, options and feasible states of the reservoir capacity conflict

DMs	Options	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}
DM 1	A_1	N	N	Y	N	N	Y	N	N	Y	N
	A_2	Y	N	N	Y	N	N	Y	N	N	Y
DM 2	B_1	Y	N	N	Y	N	N	Y	N	N	Y
	B_2	N	Y	Y	Y	N	N	N	Y	Y	Y
	B_3	N	N	N	N	Y	Y	Y	Y	Y	Y

(3) Graph Model. Figure 5 displays the integrated graph model of the reservoir capacity conflict for which the moves controlled by a given DM are indicated by the type of line that is drawn. The circles represent the feasible states. The directed arcs represent the transitions between states under the control of the corresponding DM. The arc tails represent the initial states, and the arrowheads represent the reachable states moved from the initial states. Notice that DM 1, for example, can cause the conflict to move from state s_2 to s_3 by changing its option selection from no option to option A_1, as indicated in states s_2 and s_3 in TABLE 2 for which the option selections of the DM 2 remain fixed.

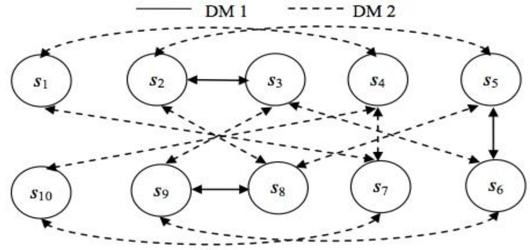

Figure 5 : The integrated graph model of the reservoir capacity conflict

(4) Preferences Information. Overcoming the difficulty for DM to order all states from most preferred to least preferred directly, as well as considering the fuzziness of DMs' judgments, literature[8] presented the preferences of DM 1 and DM 2 as shown in TABLE 3 based on their fuzzy preference information. See[8] for more details.

TABLE 3 : Fuzzy preferences result

DMs	Preferences
DM 1	$s_3 \succ s_6 \succ s_9 \succ s_4 \succ s_1 \succ s_7 \succ s_{10} \succ s_5 \succ s_8 \succ s_2$
DM 2	$s_1 \succ s_3 \succ s_6 \succ s_9 \succ s_2 \succ s_5 \succ s_4 \succ s_7 \succ s_8 \succ s_{10}$

Regular stability analysis

TABLE 4 shows each DM's preference information $\succ_i s$, unilateral transfer states $R_i(s)$ and unilateral improvement states $R_i^+(s)$, where " - " indicates no state. In TABLE 4, "$\succ_i s$" represents the states which are superior to the current state s for DM i, which can be obtained by the preference information in TABLE 4. $R_1^+(s)$(the fourth column) is the intersection of $\succ_1 s$ (the second column) and $R_1(s)$ (the third column); $R_2^+(s)$ (the seventh column) is the intersection of $\succ_2 s$(the fifth column) and $R_2(s)$ (the sixth column).

TABLE 4 : Preference and unilateral moves and improvements

s	$\succ_1 s$	$R_1(s)$	$R_1^+(s)$	$\succ_2 s$	$R_2(s)$	$R_2^+(s)$
s_1	s_3, s_4, s_6, s_9	-	-	-	s_4, s_7	-
s_2	$s_1, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_3	s_3	s_1, s_3, s_6, s_9	s_5, s_8	-
s_3	-	s_2	-	s_1	s_6, s_9	-
s_4	s_3, s_6, s_9	-	-	$s_1, s_2, s_3, s_5, s_6, s_9$	s_1, s_7, s_{10}	s_1
s_5	$s_1, s_3, s_4, s_6, s_7, s_9, s_{10}$	s_6	s_6	s_1, s_2, s_3, s_6, s_9	s_2, s_8	s_2
s_6	s_3	s_5	-	s_1, s_3	s_3, s_9	s_3
s_7	s_1, s_3, s_4, s_6, s_9	-	-	$s_1, s_2, s_3, s_4, s_5, s_6, s_9$	s_1, s_4, s_{10}	s_1, s_4
s_8	$s_1, s_3, s_4, s_5, s_6, s_7, s_9, s_{10}$	s_9	s_9	$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_9$	s_2, s_5	s_2, s_5
s_9	s_3, s_6	s_8	-	s_1, s_3, s_6	s_3, s_6	s_3, s_6
s_{10}	$s_1, s_3, s_4, s_6, s_7, s_9$	-	-	$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9$	s_4, s_7	s_4, s_7

Based on TABLE 4, the stability analysis of the conflict can be carried out by employing the four stability concepts (Nash, GMR, SMR, SEQ), with the results as shown in TABLE 5. In TABLE 5, "Δ" indicates that under a certain stability definition, a state is a stable state for a particular DM, while "●" indicates that under a certain stability definition, a state is a stable state for all DMs. A state is a stable state for a DM, if and only if under a particular stability concept, the DM is not willing to transfer to any other state from the current state. If a state is a stable state for all DMs, then the state constitutes a solution or equilibrium of the conflict. From TABLE 5, one can see that state s_1 (DM 1 selects option A_2, DM 2 takes B_1) and state s_3 (DM 1 chooses A_1, DM 2 takes B_2) are strongly stable states (strong stability refers to a stable state which is stable for all DMs under all the four stability concepts), states s_6 and s_9 are weakly stable states (only satisfy GMR and SMR stability).

