Analyzing Conflicts of Implementing High-Speed Railway Project in Central Asia Using Graph Model

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Abstract. Conflicts arise when the proposed construction of a high-speed railway project in Central Asia affects the interests of Central Asian nations located along the route. By considering the national governments in Central Asia as decision makers, their possible actions in dealing with the conflicts are analyzed by using the graph model, a conflict resolution methodology. Three criteria, geological locations, political relations, and environmental concerns, are taken into account to accurately determine the preferences of these nations. The stabilities and equilibria of the model are calculated to provide potential strategic resolutions for these nations. The equilibrium that can take place in reality indicates that Kazakhstan and Uzbekistan can support a modified project. The opposition from Kyrgyzstan and Turkmenistan calls for appropriate resolutions from China in order to secure the successful implementation of the project.

Keywords: High-speed railway · Central asia · Graph model
Conflict resolution

1 Introduction

Central Asia is strategically important as the crossroad of the Eurasian Continent. Historically, it had facilitated the spread and interaction of civilizations via the Silk Roads, in ancient China, Persia, ancient India, and ancient Greece. According to the modern definition, Central Asia refers to the region from the Caspian Sea to China, bordering Russia to the North and Afghanistan to the South. It consists of five nations with the affix of "stan", i.e., Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, and Turkmenistan. With a population of around 70 million and GDP per capita below 10,000 US Dollars (UN DESA 2017), the five nations have all been experiencing industrialization since their independence from the Soviet Union in the early 1990s. Modernizing infrastructure is among the priorities of the national governments, as most of the existing infrastructure has not been renovated since the Soviet Era, which hinders growth of the economy within the region.

Railway is an important means of transportation in Central Asia. It offers large capacity, low cost, and high resilience to adverse weather conditions. The existing

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railway system in Central Asia was inherited from the Soviet infrastructure. The railway routes connect China and Mongolia with Europe via Kazakhstan. The current railway system in Central Asia is described as "open but blocked" in the eastern part of the region due to different gauges and "missing segments" (He 2016).

The difference in gauges between Kazakhstan and China affects the efficiency of the two countries' rail transportation. To the west, some cities have not been incorporated into the rail network: hence, they are not able to enjoy the profits and opportunities brought by communication with other regions.

As part of the "Belt and Road Initiative", a high-speed railway (HSR) project has been proposed by China in cooperation with Central Asian countries, as shown in Fig. 1. The new railway will use a gauge different from the existing 1520 mm standard to connect large cities in Central Asia (He 2016). This new system is part of a larger project building railways from Urumqi in China to Tehran in Iran. After the completion of this project, cargo as well as passengers will be transported from China to Iran, via capital cities of the four republics, which include Uzbekistan, Kyrgyzstan, Tajikistan, and Turkmenistan. This will China to share its economic achievements with the countries along the route.

Fig. 1. Route of High-speed Rail Project in Central Asia (Modified based on http://www.chinadaily.com.cn/china/2015-11/21/content_22506412.htm)

Central Asia is well-known for its environmental fragility. The two major rivers in this region are Syr Darya and Amu Darya, flowing from the Tianshan Mountain westwards into the Aral Sea. The area through which the two rivers flow is called the Aral Sea Basin, as depicted in Fig. 2.

During the Soviet era, water was diverted from the two rivers to irrigate cotton fields in the north, however only half of the water actually reached the crops (McCray 1999). Water flow along the basins was reduced, and the Aral Sea shrank by 90% in size (Micklin and Aladin 2008). After the five nations gained independence in 1991,

Fig. 2. Countries in Aral Sea Basin (modified, based on Nandalal and Hipel (2007))

the Aral Sea Basin became a transboundary area overnight. Disputes arose over the allocation of water resources, sometimes intensified by ethnic diversity, bureaucracy, and ill-functioning infrastructure.

