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RESEARCH PAPER

Modeling and Analyzing a Complex Real-World Conflict Using the Graph Model for Conflict Resolution

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Abstract
Conflict among stakeholders may be a barrier to the progress of projects and a major cause for significant waste in capital. This research explores modeling and analysis of a conflict among the stakeholders of a high-technology corporation. The interaction among the stakeholders is modeled as a game. In this research, we employ a system's engineering approach for modeling and analysis of this intra-organizational conflict, using Graph Model for Conflict Resolution (GMCR+). It is an advanced methodology driven from conflict analysis, which has routes in non-cooperative game theory with a non-quantitative approach. This article focuses on a conflict among three parties. The socially optimal solution happens when one player, who has the technical knowledge, finds another investor. Using sensitivity analysis, we find an alternative, more favorable solution to reach a new agreement in setting up two plants (instead of seven) in Tehran and Kermanshah, launching the project with the remaining capital. We demonstrate that taking the case to court does not result in a favorable outcome for the players.

Keywords: conflict analysis, corporate, game theory, graph model for conflict resolution

1. Introduction

Conflict may occur among the parties involved in a project. This is an interaction between parties who have different interests and objectives (Barough et al., 2012). Strategic conflicts can be commonly found in the real world, ranging from military confrontation to resource disputes, when decision-makers (DMs) make independent choices that generate different outcomes (Li et al., 2005). The lack of systematic and integrated insights and the attempt to maximize various utilities are the main causes of controversy (Zanjanian et al., 2018). This signifies the role of negotiation that helps in the settlements of disputes, the prevention of tensions, and the maintenance of a collaborative relationship among the project parties. Part of the conflict analysts' tasks is to recognize disputes and to analyze the roots of these conflicts. To accomplish this task, an analyst needs to realize the essential principles of the negotiation theory. Various theories and models such as game theory, economic models, and behavioral approaches have been developed and employed to deal with the complex aspects of negotiations. A non-quantitative approach to game theory is selected for this study because of its suitable nature in analyzing and ultimately resolving all types of conflicts (San Cristóbal, 2015).

The concept of game theory is applied to interactive decision-making among some independent agents – agents might be individuals, groups, stakeholders, countries, or any combination of these. Game theory provides a language for the formulation, configuration, and perception of strategic scenarios (Turocy & Stengel, 2002). Each game includes players,

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strategies, and payoffs that players obtain by selecting each strategy. In other words, game theory helps predict actors' behavior based on their goals in the conflict (Madani, 2010). Game theory is principally the mathematical study of competition and cooperation. This methodology demonstrates how strategic interactions among players result in overall outcomes regarding the preferences of those players. Such outcomes might not have been planned by any player (Ross, 2019).

In this study, the conflict within Danesh Baft Alborz Company (referred to hereafter as DBA) is studied and examined to achieve a practical and constructive solution. Several reasons emphasize the importance of this conflict resolution. Firstly, Iran can save $5b annually by producing bio-implant products in every plant (The Deputy Minister of Inducstry, Mine and Trade ,and the Head of Industrial Development and Renovation Organization of Iran (IDRO), 2020). Since launching seven biotechnology firms across Iran is planned in the feasibility study, the expansion of this biotechnology company will have a considerable impact on Iran's economy (start producing bioimplant products, 2018). This company not only will provide enough capacity to meet the needs of the domestic demands but can also export bio-implant products to target countries. This knowledge is based on the state-of-the-art biotechnology. Exporting final products to other Middle Eastern countries will bring a valuable source of revenue to Iran (The CEO of the Ministry of Industry, Mine and Trade (IMT), 2020).

Furthermore, it is estimated that approximately 90% of the people after forty years old might suffer from degenerative diseases, which led to unbearable pain. Apart from the elderly, young and active people like athletes are likely to face the same issue due to the fracture and excessive strain (Kang & Fang, 2018). DBA can produce various bioimplant products to meet the rapidly increasing requirements of patients for replacing and assisting natural tissue (International Relation Department of Iran's Industrial Development and Renovation Organization of Iran (IDRO), 2011). Therefore, the implementation of this project is necessary for improving public health and saving the lives of patients in need of tissue transplants, especially with the exorbitant costs of similar foreign products (Gholamreza Shafeei, the former head of the Industrial Development and Renovation Organization of Iran (IDRO), 2009). Unfortunately, the conflict has hindered the plans for commercializing the final product, causing irreparable damages such as the loss of capital, opportunities, and lives of patients in need of tissue transplants in Iran.

This research aims to establish a foundation to find out the most appropriate solution using a scientific approach acceptable to all legitimate stakeholders in this biotechnology company. The study could be a pioneering study using the graph model for conflict resolution for the analysis of intra-organizational conflicts. The systematic analysis of this conflict tends to provide a better realization of conflict emergence and may offer suggestions for its avoidance. This study utilizes a conflict management tool to develop a win-win solution considering all stakeholders' explicit and implied interests. More specifically, this study aims to predict the most likely outcomes of this ongoing conflict and the socially optional situation for all the players to prescribe the best state to the decision-makers. The implementation of the results of this study is useful not only in the current conflict but also in similar conflicts in other organizations. Moreover, this conflict resolution procedure is helpful for both researchers and managers to better deal with the conflict among stakeholders.

The present research develops a conflict analysis model based on the graph model for conflict resolution (GMCR+) suggested in (Fang et al., 2003a, 2003b). This decision analysis technique is very suitable in the existing situation as it uses the available information in a systematic and scientific way to find feasible solutions to a conflict. Moreover, it requires very little information regarding the conflict compared to other decision-making methods (Ahmed et al., 2018). In fact, decision-making techniques are divided into four main

categories, depending on the number of decision-makers (DMs) and objectives, including 1) single participant-single objective (such as most operations research models), 2) single participant-multiple objectives (such as most MCDM methods), 3) multiple participants-single objective (such as team theory), and 4) multiple participants-multiple objectives (such as GMCR) decision making (Bashar et al., 2012). We applied GMCR+ since the ongoing conflict in DBA Company is a strategic conflict in which there are three decision-makers with multiple objectives.