TABLE 5 : Stability analysis results

s	RNash			RGMR			RSMR			RSEQ		
	DM1	DM2	RE	DM1	DM2	RE	DM1	DM2	RE	DM1	DM2	RE
s_1	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
s_2		Δ			Δ			Δ			Δ	
s_3	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
s_4	Δ			Δ			Δ			Δ		
s_5												
s_6	Δ			Δ	Δ	●	Δ	Δ	●	Δ		
s_7	Δ			Δ			Δ			Δ		
s_8												
s_9	Δ			Δ	Δ	●	Δ	Δ	●	Δ		
s_{10}	Δ			Δ			Δ			Δ		

Attitude analysis

DMs' attitudes may have significant impacts on the preference information as well as the revolution of a conflict. Therefore, in order to get a better understanding of the reservoir capacity conflict, further attitude analysis within the framework of GMCR is needed. Generally, most DMs in reality are selfish toward him/herself, but not nessecerrily sadistic toward others. This discrete attitude is suitable for the DMs in the reservior capacity conflict as well, where both DM 1 and DM 2 hold positive attitude toward him/herself and neutral attitude toward others. When taking DMs' attitudes into account within the framework of GMCR, the aforementioned relational stability concepts (RNash, RGMR, RSMR, RSEQ) are employed to carry out stability analysis after caculating DMs' relational preference information and relational unilateral moves according to DMs' attitudes.

When considering DMs' attitudes, DMs will take both their owns' and others' preference information into account. TABLE 6 shows DMs' relational preference information and unilateral moves when all DMs hold discrete attitudes. From TABLE 6, one can see that $TRP_1(s)$ and $TRP_2(s)$ in TABLE 6 are equal to $\succ_1 s$ and $\succ_2 s$ in TABLE 4, respectively. $TRR_1(s)$and$TRR_2(s)$ in TABLE 6 are equal to $R_1^+(s)$ and $R_2^+(s)$ in TABLE 4, respectively. Which means that the relational preference information under discrete attitude is the same with the preference information without considering DMs' attitudes, and the relational unilateral moves under discrete attitude are not different from the unilateral improvements in the general conflict model. Therefore, it is not simply a coincidence to find that the stability analysis results when considering DMs' discrete attitudes and when not considering DM's attitude are indifferent——still states s_1 and s_3 are the equilibia. Which also demonstrates that discrete attitudes are assumed in the general graph model.

TABLE 6 : Relational preference and relational moves

e	$e_{11} = +, e_{12} = 0$		$e_{22} = +, e_{21} = 0$	
s	$TRP_1(s)$	$TRR_1(s)$	$TRP_2(s)$	$TRR_2(s)$
s_1	s_3, s_4, s_6, s_9	-	-	-
s_2	s_1, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}	s_3	s_1, s_3, s_6, s_9	-
s_3	-	-	s_1	-
s_4	s_3, s_6, s_9	-	s_1, s_2, s_3, s_5, s_6, s_9	s_1
s_5	s_1, s_3, s_4, s_6, s_7, s_9, s_{10}	s_6	s_1, s_2, s_3, s_6, s_9	s_2
s_6	s_3	-	s_1, s_3	s_3
s_7	s_1, s_3, s_4, s_6, s_9	-	s_1, s_2, s_3,s_4, s_5, s_6, s_9	s_1, s_4
s_8	s_1, s_3, s_4, s_5, s_6, s_7, s_9, s_{10}	s_9	s_1, s_2, s_3,s_4, s_5, s_6,s_7, s_9	s_2, s_5
s_9	s_3, s_6	-	s_1, s_3, s_6	s_3, s_6
s_{10}	s_1, s_3, s_4, s_6, s_7, s_9	-	s_1,s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9	s_4, s_7

In order to analyze DMs' different attitudes may have significant influences on DMs' preference information and the conflict analysis results, attitude analysis when DMs have totally positive attitudes, totally negative attitudes, and totally neutral attitudes are conducted respectively.