Environmental impacts should be considered in constructing the high-speed railway (HSR) in Central Asia. Compared with other means of transportation, such as private cars and buses, HSR will produce less carbon emissions per capita. However, the construction of HSR can still affect the environment in the following ways:

- It may deteriorate wetlands and affect water quality.
- It may occupy agricultural land, which is precious in Central Asia.
- After the completion of the project, the increase in pollution along the railway, caused by either passengers or new inhabitants, will result in higher demand for water, thereby exerting pressure on the limited water resources.
- The noise and vibrations along the railway may also have negative effects on local residents and wildlife.

Accordingly, decision makers in these nations should evaluate the project by considering these consequences.

Potential environmental conflicts for implementing the project may arise among parties situated along the proposed railway and the two rivers. Some stakeholders welcome the project due to the potential economic benefits, while opposition may come from stakeholders with environmental concerns. From the perspective of the five national governments, the construction of HSR can improve the economy in the region. However, their attitudes towards the project depend on various factors, such as geological features along the construction route, the flow of the two rivers, and political relationships with China and neighboring countries. As the biggest economy in the region, Kazakhstan has shown an interest in building HSR with China (Tabyldy 2017). Although China has sponsored Uzbekistan and Turkmenistan for linking the conventional railways with Kazakhstan in 2014 (Arina 2016), the difficult bilateral relations between Tajikistan and Uzbekistan, and the negative view of Kyrgyzstan on railway projects passing through its territory may affect the implementation of HSR (Savi and Peremen 2017). Hence, the actions of the national governments as stakeholders towards the implantation of the HSR project proposed by China should be systematically analyzed by considering geological, political, and environmental factors. This paper raises the following related questions:

- Assuming that each national government strives to achieve maximum benefits, how can one determine the preference of each decision maker (DM) when their value systems are hard to evaluate due to difficulties in accessing information or data?
- Under different behavioral patterns, what are DMs' potential actions, or strategic resolutions, in dealing with the conflicts caused by the implementation of the HSR project?
- What can each national government learn from this conflict to guide their actions when the strategies of its own and others can be obtained?

Note that a DM in this paper refers to a stakeholder: not only can the stakeholder's interests be affected in/by a conflict, but the stakeholder can also impact the conflict by taking actions. To formally investigate these questions, an appropriate conflict analysis methodology should be employed.

2 Literature Review

Various conflict analysis methodologies have been utilized to systematically study strategic conflicts. Game theoretic models (Von Neumann and Morgenstern 1944) have been widely used to handle conflicts with multiple DMs and objectives. In most game theoretic models, the value systems for DMs are characterized by numbers, either certain or with uncertainty. In reality, payoffs in cardinal numbers such as utility values are hard to determine. In many cases, resolution of a conflict can still be obtained without the requirement of cardinal utilities. Thus, non-quantitative models are developed by using relative preferences to represent the payoffs of DMs, such as Metagame Analysis (Howard 1971) and Conflict Analysis (Fraser and Hipel 1979, 1984), in which the modeling structures are more flexible by allowing irreversible moves and introducing more solution concepts to describe the behavior patterns of DMs. The genealogy of conflict analysis methodologies is shown in Fig. 3.

The Graph Model for Conflict Resolution (GMCR) (Fang et al. 1993; Kilgour and Hipel 2005) is an extension of Conflict Analysis representing outcomes of a strategic conflict, usually called states, and moves between states – as transitions; they are represented with graphs. The behavior of DMs is analyzed under four major solution concepts: Nash stability (R) (Nash 1950, 1951), sequential stability (SEQ) (Fraser and Hipel 1979, 1984), general metarationality (GMR) (Howard 1971), and symmetric metarationality (SMR) (Howard 1971). The strategic resolutions for DMs can be obtained by decision support systems (Fang et al. 2003a, b; Kinsara et al. 2015).