Moreover, the graph model for conflict resolution, as a branch of game theory, is more suitable in comparison to linear and nonlinear optimization (Bartholomew-Biggs, 2008; Murty, 2009) and multiple-criteria decision analysis (MCDA) (Greco et al., 2016) for solving this problem. The reason is that formal optimization methods – linear or dynamic programming – assume all parties are willing to act towards the best system-wide outcome, which means cooperation among the decision-makers to reach the system's optimal solutions without prioritizing their own objectives (Madani, 2010). However, in this game each decision-maker wants to optimize his own objective, knowing that other players' decisions affect his objective value and that his decision affects others' payoffs and decisions. As for multi-criteria decision-making, most of them assume a single decision-maker and require the definition of quantitative weights to assess the relative importance of the different criteria, which is one of the critical problems in this method (Pamučar et al., 2018). Yet, the contradiction of decision-makers attitudes, including their risk-taking and visions, is better addressed by the game theory (Leoneti, 2016).

Although an approach based on game theory is selected for this research, classical game theory, such as prisoner's dilemma and the chicken game, has the following limitations for modeling and analyzing complex real-world conflicts. We discuss a classification for various game theory methods in the next section.

- The illustration of a game with more than three players is not easy in strategic (matrix) form (Daskalakis et al., 2009).
- In classical game theory, players' payoff and utility values need to be shown in cardinal values, i.e., specific (quantified) payoffs (Ross, 2019). However, it is not convenient to express all players' payoffs in cardinal values with limited information that exists for real-world conflicts.
- Definition of strategy in classical form is "choosing one and only one action" by each decision-maker of the game (Madani & Hipel, 2011). However, a player might select more than one option.
- Infeasible combinations of strategies cannot be removed.
- Irreversible moves and intransitive preferences of the players cannot be considered in formal game theory (Zhao & Xu, 2019).
- Classical game theory uses only Nash stability (McEachern, 2017), while people involved in a conflict may have different solution concepts for stability definition.

Therefore, the graph model for conflict resolution used in this research is the perfect methodology for the DBA conflict since this is an advanced methodology to handle the complexities of this controversial and complicated conflict. Moreover, the systematic method employed in this research provides the necessary information and constructive advice to the players to avoid making irrational decisions.

2. Literature Review

Organizational conflict is inevitable, which spoils the organization's goal due to the exaltation, the gap between reality and ideals, or the various interests of different stakeholders

(Cheon et al., 2018). In order to analyze intra-organizational conflicts, multiple approaches have been developed. The majority of them rely on conflict management solutions such as communication, compromise, arbitration, mediation, and negotiation methods (Eunson, 2012). Furthermore, other methodologies such as the behavioral theory of the firm (which is based on coalition assumption) have been applied for solving intra-organizational conflicts (Cheon et al., 2018). Some studies have utilized descriptive-qualitative methods to analyze the causes of conflict (Purnaweni et al., 2019). However, DBA conflict is a strategic conflict among stakeholders in which decision-makers do not tend to form a coalition. We intend to apply a mathematical methodology rather than descriptive methods to predict the final state according to the current decision-makers' approach so that we can advise them to change their present attitudes toward this strategic conflict.

In order to handle strategic conflicts, many methods have been developed (Li et al., 2004), including metagame analysis (Howard, 1971), hyper game analysis (Bennett, 1980; Wang et al., 1988), drama theory (Howard, 1999), the theory of moves (Brams, 1993), conflict analysis (Fraser & Hipel, 1988), the graph model for conflict resolution (GMCR) (Fang et al., 1993; Kilgour et al., 1987), with all having game-theoretic roots (Kilgour et al., 1996).

In general, game theory as a formal conflict analysis methodology is classified into two types: non-cooperative and cooperative theory; the former analyzes the choice of actions for individual DMs without binding agreements, and the latter focuses on allocating resources (Kilgour et al. 2005). In most game-theoretic models, the preferences of DMs as the reflection of their value systems are represented by cardinal utilities. These models are called quantitative models, in which an actual number represents a preference; a higher number means higher preference. Methods like extensive form, normal form, and cooperative game theory all rely upon cardinal preference information and are referred to as classical game theory techniques (Hipel & Fang, 2020). Conflict analysis falls into the category of non-cooperative approaches, which is classified according to relative or qualitative preferences wherein one only must know if a DM prefers one state over another or equally preferred (He, 2019). The development of conflict methodologies from game-theoretic models to GMCR is displayed in Figure 1. GMCR equips decision-makers with a tool for a systematic study and provides an adequate understanding of the project's implementation. Fang et al. (2003a, 2003b) elaborated that there are various implementations of GMCR for studying conflicts. Decision support systems (DSS) of GMCR let the analysts and researchers apply the methodology to settle real-world disputes. DSS includes other methods such as GMCRI (Fang et al., 1993), GMCR II (Fang et al., 2003a, 2003b; Hipel et al., 1997), and GMCR+ (Fang et al., 2003a, 2003b; Kinsara et al., 2015). GMCR I calculates the stability of all possible outcomes of a conflict from each decision-maker's view (Kilgour & Hipel, 2005). GMRC II provides more intuitive and informative options and preferences for each player, including option prioritization, option weighting, and direct entrance (Fang et al., 2003a, 2003b: Hipel et al., 1997). Such processes do not consider ordinal preferences, stating well how a decision-maker thinks of his preferences (Kilgour & Hipel, 2005). In the latest DSS, GMCR+, the interface, and the analysis engine have been improved, and the data visualization has been expanded (Kinsara et al., 2015).

Conflict resolution has extensive applications and cross-border use in addressing and solving today's complex issues. We classified some case studies in Table 1, in which a graph model for conflict resolution was employed. This table illustrates various real-world conflicts in many areas at the international and national levels, such as the water allocation (see conflicts number 1 and 9 in the table), energy (conflicts 2 and 7), transportation (conflict 3), environment (conflicts 2 and 4), society (conflict 4), business (conflict 5), and politics (conflicts 6 and 8). However, to the best of our knowledge, none of them have dealt with conflicts among

shareholders within companies to provide strategic insights and advice for decision-makers. Therefore, this research can be a pioneer in solving intra-organizational disputes using the GMCR approach. Furthermore, the key information summarized in this table, including the actors, options, and predicted results, can give researchers a broad vision of the graph model for conflict analysis. In other words, the result and solutions in the fourth column of this table depict the extensive capabilities of this methodology in providing practical approaches. Besides, the diversity of players and their options shows that this methodology is helpful among all categories, including countries, organizations, and individuals.