When all DMs' attitudes are totally positive, DMs' totally relational preferences and totally relational reply information are as shown in TABLE 7. As can be seen from TABLE 7, two DMs have equal totally relational preference ($TRP_1(s) = TRP_2(s)$), which is the intersection between $\succ_1 s$and $\succ_2 s$. $TRR_1(s)$is the intersection of $TRP_1(s)$ and $R_1(s)$; $TRR_2(s)$ is the intersection of $TRP_2(s)$ and $R_2(s)$. By performing stability calculations, the stability analysis results are as shown in TABLE 10. Besides states s_1 and s_3, s_4 (DM 1 selects option A_2, DM 2 chooses options B_1 and B_2 together) becomes a possible equilibrium as well. Which shows that when both DMs hold a positive, cooperative attitude in the negotiation, the conflict will be more likely to be solved effectively.

When all DMs' attitudes are totally negative, DMs' totally relational preferences and totally relational reply information are as shown in TABLE 8. As can be seen from TABLE 8, two DMs have equal totally relational preference ($TRP_1(s) = TRP_2(s)$) as well, but it is the complementary set of both $\succ_1 s$and $\succ_2 s$. $TRR_1(s)$is the intersection of $TRP_1(s)$ and $R_1(s)$; $TRR_2(s)$ is the intersection of $TRP_2(s)$ and $R_2(s)$. The stability analysis results are as shown in TABLE 10 as well. One can see that the equilibia are states s_2 (No option is selected by DM 1, DM 2 takes option B_2), s_8 (No option is selected by DM 1, DM 2 takes options $B_2$and B_3), and s_{10} (DM 1 selects option A_2, DM 2 chooses options B_1, B_2, and B_3 together). Which shows that when both DMs hold a negative, uncooperative attitude in the negotiation, the conflict will develop more likely towards the bad directions.

TABLE 7 : Relational preference and relational moves

e	$e_{11}=+, e_{12}=+$		$e_{22}=+, e_{21}=+$	
s	$TRP_1(s)$	$TRR_1(s)$	$TRP_2(s)$	$TRR_2(s)$
s_1	-	-	-	-
s_2	s_1, s_3, s_6, s_9	s_3	s_1, s_3, s_6, s_9	-
s_3	-	-	-	-
s_4	s_3, s_6, s_9	-	s_3, s_6, s_9	-
s_5	s_1, s_3, s_6, s_9	s_6	s_1, s_3, s_6, s_9	-
s_6	s_3	-	s_3	s_3
s_7	s_1, s_3, s_4, s_6, s_9	-	s_1, s_3, s_4, s_6, s_9	s_1, s_4
s_8	$s_1, s_3, s_4, s_5, s_6, s_7, s_9$	s_9	$s_1, s_3, s_4, s_5, s_6, s_7, s_9$	s_5
s_9	s_3, s_6	-	s_3, s_6	s_3, s_6
s_{10}	$s_1, s_3, s_4, s_6, s_7, s_9$	-	$s_1, s_3, s_4, s_6, s_7, s_9$	s_4, s_7

TABLE 8 : Relational preference and relational moves

e	$e_{11}=-, e_{12}=-$		$e_{22}=-, e_{21}=-$	
s	$TRP_1(s)$	$TRR_1(s)$	$TRP_2(s)$	$TRR_2(s)$
s_1	$s_2, s_5, s_7, s_8, s_{10}$	-	$s_2, s_5, s_7, s_8, s_{10}$	s_7
s_2	-	-	-	-
s_3	$s_2, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_2	$s_2, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_6, s_9
s_4	s_7, s_8, s_{10}	-	s_7, s_8, s_{10}	s_7, s_{10}
s_5	s_8	-	s_8	s_8
s_6	$s_2, s_4, s_5, s_7, s_8, s_9, s_{10}$	s_5	$s_2, s_4, s_5, s_7, s_8, s_9, s_{10}$	s_3, s_9
s_7	s_8, s_{10}	-	s_8, s_{10}	s_{10}
s_8	-	-	-	-
s_9	$s_2, s_4, s_5, s_7, s_8, s_{10}$	s_8	$s_2, s_4, s_5, s_7, s_8, s_{10}$	-
s_{10}	-	-	-	-

When all DMs' attitudes are totally neutral, DMs' totally relational preferences and totally relational reply information are as shown in TABLE 9. As both DMs are indifferent to their own utilities as well as their adversaries', both of them have equal preferences over all states. And as a result, they have equal totally relational preference ($TRP_1(s) = TRP_2(s)$) which is the complementary set of s. From the stability analysis results as shown in TABLE 10, one can see that no equilibrium state exists. This result shows that DMs' sufficient preferences information is vital and necessary inputs to run stability analysis.