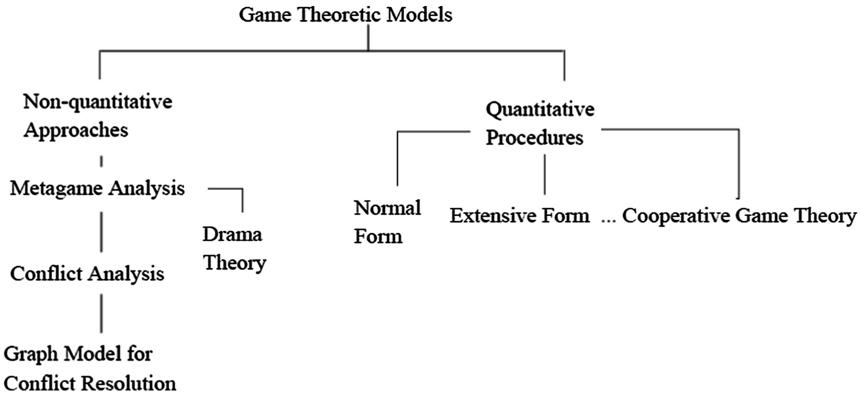

Fig. 3. Genealogy of conflict analysis methodologies (Hipel and Fang 2005)

Preferences in decision making have been extensively studied. Techniques have been utilized to assess preferences of DMs according to multiple criteria (Belton and Stewart 2002). Some factors affecting the preferences of DMs are conflicting (Keeny et al. 1994). Scoring systems like PROMETHEE (Brans and Mareschal 2005) and AHP (Analytic Hierarchical Process) (Saaty 2001) were developed to describe the value systems of decision makers by considering various criteria. Uncertainties in preferences have been studied by using fuzzy logic (Grabisch and Labreuche 2005) and grey theory (Liu and Lin 2010).

Within the paradigm of GMCR, Ke (2008) developed a GMCR model by and augment it with an AHP model used to elicit relative preferences. The AHP model considers criteria for selecting options. Multiple objectives of DMs are analyzed by Bristow et al. (2012) within the paradigm of GMCR. Objectives of DMs are compared pairwise and preferences are represented separately by different value systems. Option Prioritization approach (Fang et al. 2003a, b) has been developed to effectively represent the preferences by the options of decision makers, because the number of options in a graph model is significantly smaller than the number of outcomes. The criteria that affect the preferences should be considered so that they may be expressed more precisely.

In the remainder of the paper, the theoretical structure of the existing methodology, GMCR, is briefly introduced in Sect. 3. The two steps of investigating the HSR construction conflict, modeling and analysis, are mentioned in Sects. 4 and 5, respectively. The conclusions and further study are given in Sect. 6.

3 Graph Model for Conflict Resolution

A strategic conflict can be studied using graph model in two steps: modelling and analysis, as shown in Fig. 4. A graph model can be represented by a 4-tuple set $G = \{N, S, A, \succsim\}$ consisting of the sets of DMs (N), states (S), unilateral moves (A), and preference relations on $S\,(\succsim)$.

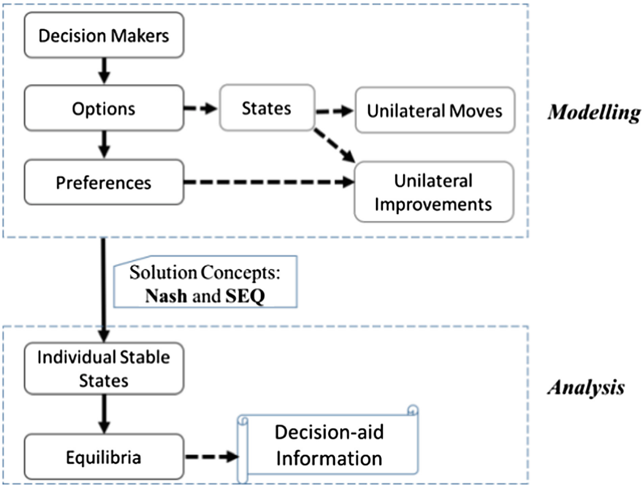

Fig. 4. Process of investigating strategic conflicts using Graph Model for Conflict Resolution (modified based on Fang et al. (1993))

Within the GMCR paradigm, DMs in a real world conflict are identified in the modelling part. The options and preferences of each DM can be obtained according to the background of the conflict. An option is a possible choice that can be taken by a DM. By knowing the options, each state in the conflict can be represented as a combination of the selection of options from all DMs.