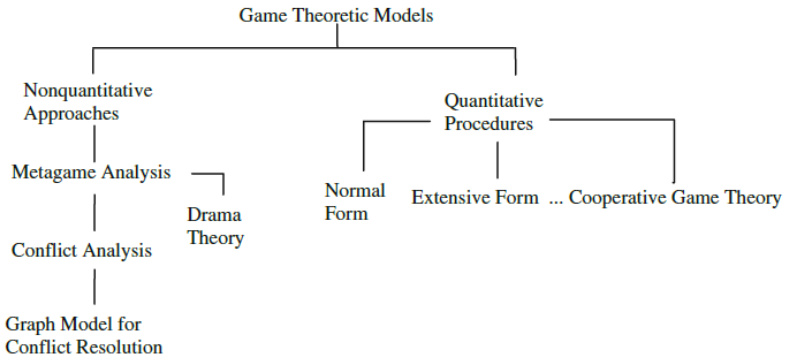

Figure 1. Genealogy of Conflict Analysis Methodologies (Xu et al., 2018)

This study aims to illustrate a real-world example of intra-organizational conflicts for managers, researchers, and government officials. More specifically, this research reveals situations in which GMCR+ can be beneficially applied in an organization to manage possible conflicts. First, the consultants of a company can use GMCR+ in simulation and role-playing exercises, for example, to help stakeholders understand the thinking of other decision-makers in board committees. Secondly, a mediator among stakeholders may use GMCR+ to guide conflicting parties toward a stable win/win resolution. Finally, others who are interested in the outcomes of strategic conflicts, such as the representatives of third parties and regulators who frame the rules, can use this methodology to manage conflicts. For example, in this conflict, the government as a third party can take this responsibility and invest in conflict management research to increase the GDP and provide job opportunities in Iran.

Table 1. Real-World Conflicts Using GMCR

Conflict	Players	Options/ feasible states	Results/practical solutions	Citation
1. The water allocation in the Ilam dam	4 DMs -JAO -WWC -Water authority -Environmental organizations	-14 options -33 FS -8 FS with the third party	The Jihad Agriculture Organization (JAO) and the Water and Wastewater Company (WWC) withdraw more water. Therefore, there exists no water to meet the environmental water right. The third party's participation can change the conflict's future; Justice is the most influential third party that can move the conflict towards the desired equilibrium.	Zanjanian et al., 2018
2. The energy-environment conflict in Pakistan	3 DMs -The public -The government -L1: China -L2: The environmentalists	Level 1: -7 options -72 FS Level 2: -7 options -55 FS	The development of monitoring institutions and the transmission system along with the synthesis of current energy sources would ensure environmental protection and resolve the energy shortage problem.	Ali et al., 2019
3. Pakistan Railway infrastructure development disputes	4 DMs -Federal -Baluchistan -KPK -China	-8 options -54 FS	The Chinese and Pakistani governments tend to complete the eastern route on time. The government of Pakistan could negotiate with the Chinese government in the development of the central route-II.	Ahmed et al., 2018

Table 1.

Conflict	**Players**	**Options/ feasible states**	**Results/practical solutions**	**Citation**
4. A Brownfield conflict at a school in Jiangsu, China	3 DMs -The public and the environmental protection agency -The BP firm -The local government	-5 options -16 FS	The BP Company should purify the soil by fully enclosing the site. The local government should not relocate the school, and the environmental protection agency and the public should closely monitor the firm's activities. Positive interactions should foster among the local government, the BP firm, and the public to ensure sustainable Brownfield land redevelopment in the future.	Yu & Pei, 2018
5. Market competition between Airbus and Boeing	4 DMs -Airbus (A) -Boeing (B) -Customer X (X) -Customer Z (Z)	-7 options -96 FS	Customer X will use two types of aircraft to increase the variety of its fleet, and customer Z will choose Airbus for its performance. The future narrow-body aircraft should have high efficiency of upgrading the fleet. The upgraded versions are essential for cost efficiency during operation and higher sales aircraft in the narrow-body market.	He et al., 2017
6. Yemen's Humanitarian Crisis	5 DMs -The KSA -The UAE -Mansour Hadi -Southern forces -Ansarullah	-14 options -24 FS	For years, the war is going on because direct decision-makers hesitate to change their situation or moderate their preference list. Therefore, the Yemen crisis needs an external intervention to put an end to the war	Nassereddine et al., 2021
7. The Great Canadian Hydroelectric Power Conflict	3 DMs -Brinco -Hydro-Quebec -Investors	Pre 1966 -7 options -12 FS After 1966 -5 options -4 FS	Intervention is needed since plans for the development of the expensive maritime transmission line are ongoing. These resources could be better directed toward expanding and maintaining the current QC transmission line. Finally, policies and regulations should be introduced or amended to protect the public interest in long-term contracts.	Matbouli et al., 2014
8. Iran's Nuclear Program Conflict	3 DMs -UNSC -IAEA -IRAN	-8 options -15 FS	Both Iran and the UNSC should change their perceptions. Iran should notice that military action is a consequential option and take UNSC resolutions seriously, while UNSC should realize Iran may risk war if military action occurs.	Sheikhmohammady et al., 2009
9. Water conflicts in the Hawizeh Wetland	3 DMs -Iran -Iraq -Turkey	-12 options -15 FS	Three strong equilibrium points were identified (a) Establishing a regional compromise among Iran, Iraq, and Turkey to reduce the effects of conflicts in the Hawizeh/Hoor-Al-Azim Wetland. (b) Iran and Iraq's coalition to motivate Turkey to diminish water withdrawal from the Tigris River. (c) The exchange of water release for commodity market in Iran and Iraq for Turkey.	Dowlatabadi et al., 2020

3. Methodology

Developing and analyzing the GMCR model include unified algorithms for predicting the possible outcomes and their analysis support (Kilgour & Hipel, 2005). We first introduce the elements and definitions which are applied to generate a graph model for conflict resolution in the following summary and then describe each step for this procedure.