TABLE 9 : Relational preference and relational moves

e	$e_{11}=0, e_{12}=0$		$e_{22}=0, e_{21}=0$	
s	$TRP_1(s)$	$TRR_1(s)$	$TRP_2(s)$	$TRR_2(s)$
s_1	$s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	-	$s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_4, s_7
s_2	$s_1, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_3	$s_1, s_3, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_5, s_8
s_3	$s_1, s_2, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_2	$s_1, s_2, s_4, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_6, s_9
s_4	$s_1, s_2, s_3, s_5, s_6, s_7, s_8, s_9, s_{10}$	-	$s_1, s_2, s_3, s_5, s_6, s_7, s_8, s_9, s_{10}$	s_1, s_7, s_{10}
s_5	$s_1, s_2, s_3, s_4, s_6, s_7, s_8, s_9, s_{10}$	s_6	$s_1, s_2, s_3, s_4, s_6, s_7, s_8, s_9, s_{10}$	s_2, s_8
s_6	$s_1, s_2, s_3, s_4, s_5, s_7, s_8, s_9, s_{10}$	s_5	$s_1, s_2, s_3, s_4, s_5, s_7, s_8, s_9, s_{10}$	s_3, s_9
s_7	$s_1, s_2, s_3, s_4, s_5, s_6, s_8, s_9, s_{10}$	-	$s_1, s_2, s_3, s_4, s_5, s_6, s_8, s_9, s_{10}$	s_1, s_4, s_{10}
s_8	$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_9, s_{10}$	s_9	$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_9, s_{10}$	s_2, s_5
s_9	$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_{10}$	s_8	$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_{10}$	s_3, s_6
s_{10}	$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9$	-	$s_1, s_2, s_3, s_4, s_5, s_6, s_7, s_8, s_9$	s_4, s_7

TABLE 10 : Relational stability analysis results

e	s	RNash			RGMR			RSMR			RSEQ		
		DM1	DM2	RE	DM1	DM2	RE	DM1	DM2	RE	DM1	DM2	RE
	s_1	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
	s_2		Δ			Δ			Δ			Δ	
	s_3	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
$e_{11} = +$	s_4	Δ			Δ			Δ			Δ		
$e_{12} = 0$	s_5												
$e_{22} = +$	s_6	Δ			Δ	Δ	●	Δ	Δ	●	Δ		
$e_{21} = 0$	s_7	Δ			Δ			Δ			Δ		
	s_8												
	s_9	Δ			Δ	Δ	●	Δ	Δ	●	Δ		
	s_{10}	Δ			Δ			Δ			Δ		
	s_1	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
	s_2		Δ			Δ			Δ			Δ	
	s_3	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
$e_{11} = +$	s_4	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
$e_{12} = +$	s_5		Δ			Δ			Δ			Δ	
$e_{22} = +$	s_6	Δ			Δ	Δ	●	Δ	Δ	●	Δ		
$e_{21} = +$	s_7	Δ			Δ			Δ			Δ		
	s_8												
	s_9	Δ			Δ	Δ	●	Δ	Δ	●	Δ		
	s_{10}	Δ			Δ						Δ		
	s_1	Δ			Δ			Δ			Δ		
	s_2	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
	s_3												
$e_{11} = -$	s_4	Δ			Δ			Δ			Δ		
$e_{12} = -$	s_5	Δ			Δ	Δ	●	Δ	Δ	●	Δ		
$e_{22} = -$	s_6												
$e_{21} = -$	s_7	Δ			Δ			Δ			Δ		
	s_8	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
	s_9		Δ			Δ			Δ			Δ	
	s_{10}	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●	Δ	Δ	●
	s_1	Δ			Δ			Δ			Δ		
	s_2												
	s_3												
$e_{11} = 0$	s_4	Δ			Δ			Δ			Δ		
$e_{12} = 0$	s_5												
$e_{22} = 0$	s_6												
$e_{21} = 0$	s_7	Δ			Δ			Δ			Δ		
	s_8												
	s_9												
	s_{10}	Δ			Δ			Δ			Δ		

Note that different DMs may have different attitudes in a conflict model. Take the water reservoir capacity conflict for example, DM 1 may hold discrete attitude, while DM 2 might be positive towards himself and negative towards DM 1. Similar to all the above mentioned attitude analysis procedure, one can take attitude analysis under any attitudes combinations.

CONCLUTIONS

DMs' attitude analysis is introduced under the framework of GMCR, and then applied to analyze a water reservoir capacity conflict to get more strategic insights. The analysis results show that DMs' attitudes can have significant effect on DMs' preferences information as well as conflict resolutions, since DMs have to take both themselves' and others' preferences information into account in attitude analysis procedure. Thus, conflict analysis results that are more consistent with realities can be obtained through DMs' attitude analysis. Generally, DMs' positive attitude (either to himself or others) will contribute to the effective solve of a conflict. In addition, attitude analysis can detect the stability and applicability of equilibrium, as well as the robustness of a conflict analysis model. The situations when both DMs hold totally positive, totally negative, totally neutral, and discrete attitudesare analyzed in this paper, but DMs' other attitude combinations are not taken into account here.

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