A DM may move unilaterally from one state to another by changing its option selections. For each DM $i \in N$, the set of unilateral moves is expressed as $A_i \subseteq S \times S$. For two states $s, s' \in S$, if i has a unilateral move (UM) from s to s' in one step, this move can be denoted as $(s, s') \in A_i$.

In graph model G, each DM's preferences on S are completely determined by the relation $\succsim$ which is assumed to be complete and reflexive. In particular, $s \succ_i s'$, $s \sim_i s'$, and $s \prec_i s'$ indicate that s is more, equally, and less preferred to s' for i, respectively. The three relations can also be combined. For instance, $s \precsim_i s'$ represents that s no better than s' for i. Some UMs for a DM are also called unilateral improvements (UIs) if these UMs can result in more preferred states for the DM. Specifically, a UM for i, $(s, s') \in A_i$, is UI if $s \prec_i s'$.

In the analysis part, stabilities of states are calculated. Stabilities, also called solution concepts, are utilized to describe possible behavior patterns of DMs in real world conflicts, varying by DM's scope of moves and the perceptions on counteractions from other DMs. Four types of stabilities are investigated, including Nash stability (Nash), sequential stability (SEQ), general metarationality (GMR), and symmetric metarationality (SMR). (this was mentioned earlier) For simplicity, the two representative stabilities, Nash and SEQ, are analyzed in this paper. Theoretically, Nash and SEQ are stronger stabilities than GMR and SMR because only the favorable actions of DMs within two steps are considered. In comparison, the unfavorable moves of DMs as counteractions are included in GMR; SMR involves moves of DMs in three steps.

Thus, Nash and SEQ reflect behavioral patterns of DMs that take place in reality more commonly.

A state is Nash stable for a given DM if and only if there is no UI for the DM at this state. The mathematical definition is written as (Nash 1950, 1951): $s \in S$ is Nash stable for $i \in N$ if and only if $R_i^+(s) = \emptyset$, where $R_i^+(s)$ denotes the set of UIs at s for i.

An SEQ state for a focal DM reflects a situation at which the DM can be worse off by the subsequent sanctions from other DMs against its UIs. Theoretically, SEQ (Fraser and Hipel 1979, 1984) is defined as: $s \in S$ is SEQ for $i \in N$ if and only if for every $q \in R_i^+(s)$, there exists $r \in R_{N-i}^+(q)$, such that $s \prec_i r$, where $R_{N-i}^+(q)$ represents the set of UIs for all DMs except i, marked as $N - i$, at state q.

A state can be stable by either Nash or SEQ for a given DM. A stable state for the DM indicates an outcome of a conflict at which the given DM is unlikely to move away. A state is stable for all DMs, either Nash or SEQ, suggests an outcome that is likely to happen or useful resolution for all DMs, as no DM is inclined to move away from this state. This stable state is called equilibrium. The equilibria in a conflict are a useful output, indicating guidance of actions for DMs to follow in reality.

4 Conflict Modeling

4.1 Decision Makers and Options

In a strategic conflict, DMs are parties or groups who are concerned about their interests and are able to impact the conflict by taking actions. In the HSR disputes, four national governments in Central Asia, consisting of Kazakhstan (KZ), Uzbekistan (UZ), Kyrgyzstan (KY), and Turkmenistan (TK), are considered DMs as they are situated along the planned railway route. Tajikistan is not a DM as it is not included in the current plan. The Chinese national government (CN) is another DM, because the construction of the HSR project is of its great interest. Although Tehran is the destination of the project, Iranian national government is not included: the impacts of the HSR project in Central Asia are out of its scope of considerations. Thus, the five DMs in the conflict are KZ, KY, UZ, TK, and CN.