1. A set of decision-makers (DMs): a decision-maker is one of the participants who can make some change in the conflict.
2. A set of possible states: they point to the static situations which decision-makers can choose at any time.
3. Reachability: if a decision-maker can unilaterally push the conflict forward from one state to another, this is considered reachability. If the new state is more preferred by DM, it is Unilateral Improvement (UI). Otherwise, it is termed Unilateral Disimprovement (UD).

4. Equilibria: in such a state, none of the participants has unilateral improvement regarding the acceptable risks. By the time a full equilibria state is achieved, the conflict will remain at that state until a new input changes it.
5. Foresight: it refers to several subsequent moves that a DM can predict.
6. Stability: determines DM's ability and motivation to change the dispute. Significant features of each stability definition are summarized in Table 2.

Figure 2 shows the general approach of analysis and modeling of the graph model (Xu et al., 2018). As is observed, the GMCR method as a graph model for conflict resolution methodology consists of two stages: modeling and analysis. In the modeling stage, the essential elements of conflicts are identified, including the decision-makers (DMs), options, and relative preferences (Payganeh et al., 2018). Then, the user inputs the list of DMs and their preferences corresponding to the model. The software system then generates the number of possible combinations of options, known as states. In a real-world conflict, all of the mathematically considered situations are not representative of the acceptable or feasible state. By eliminating the infeasible combinations of strategies, the number of considered states decreases (Fang et al., 1993).

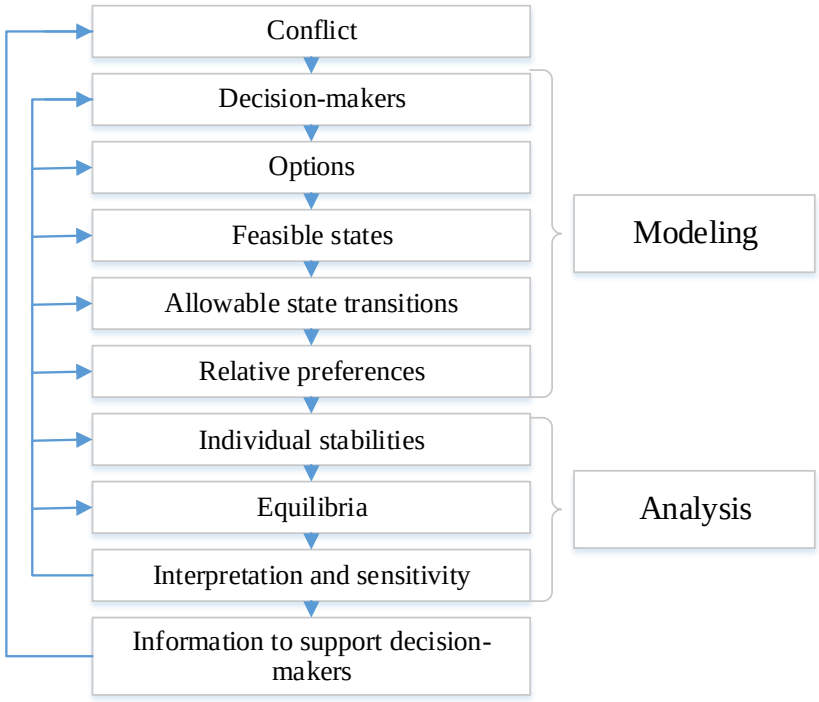

Figure 2. General Steps of the Graph Model for Conflict Analysis

The next step is to enter preferences into the model. Extracting and ranking each decision-maker's preferences is a subjective and challenging task. The graph model simplifies this step without the need to employ cardinal utility values; it uses relative preferences (Putri & Alamanda, 2015). The relative preferences of each decision-maker in a conflict are accessible by using the adequately documented conflicts. Such preferences can be collected through academic articles, media interviews, the perceived preferences through the players' past behavior, and the preferences stated in the conflict's legal documents and interviews (Philpot et al., 2016). In the modeling of DBA conflict, preferences were collected through the authoritative documents of the company, reliable websites, and direct interviews with the parties involved. The GMCR+ offers three methods to introduce preferences into the model, namely options prioritization, options weighting, and direct ranking (Fang et al., 2003a, 2003b).

Then this data is fed into the next stage, i.e., analysis. In this stage, the stability of each state is calculated from each DM's viewpoint. Subsequently, the overall equilibria, which contain stable states for all DMs, can be obtained. Different players may have different attitudes to decide whether to stay in a specific state or move from it. GMCR+ relies on a range of stability definition methods, including Nash (R), symmetric meta rationality (SMR), sequential stability (SEQ), limited-move stability (LM), non-myopic stability (NM), and general meta-rationality (GMR), to identify the likely outcomes (equilibria) of conflicts (Sheikhmohammady et al., 2013). Various solution concepts for stability definition are summarized in Table 2.

Table 2. Stability Definition and Players' Behavior (Adopted From Madani & Hipel, 2011)

Solution concept	Stability description	Foresight	Knowledge of preferences	Disimprovement
Nash Stability (R)	Decision-maker cannot unilaterally move to a more preferred state.	Low (1 move)	Own	Never
General Meta-rationality (GMR)	Unilateral improvements are blocked by subsequent unilateral moves by others.	Medium (2 moves)	Own	By opponents
Symmetric Meta-rationality (SMR)	Unilateral improvements are still blocked even after possible responses by the player.	Medium (3 moves)	Own	By opponents
Sequential Stability (SEQ)	Unilateral improvements are blocked by subsequent UIs by others.	Medium (2 moves)	All	Never
Limited (h)-Move Stability	All players are assumed to act optimally, and the maximum number of state transitions is specified.	Variable (h moves)	All	Strategic
Non-Myopic Stability	Limiting case of limited move stability as the maximum number of state transitions increase to infinity.	Unlimited	All	Strategic

After stability analysis, the next stage will be sensitivity analysis for finding out what will happen to the decision-makers if they move from one state (usually from the status quo state) to another. In several situations, somebody may use sensitivity to decide how the decision-maker's preference must change to deliver the more wanted equilibria for other decision-makers. The result can be called equilibria if it is a stable condition for all parties. With interpretation and sensitivity analysis, decision-makers or other interested parties can understand the meaning of resolutions in terms of real-world disputes (Putri & Alamanda, 2015). Different subjectivity can be examined under sensitivity analysis (Fang et al., 2003a, 2003b; Kilgour & Hipel, 2005). Feedback is allowed in the procedure, which means that, at each step of the modeling or analysis stage, one may return to any former point whenever new information is found. This characteristic makes GMCR more flexible and practical (Ke, 2008).

