A Game-theoretical Model For Selecting a Site of Non-preferred Waste Facilities

Seong Ho KIM, Tae-Woon KIM
Korea Atomic Energy Research Institute
well48@hanmir.com

In the present work, a game-theoretic model (GTM) as a tool of conflict analysis is proposed for multiplayer multicriteria decision-making problems in a conflict situation. The developed GTM is used for obtaining the most possible resolutions in the conflict among multiple decision makers. The GTM is based on directed graph structure and solution concepts. To demonstrate the performance of the GTM, using a numerical example, the GTM is applied to an environmental conflict problem, especially a non-preferred waste disposal siting conflict available in the literature. It is found that with GTM the states in equilibrium can be recognized.

The conflict under consideration is to select a site of non-preferred waste facilities. The government is to choose a site of installation for users of a toxic waste disposal facility. A certain time-point of interest is a period of time to select one of candidate sites that completely meet regular criteria of governmental body in charge of permitting a facility site. The facility siting conflict among multiple players (i.e., decision-makers, DMs) of concern is viewed as a multiple player-multiple criteria (MPMC) domain. For instance, three possible sites (i.e., site A, site B, and site C) to be selected by multiple players are characterized by the building cost, accessibility, and proximity to the residential area. Concerning the site A, the installation of a facility is not expensive, the accessible to a facility is easy, and the site A is located very near a residential area. Concerning site B, the facility is expensive to build, the facility is easily accessible, and the site is located near the residential area. Concerning site C, the installation cost is expensive, the accessibility is difficult, and the location of site is far from the residential area. In simple models, three main groups of players could be considered to be the government, users, and local residents. The government is to play a role as one of proponents or developers of the facility. Users are to use and maintain the disposal facility, if the government installs a facility. Local residents are concerning about the possible environmental impact of the facility on their health and properties. Furthermore, the options (i.e., courses of possible actions) should be identified for each player group. The main objectives of this work are firstly to propose a game-theoretic model for applying to a government-public conflict and secondly to demonstrate the applicability of the proposed method using a conflict case, the site selection of a toxic waste disposal facility among multiple participants in conflict [Fang et al. 1996].

Players: The set of DMs can be expressed by DM={DM1, DM2, DM3}, where DM1=government, DM2=users of the facility, and DM3=residents. **Options**: The set of options, O={O1, O2, O3} is composed of options for the government, users, and residents, respectively. Here O1={select site A, select site B, select site C} for government, O2={support the government's selection} for users, and O3={oppose the government's selection} for residents. Based on the modeled opinions for three players, each player's strategies are obtained. Using 1s and 0s, the strategies are represented. Here a 1 denotes that an option is taken by a player, whereas a 0 indicates that it is not taken. Therefore, an outcome is viewed as the situation where each of players selects a strategy. To identify feasible states out of possible states, the inspection method is used for this conflict problem. Among possible states, logically infeasible sets of outcomes for the government such as (110,-,-), (101,-,-), (011,-,-), and (111,-,-) are removed as the government cannot choose two or more sites for a facility. Here a dash means that the it does not matter whether a option is taken or not. **Preferences**: The ordinal scale for representing various levels of preference [Cook and Kress 1991] with respect to each DM is employed to obtain a preference vector. In the preference vector for each player, the outcomes are ordered from most preferred on the left to least preferred on the right. The player's viewpoint is incorporated into each preference vector.

In the present work, the game-theoretic model, based on the solution concepts in the framework of directed graph structure [Fang et al.1993], is applied to a conflict situation. Here, the solution concepts such as Nash rationality (NR), sequential sanction (SEQ), general meta-rationality (GMR), and symmetric meta-rationality (SMR) are considered to define players' **possible behavior** in the decision-making conflict associated with multiple players. The GTM can be implemented according to three stages as follows: (1) the data processing stage, (2) the structure modeling stage, and (3) the stability evaluating stage. At the data stage, the preference information such as preference rating of alternatives is represented by payoff functions for each player. At the structure stage, directed graphs for all players are constructed using vertices representing feasible states as well as arcs indicating **unilateral moves** among states. At the stability stage, for each player, the stability of states is checked using different definitions of stability. The outputs are **the individual stabilities** of state for each player and **the overall equilibriums** for all players. The readers having interest in detail of technical procedure might refer to a book [Chapter 3, Fang et al. 1993].

It is found that the state 10, (001,1,0), that is, government selects site C, users support it, and residents do not oppose it, is Nash rational for each player. Regarding overall equilibrium, state 10 is an equilibrium under Nash, GMR, SEQ definitions. States 4/6/8/10 are equilibriums under GMR and SMR definitions. Therefore, state 10 is the most likely resolution to this conflict.

Using a game-theoretic model, waste disposal facility siting decision making is handled in the conflict among the installation government, users, and local residents. In evaluating a case example, the performance of the proposed GTM as a tool of the conflict analysis. It is found that with GTM the state 10 is equilibrium. For the future work, a real conflict problem of nuclear waste facilities will be modeled to demonstrate the applicability of the proposed game-theoretic model.

References

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