Each DM has at least one option in the conflict. Each central Asian nation can either agree with CN or show opposition, which can be combined into one option as "Agree": the opposition is expressed as the negation of "Agree". If KZ agrees with CN, for instance, its option "Agree" is marked with a "Y". Otherwise, an "N" is labeled with this option. CN can initiate the construct plan or suspend the construction. Considering the possible oppositions from the four central Asian governments, CN could also modify the project, by providing financial support to these nations, changing the detailed construction plan, or transferring green technologies to alleviate possible damage to the environment along the route. The options for CN are written as "Initiate" and "Modify". The negation of "Initiate" refers to the suspension of the project; the opposite of "Modify" means no change to the original plan. The selection of the two options for CN implies different meanings. For example, Y for "Initiate" and N for "Modify" means that CN will implement the original project; N for "Initiate" and Y for "Modify" denote that CN suspends the project although it is modified. The DMs and

Table 1. Decision makers, options, and sample states

Decision makers	Options	Sample state
KZ	(1) Agree	N
KY	(2) Agree	N
UZ	(3) Agree	N
TK	(4) Agree	N
CN	(5) Initiate	Y
	(6) Modify	Y

their options are listed in Table 1. The options of all DMs are assigned a number followed by a half parenthesis, for labeling purposes.

As defined in Sect. 3, a state, regarded as a possible scenario of conflict, is a combination of option selections for all DMs. As each option can be chosen by the corresponding DM or not, there are 2^6 states for the total of 6 options. A sample state is also listed in Table 1, indicating the scenario in which CN's implementation of modified project is opposed by all of the central Asian nations along the route.

4.2 Multiple Criteria Preferences

The preferences of the DMs in the HSR project conflict are determined from the perspectives of the nations' geological locations, political relationships, and environmental concerns. Geological location of a nation refers to its position along the HSR. According to Fig. 1, countries are linked in a sequence starting from CN in the east westbound to TK via KZ, KY, and UZ. A nation to the west relies on the connectivity of the route in its eastern neighbors. Hence, the rear nations along the route are more dependent on the actions of the nations in the front. Political relations of a nation with others is another criterion to consider.

According to the background scanning of the HSR project, UZ and TK are likely to favor the project as they had similar collaboration with CN in the past (Savi and Peremen 2017). KZ could also be supportive as it has shown an interest to the HSR project (Tabyldy 2017). KY could be less favorable because it reportedly dislikes the connection of its railway to UZ due to their territorial disputes. Environmental factors are also important in shaping the preferences of the DMs. By taking into account possible impact on water resources and soil, the position of each nation along Syr Darya and Amu Darya matters. A downstream DM is more concerned with the environmental impacts as it is more vulnerable to potential environmental damages than an upstream DM. KZ, UZ, and TK are at the relatively downstream position compared with KY. The rules to determine the preferences according to the three criteria are listed in Table 2.

Table 2. Preference rules by criterion

Geological	Political	Environmental
CN - KZ - KY - UZ - TK	Favor: UZ, TK, KZ Dislike: KY	Syr Darya: KY - UZ - KZ Amu Darya: UZ - TK

Preferences are often represented in terms of the ranking of states in a conflict. When the number of states is large, Option Prioritization Approach (Fang et al. 2003a, b) is employed by ranking the options for all DMs instead of the states, because the number of options is much smaller than that of the states. By using this approach, the preferences for a DM are expressed by the statements of options connected by logical symbols, such as AND (&), OR (|), NOT (-), IF, and IFF meaning if and only if. These statements are ranked from the most important for the focal DM at the top to the least important at the bottom. The preferences for DMs in the HSR conflict are investigated by the three above mentioned criteria: geological position, political relations, and environmental concerns.