In this method, we investigate the evolution of the conflict from the status quo (current situation) through intermediate states to reach a final resolution of the conflict called equilibrium. What we are looking for is predicting the most likely outcome(s) of this conflict. Besides, we provide practical solutions and rational advice to the decision-makers to follow the socially optimal solution.

4. Modeling

In this section, the origins of the conflict in the DBA Company, along with the players and their strategies, are explained. Parameters for this model are acquired from interviews and the

documents exchanged between the firms. After removing the infeasible combinations, the decision-makers' preferences are identified. Finally, the equilibria, associated with various stability concepts, are determined.

4.1. Historical Background

A team of medical students at Imam-Khomeini hospital discovered a new method for tissue implant and applied it to a recipient in 1993. Ten years later, they established Tissue Regeneration Cooperation (TRC). Investment in this company was partly financed by Industrial Development and Renovation Organization of Iran (IDRO) as a governmental investor.

In a personal interview, the DBA's CEO explained that "TRC, known as the first and most prominent industrial firm not only in Iran but also in the West Asia region, began its production in 2006" (S. Naghavi, personal communication, April 23, 2016).

In 2010, following a decree by Iran's Minister of Mining and Industry and IDRO's attempt, a feasibility study was conducted to develop the tissue engineering industry in Iran. The documents proposed launching seven similar firms across Iran, including Tehran, Shiraz, Kermanshah, Tabriz, Karaj, Isfahan, and Mashhad, aimed to develop research in the field of tissue engineering and to manufacture 27 different products for the national medical society (International Relation Department of Iran's Industrial Development and Renovation Organization of Iran (IDRO), 2011).

IDRO also issued a statement announcing its readiness to expand this national project. Furthermore, based on the public invitation to participate in this national project, the Cooperative Foundation of NAJA (Disciplinary Force of the Islamic Republic of Iran) decided to invest in this project. Thus, an agreement was signed among the following parties:

1. Managing director of IDRO
2. CEO of TRC
3. Cooperative Foundation of NAJA's CEO (Sanaat Nasr Maadan Firm)

Based on the agreement, the technology owner (TRC) grants the concession of the complete technical knowledge to DBA; TRC is the concessionaire, and DBA is the concession holder. The details of this concession are as follows:

1. Transferring the technical knowledge and experience required for designing, building, and operationalizing the plants,
2. Cooperation to buy, produce, and export equipment, machinery, hardware, software, and any other equipment required for operating the plants,
3. Manufacturing products anywhere in Iran and selling the products within the country or any other country.

4.1.1. Main Origins of Disputes

- Change in exchange rate shortly after signing the contract and before buying all items of equipment,
- Leaving the appendices incomplete once the agreement was signed,
- Lack of enough attention to the clauses of the statute and the stakeholders' refusal to attempt to clarify the clauses,
- The problems of importing equipment due to sanctions,
- Making unlawful agreements between one of the shareholders and another company.

4.1.2. Description of Disputes

1. NAJA's insufficient consideration of clauses 29-30 of the statute, which reads that the appointment of the executive manager and CEO should be approved by TRC. The clauses 29-30 read, "Executive manager and CEO appointment, adopting educational policies, designing products, controlling, and managing the quality shall be agreed by TRC. Financial manager assignment shall be agreed by NAJA Cooperative Foundation."
2. While human resources training was assumed to be free, TCR claimed plenty of money to train the human resources once the agreement was signed. In fact, the ambiguities of the clause related to human resources training caused discontent of one of the shareholders with the technology shareholder.
3. Annex number 9 of the agreement ensures the transfer of technical knowledge. It is the key to implement the project commitments and is a basis to arrange the timetable and the project requirements. Despite this significance, this annex has been left incomplete.
4. Foreseeing no training program for production and quality managers, required for the project, as the result of signing no agreement related to this (TCR alleges that in order to train the employees, signing a training contract and receiving a separate fee is required).
5. Shareholders (with up to 80% share) did not trust in the owner of technical knowledge. Therefore, they sought to find and negotiate with a new party; they had plans to dismiss TRC.
6. TRC proposed the conclusion of a cleanroom[1] contract with Ganjineh-Toos Firm. NAJA suspected this contract, claiming it had not been aware of kinship ties between the contract parties. According to the law, contracting with relatives requires notification and awareness in advance; otherwise, it is unlawful.
7. NAJA accused TRC of colluding with Ganjineh-Toos, the cleanroom manufacturing company.
8. Lack of enough attention to the opinion of the technology shareholder about constructing a plant in Kermanshah.
9. NAJA's objection to the size of the cleanroom.
10. Following the accusation against TRC, the firm was discouraged from importing and purchasing the project's required equipment.
11. Following the accusation against TRC over cleanroom construction, it rejected the Turnkey[2] contract proposal (According to this proposal, cleanroom construction is assigned to TRC, and the resulted profit is shared among the shareholders). TRC's refusal to accept the proposal made NAJA Foundation feel that TRC seeks an excuse to terminate the agreement.

1. **Cleanroom**: A type of controlled environment facility in which all incoming air passes through a filter capable of removing 99.97 percent of all particles 0.3 microns and larger. In a cleanroom, the temperature, pressure, and humidity are controlled. External sources of particulate contaminants are excluded, and internal sources are controlled to required cleanliness levels (Useller, 1969).
2. **Turnkey contract**: The single point responsibility in turnkey contract models require the contract to take responsibility for all designs, engineering, procurements, construction, commissioning, and testing activities of the project. Henceforth, problems that arise in the project are solved by one party (i.e., the contractor), who is also responsible for compensations (Merna & Smith, 1990)

4.2. Players

In this section, the conflict's players are introduced. Then, each player's existing options are brought up. Three players of this game are as follows:

1. NAJA Cooperative Foundation, with a 40% share
2. TRC, with a 20% share (the owner of the technology whose contribution is estimated through its equivalent in Rials)
3. IDRO, with a 40% share

Furthermore, in this study, the first player is called NAJA, and the second and third players are referred to as TRC and IDRO, respectively.