Table 3. Preference statements for DMs by criterion

<table>
<tr><th colspan="2">Geological Position</th><th colspan="2">Political Relations</th><th colspan="2">Environmental Concerns</th></tr>
<tr><td>Ranking</td><td>2nd</td><td colspan="2">1st</td><td colspan="2">3rd</td></tr>
<tr><td>CN 1
2
3
4
5 IF 1
(5&6) IF -1</td><td>Support along the route by vicinity.
At least KZ supports</td><td>1&2&3&4
6 IF (-1|-2|-3|-4)</td><td>All support
Modify if at least one opposition</td><td>6 IF -2</td><td>Modify if KY opposes</td></tr>
<tr><td>Ranking</td><td>3rd</td><td colspan="2">1st</td><td colspan="2">2nd</td></tr>
<tr><td>KZ 2 IF 1</td><td>Connection via KY if KZ agrees</td><td>1 IF 6
5
6 IF -1</td><td>KZ wishes CN to modify</td><td>(-3)IF 1
(-2)&(-3) IF -1
(-2)|(-3) IF -1
(-4) IF -1</td><td>Opposition from upstream UZ
Coalition from other nations if opposes</td></tr>
<tr><td colspan="2">Ranking 2nd</td><td colspan="2">1st</td><td colspan="2">3rd</td></tr>
<tr><td>KY -3
2 IF 1</td><td>Expect opposition from west neighbor
Support if east neighbor supports</td><td>-5
6
-2</td><td>No original project
Better oppose</td><td></td><td></td></tr>
<tr><td colspan="2">Ranking 2nd</td><td colspan="2">1st</td><td colspan="2">3rd</td></tr>
<tr><td>UZ 1&2
2 IF 3</td><td>Connection via KZ and KY
Connection via KY</td><td>3 IF 6</td><td>Support the modified project</td><td>6 IF (-1) & 5
6 IF (-2) & 5</td><td>Hope modify if downstream and upstream oppose original</td></tr>
<tr><td colspan="2">Ranking 1st</td><td colspan="2">3rd</td><td colspan="2">2nd</td></tr>
<tr><td>TK 1&2&3IF 4</td><td>Connection via precedent nations</td><td>6
4 IF 6</td><td>Support the modified</td><td>(-3) IF 5
(-4) IF 3</td><td>Upstream opposes o
Oppose if upstream supports</td></tr>
</table>

First, preference statements are written for each DM using each criterion. For example, when considering the political relations, the most desired outcome is the support from all other nations, denoted as the selection of option 1, 2, 3, and 4. Thus, the first preference statement for CN is written as 1&2&3&4, positioned at the top in the corresponding cell of Table 3. To follow up, CN will modify the project (Option 6) if at least one other nation shows opposition, which can be expressed as 6 IF (-1|-2|-3|-4) placed below the first statement in Table 3. Note that we assume the three criteria to be independent. Thus, the preference statements are elicited by considering only one criterion at one time.

For each DM, the importance of these criteria is different, represented by a ranking from 1 to 3. For instance, geological position is the most important criterion for TK: as it is situated at the rear of the route, TK is more dependent on the connectivity of HSR than other nations. The environmental concerns are important at the second place, as TK is a downstream country along the Amu Darya. The preference statements for each DM by criterion are shown in Table 3. Brief explanations to these statements are provided to the right. The complete preference statements for the DMs are listed in Table 4, reflecting not only the ranking of the statements within a criterion but also the ranking of the criteria for each DM.