This conflict is classified as a non-cooperative game. Besides, each player possesses comprehensive information. In other words, each player knows a full history of moves played by itself and other players.

4.3. Players' Options

Based on reviewing DBA's document and direct interviews' analysis, each player's options are identified. Here is a list of these options:

NAJA options

1. Selling its shares
2. Accepting the DBA dissolution
3. Taking legal action via court
4. Continuing to cooperate in the project implementation (by clarifying ambiguities associated with the cleanroom constructor and agreeing with the condition proposed by TRC, the termination of the concession)

TRC Options

1. Transferring the technical knowledge, and continuing to cooperate in the project implementation
2. Taking legal action via court
3. Persuading a new stakeholder to purchase IDRO and NAJA shares
4. Accepting the DBA dissolution

IDRO Options

1. Transferring its share to Iran's Privatization Organization
2. Mediating between the partners and managing the conflict so that it can sell its share
3. Accepting DBA dissolution

4.4. Feasible States

Overall, the involved parties may take 11 actions, which means there are 2^{11} combinations of the players' strategies. In GMCR+ (decision support system), the implausible or less likely states are removed.

The following cases are the combinations that are unlikely to happen at the same time:

1. NAJA sells its share and accepts the DBA dissolution.

2. NAJA sells its share and takes legal action.
3. NAJA sells its share and cooperates in the project implementation.
4. DBA is dissolved, and TRC transfers the technology.
5. DBA is dissolved, and NAJA cooperates in the project implementation.
6. IDRO transfers its share to the Privatization Company and agrees with DBA's dissolution.
7. TRC takes legal action and persuades a new shareholder to purchase NAJA Share.

The following statements represent option dependency between the players:

1. If TRC takes court action, then NAJA should reciprocally take legal action and vice versa.
2. If NAJA asks for DBA's dissolution, then others will do the same.
3. If NAJA is not interested in selling its share, TRC may not persuade a new shareholder to purchase its share.
4. If NAJA and IDRO take no move, then TRC will not transfer its technology.
5. If NAJA and TRC take court action, IDRO cannot transfer its share to the Iranian Privatization Organization.
6. If NAJA and TRC make no move, IDRO cannot transfer its share to the Iranian Privatization Organization since it is not transferrable until the disputes resolve.

After reducing the latter situations, 36 feasible states remain which are shown in Table 3. In this table, each column represents a state. Y shows selection by an individual player, while N states that no action is taken by the player. For example, state 10 represents the situation in which NAJA sells its shares, TRC persuades a new advocate stakeholder to purchase IDRO and NAJA shares, and IDRO takes no one of its options.

Table 3. Feasible States

	State	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
NAJA	**N1**	N	Y	N	Y	N	N	N	N	N	Y	Y	Y	N	Y	N	Y	Y	N
	N2	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	N3	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N
	N4	N	N	Y	N	Y	N	Y	N	Y	N	N	N	Y	N	Y	N	N	N
TRC	**T1**	N	N	N	Y	Y	N	N	Y	Y	N	Y	N	N	Y	Y	N	Y	N
	T2	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N
	T3	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	Y	Y	N
	T4	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
IDRO	**I1**	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N
	I2	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
	I3	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

	State	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
NAJA	**N1**	Y	N	Y	N	N	N	N	N	Y	Y	Y	N	Y	N	Y	Y	N	N
	N2	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y
	N3	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	Y
	N4	N	Y	N	Y	N	Y	N	Y	N	N	N	Y	N	Y	N	N	N	N
TRC	**T1**	N	N	Y	Y	N	N	Y	Y	N	Y	N	N	Y	Y	N	Y	N	N
	T2	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	Y
	T3	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	Y	Y	N	N
	T4	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y
IDRO	**I1**	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N	N
	I2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	I3	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y

4.5. Irreversible Moves

Some options have a one-direction arrow from No to Yes, such as selling the share by NAJA, deciding to dissolve the company, transferring technology by TRC, and transferring the share to the Privatization Organization by IDRO. In other words, if a decision-maker decides to take each of these actions, it will not be reversed. All irreversible moves in the conflict are shown in Figure 3.

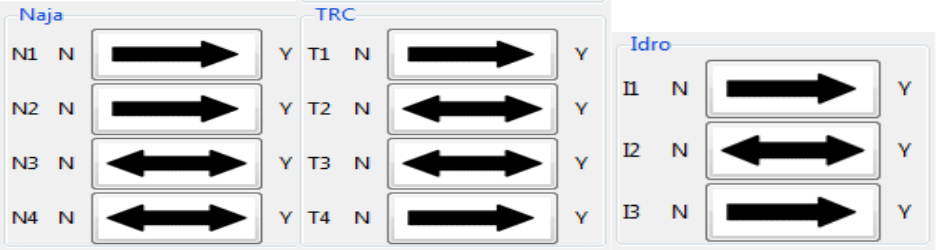

Figure 3. Irreversible Moves

4.6. Decision-Makers' Preferences

We now express each decision-maker's main preferences:

NAJA's Preferences

1. NAJA is interested in selling its share at a reasonable price. However, this will happen only in a situation that TRC promises a reasonable profit to new shareholders and persuades them to buy NAJA's share.
2. NAJA is interested in transferring technology by TRC so that it has the honor of investing in a knowledge-based project. However, NAJA is less likely to accept the concession's termination, which is the condition of TRC to cooperate. Hence, it is more beneficial for NAJA that IDRO intervenes and persuades TRC to transfer the technology without any demand for termination.
3. If TRC does not introduce its reliable shareholder, NAJA hopes to find a buyer to sell the share through IDRO's mediation.
4. NAJA is not interested in IDRO leaving the project as long as it (NAJA) remains the stakeholder.
5. NAJA is not interested in dissolving the project. However, as long as its attempt does not work out, it prefers dissolution rather than court action, as it takes a great deal of time and money. However, NAJA will agree with the project dissolution if the technology shareholder is removed, and the total share is divided between other shareholders.
6. If NAJA does not sell its share and TRC does not agree to transfer the technology, then NAJA will take court action.
7. The best scenario for NAJA is when TRC is convicted guilty by the court and is asked to transfer the knowledge or pay compensation.
8. If the court action is taken and NAJA is found guilty by the court, its reputation will be tarnished.
9. The worst-case scenario for this player is when the court issues the sentence of DBA's dissolution. To NAJA, it means wasting a lot of money and time and dealing with massive damage caused by selling the properties and equipment.