Table 4. Complete preference statements for DMs

CN	1&2&3&4 6 IF (-1|-2|-3|-4)	Political
	1 2 3 4 5 IF 1 (5&6) IF -1	Geological
	6 IF -2	Environmental
KZ	1 IF 6 5 6 IF -1	Political
	(-3)IF 1 (-2)&(-3) IF (-1) (-2)|(-3) IF (-1) (-4) IF -1	Environmental
	2 IF 1	Geological
KY	-5 6 -2	Political
	-3 2 IF 1	Geological
UZ	3 IF 6	Political
	1&2 2 IF 3	Geological
	6 IF (-1) & 5 6 IF (-2) & 5	Environmental

(*continued*)

Table 4. (*continued*)

TK	(1&2&3) IF 4	Geological
	(-3) IF 5 (-4) IF 3	Environmental
	6 4 IF 6	Political

5 Stability Analysis Using GMCR II

Individual stabilities and equilibria for DMs in the HSR project conflict are analyzed using a decision support system GMCR II (Peng et al. 1997). GMCR II was designed to carry out calculations for stabilities by typing information about DMs, options, and preference statements in the modeling subsystem.

A list of feasible states, the transition of states, and the state rankings for each DM can be displayed. Stabilities for DMs and equilibria can be obtained as the output of the system. In-depth analysis can also be implemented such as sensitivity analysis to examine whether and to what extent the change in the model output is affected by the input information. The structure of GMCR II is described in part (I) of Fig. 5.

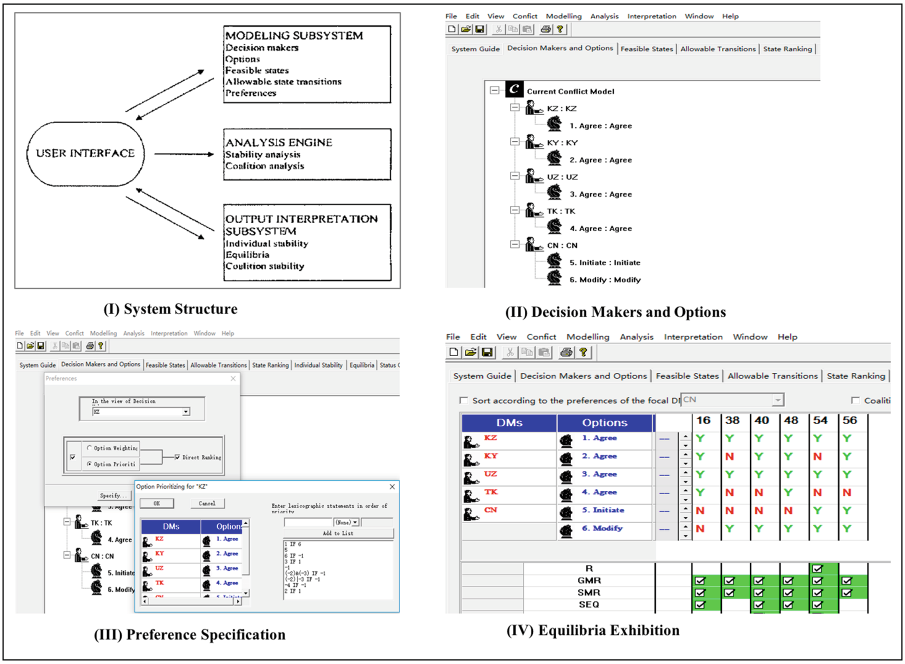

Fig. 5. Modeling and analysis in GMCR II

To start modelling using GMCR II, the five DMs and their options are typed into the panel called "DMs and Options" as shown in part (II) of Fig. 5. The total of 2^6 states can be displayed in the panel called "feasible states", each of which is assigned a number ranging from 1 to 64. The preference statements can be specified in the "Preferences" panel by selecting "Option Prioritization", as displayed in part (III) of Fig. 5. By clicking the "Analysis" on the top bar in part (IV) of Fig. 5, the equilibria of HSR construction dispute under the four solution concepts can be displayed. In this paper, the two representative solution concepts, Nash and SEQ, are analyzed: they are "stronger" than GMR and SMR, and therefore can suggest outcomes that are more likely to happen and provide more meaningful resolutions. According to the screen exhibiting the equilibria in Fig. 5, state 54 is Nash equilibrium and the SEQ equilibria are states 16, 40, and 48.