TRC's Preferences

1. TRC is interested in DBA's dissolution. However, it should note the fact that NAJA agrees to dissolve DBA only if no share is allocated to TRC. Taking court action takes a lot of time and is a fruitless engagement for TRC. Thus, it seeks to persuade a new stakeholder to purchase NAJA's share, continuing the project without NAJA.
2. TRC's interest in DBA's dissolution still remains in place.
3. TRC will prefer any new shareholder instead of NAJA, even if it cannot persuade anyone to purchase NAJA's share.
4. If NAJA does not agree to sell its share, dissolve DBA, or implement the project via the termination of the concession, TRC will take legal action.
5. Legal action seems costly to TRC. Moreover, according to the consulting engineering firm's report, taking legal action will likely lead to an unfavorable court decision for TRC.
6. TRC still has no interest in cooperation with NAJA, even if the latter agrees to implement the project by terminating the concession.
7. TRC, the exclusive owner of the technology, has no interest in prolonging the conflict since it may prevent expanding its business throughout the country. Thus, to make the situation of shareholders clear, it seeks to settle the dispute.
8. The best-case scenario for TRC is that the court issues DBA's dissolution sentence or it convicts NAJA, compelling it to terminate the concession and continue partnership in the project.
9. The worst-case scenario is that the court finds TRC guilty.

IDRO's Preferences

1. IDRO primarily prefers DBA's dissolution because of the money that returns to it.
2. IDRO is interested in leaving the project, but it is possible only when there is no dispute among the shareholders. Therefore, it prefers to slow down the conflict through transferring the technology and NAJA's withdrawal of the disputes. Only then, the Privatization Organization can readily launch to purchase its share.
3. The worst-case scenario for IDRO is taking legal action
4. IDRO mediates between the conflict's parties to protect its interest. That means either side of the dispute is equal to it. If the key to resolve the conflict is cooperating in a joint action with any of these parties, it will form a coalition with either party.

Table 4 demonstrates each player's ordinal preferences over the feasible states. The states on the left side of this table are the preferable ones. The more we move to the right side, the less the states are preferred. As Table 4 indicates, NAJA is indifferent to states 1 and 18. This player is also indifferent to states 8 and 25.

Table 4. Ordinal Preferences of the Players

Player		Preferences
NAJA	High	28,11,34,17,27,10,33,16,22,5,32,15,21,4,31,14,29,19
	Low	2,12, [1,18],35,26,9, [8,25],20,3,30,13,23,6,36,24,7
TRC	High	28,27,11,10,34,33,17,16,35,19,21,2,4,29,31,12,14,22,
	Low	5, [15,32],20, [3,13,30], [1,18],36,24,7,26,9, [6,23], [8,25]
IDRO	High	35,[16,17,33,34],[12,14,29,31],[15,32],[13,30],[10,11,27,28]
	Low	[2,4,19,21], [5,22], [3,20],18,1,26,9,36,24,7,25,8, [6,23]

5. Conflict Analysis

5.1. Stability Analysis

If a player does not tend to leave a state, that state of conflict will be considered the stable state of a player. A state that is stable for all players is called equilibria.

As mentioned before, various logics exist to obtain the equilibria states of a conflict. It depends on the players' attitudes and their horizon of decision-making. In Nash equilibria, the player merely thinks of a state ahead. A player with the Nash stability attitude will make no move if the state ahead does not show any superiority to the present state. The player decides to move concerning the two following steps in the general meta-rationality (GMR) and sequential stability (SEQ) methods. In symmetric meta-rationality, in addition to exploring one's movements and the other players' reactions in two steps, the players review the opportunities in response. In this study, the different ways to obtain the equilibria states are applied using GMCR +.

5.2. Equilibria

After inserting all of the information in GMCR+, four different categories of equilibria are obtained after running the software DSS (see Figure 4).

The equilibria of the first group are taking court action in states 6, 9, 23, and 26. However, in the case of settlement, the partnership will be continued.

The equilibria of the second group are states 32 and 15, in which TRC and NAJA agree not to take legal action. By slowing down the disputes, IDRO would be able to sell its share.

The equilibria of the third group include states 34, 33, and 17. These occur when TRC persuades its approved shareholder to purchase NAJA's shares at a reasonable price. Meanwhile, to present proof of its rightfulness, TRC should prepare the ground to transfer the technology so that the buyer agrees to invest. If TRC does not agree to do so, the equilibria are acceptable with respect to GMR and SMR. Therefore, by alleviating tensions, IDRO will transfer its share to the Privatization Organization.

The equilibria of the fourth group are states 35 and 36, which indicate the company's dissolution. It costs all players considerably if the court issues such a sentence.

Table 5 shows the players' total payoffs for all players. According to this table, the stable state that constitutes the best outcome for all players is the equilibria of the third group, whose total payoffs for state 34 is 76. Then, states 17 and 33 have other outcomes. The total payoffs of the players at these states are considered 73 and 71, respectively. Thus, States 34 and 17 are considered equilibria according to all stability definitions. State 33, however, is equilibrium with respect to solution concepts of GMR and SMR. Because TRC might not deliver the technology with Nash's definition, this equilibrium state is not strong enough; hence, a new buyer would not invest.