An evolution analysis is further carried out to examine which equilibrium can be reached from the starting state by initiating UIs from DMs, also called the status quo. This particular equilibrium can be used to interpret the outcome of the HSR construction conflict. As an assumption in GMCR, the order of UIs does not affect the final outcome. The path of the evolution is demonstrated by Table 5. The status quo, state 1, represents the scenario before the implementation of the HSR project, at which point no other nation agrees with this project. Starting from state 1, CN can initiate a UI by adapting to a modified plan, resulting in state 49. To follow up, KZ's UI by changing option (1) from N to Y leads to state 50. The evolution of the conflict stops at state 54, as no DM has UI at this state after it evolved from state 50 by UZ's subsequent UI. Further analysis has been carried out, indicating that state 54 is the only equilibrium that can be reached from the status quo. Thus, Nash equilibrium is regarded as the possible outcome of the conflict.

Table 5. Evolution of HSR construction conflict

			State 1 (Status Quo)	State 49	State 50	State 54
KZ	1)	Agree	N	N	→ Y	Y
KY	2)	Agree	N	N	N	N
UZ	3)	Agree	N	N	N	→ Y
TK	4)	Agree	N	N	N	N
CN	5)	Initiate	N	→ Y	Y	Y
	6)	Modify	N	→ Y	Y	Y

At state 54, the modified version of the project will be supported by KZ and UZ. KY and TK will oppose the project even if it is modified. Hence, not all of the Central Asian countries will support the HSR project. Several implications can be obtained from state 54:

(1) As state 54 is the equilibrium at which the HSR project can receive the support from the most Central Asian nations, the support from all the nations cannot be realized regardless of the effort from CN under the current preference settings.

(2) According to Table 3, TK will oppose the project although it prefers to support the modified version from the viewpoint of political relations. TK's opposition is due to its comprehensive consideration of all criteria including the geological location and environmental concerns. To gain support from TK, CN should mitigate potential environmental damages in TK by, for example, transferring clean technology and by allocating special funding for compensating the damages.
(3) KY will also oppose the project out of the political and geological concerns. China should be proactive in holding multilateral negotiations with UZ and KZ to solve the territorial disputes related with the project.
(4) Comprehensive initiatives should be taken by CN to attract the Central Asian nations in implementing the HSR project with CN. Some details of the construction plan may be redesigned to protect the environment in the four nations. Financing solution scan be adopted. For example, special funding for environmental protection and mortgages to relieve the financial burden of the construction can be provided.

6 Conclusions and Further Study

In this paper, conflicts caused by the construction of high-speed railway project in Central Asia from the perspectives of geological locations, political relations, and environmental concerns are analyzed using Graph Model for Conflict Resolution. A multiple criteria preference structure under the framework of Option Prioritization is designed. This new preference structure can describe the preferences for DMs in the conflict more precisely by considering the impacts of the three criteria on the preferences. The equilibrium obtained by GMCR II indicates that the national governments of Kazakhstan and Uzbekistan will support the project when it is modified. China should seek support from Kyrgyzstan and Turkmenistan using various means, including multilateral negotiation and financial aid.

The limitation of the model presented in this paper is inadequate specificity; the options for DMs need to be elaborated further. For example, modification as option (6) includes financial support, change of the project plan, and transfer of technologies. Further study should be carried out to analyze this conflict with more specific options. Besides, machine learning techniques can be applied to the determination of preferences in order to improve the accuracy of describing preferences. As the current HSR project is still under planning, the evolution of equilibria at different stages of the conflict can be studied by considering the time frame. Moreover, the conflict model can be expanded by taking into account the influence of global powers such as Russia, the United States, and the European Union.

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