Table 5. Total Payoffs for all Players in the Equilibria

	State	**6**	**9**	**15**	**17**	**23**	**26**	**32**	**33**	**34**	**35**	**36**
Payoff for:	**NAJA**	4	11	23	31	5	12	24	28	32	13	3
Payoff for:	**TRC**	2	3	11	24	2	4	11	25	26	22	7
Payoff for:	**IDRO**	1	7	16	18	1	8	16	18	18	19	6
Sum		7	21	50	73	8	24	51	71	**76**	54	16
	Nash	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y
	GMR	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	SEQ	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y
	SIM	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y
	SEQ & SIM	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y
	SMR	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

	Ordered		6	9	15	17	23	26	32	33	34	35	36
	Decimal	Filter	36	60	280	337	548	572	792	833	849	1154	1190
1 - Naja	N1	-	N	N	N	Y	N	N	N	Y	Y	N	N
	N2	-	N	N	N	N	N	N	N	N	N	Y	Y
	N3	-	Y	Y	N	N	Y	Y	N	N	N	N	Y
	N4	-	N	Y	Y	N	N	Y	Y	N	N	N	N
2 - TRC	T1	-	N	Y	Y	Y	N	Y	Y	N	Y	N	N
	T2	-	Y	Y	N	N	Y	Y	N	N	N	N	Y
	T3	-	N	N	N	Y	N	N	N	Y	Y	N	N
	T4	-	N	N	N	N	N	N	N	N	N	Y	Y
3 - Idro	I1	-	N	N	Y	Y	N	N	Y	Y	Y	N	N
	I2	-	N	N	N	N	Y	Y	Y	Y	Y	N	N
	I3	-	N	N	N	N	N	N	N	N	N	Y	Y
Payoff For:	Naja	-	4	11	23	31	5	12	24	28	32	13	3
Payoff For:	TRC	-	2	3	11	24	2	4	11	25	26	22	7
Payoff For:	Idro	-	1	7	16	18	1	8	16	18	18	19	6
	Nash	-	Y		Y	Y	Y	Y	Y		Y	Y	Y
	GMR	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	SEQ	-	Y		Y	Y	Y	Y	Y		Y	Y	Y
	SIM	-	Y		Y	Y	Y	Y	Y		Y	Y	Y
	SEQ & SIM	-	Y		Y	Y	Y	Y	Y		Y	Y	Y
	SMR	-	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Figure 4. Equilibria Results Screen

5.3. Graphical Representation

The complexities of a conflict's graph model are often most easily understood when presented in a visual form, facilitating the presentation and allowing the deeper analysis (Kinsara et al., 2015).

Figure 5 demonstrates the graph model for changing the situation in this conflict. Each vertex shows one of the possible states. Any possible Unilateral Moves (UM) between states are shown as a directional arrow, which is displayed with the player's unique color, and if the new state is more preferred by DM, it is Unilateral Improvement (UI). For example, NAJA can have a UI from state 13 to 15, which is shown in blue and bolded. In addition, in the equilibria state, none of the participants has unilateral improvement, as seen in state 34.

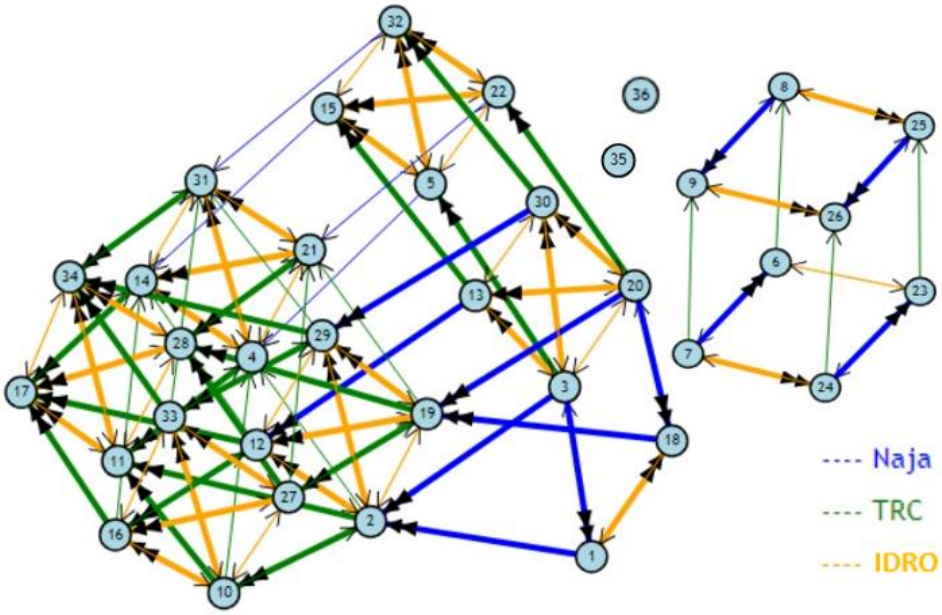

Figure 5. Graph Diagram for the Conflict

Figure 6 illustrates a tree diagram representing a status quo analysis. The top of the tree indicates the status quo, and the branches are the possible unilateral moves from that state by each DM. In addition, the steps needed to be taken by each player to move from the current state to the desired states are also illustrated. Again, lines are color- and dash-coded for each DM.

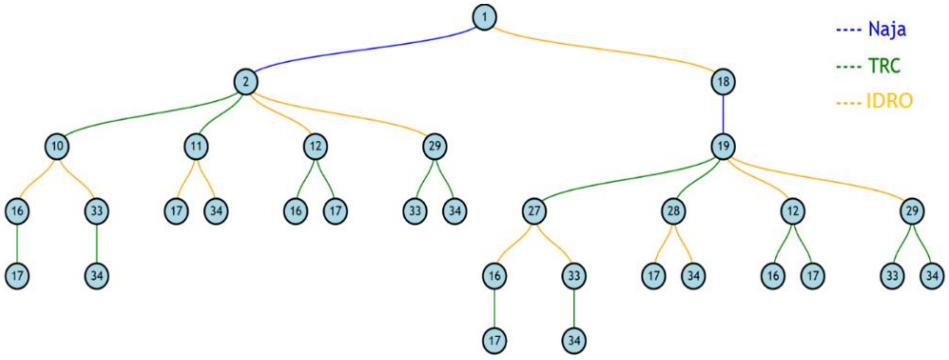

Figure 6. Tree Diagram

6. Sensitivity Analysis

When the analyst is uncertain about some of the input data, sensitivity analysis is adopted to investigate the extent to which the most likely outcomes (output) would alter when some input data change slightly. Sensitivity analysis, which we focus on here, is related to disagreement among the participants interviewed. Based on this analysis, some players believe that NAJA does not agree to sell its share at a fair price, and it may tend to purchase IDRO's share under particular conditions. It is also likely that players continue the partnership with building two plants with the remaining capital. In addition, with the attention to tissue engineering from some of the Iranian universities and the field's considerable development in the country, new opportunities for establishing knowledge-based firms have emerged. In this situation, TRC might be substituted with other similar firms as the technological knowledge shareholder. IDRO is no longer inactive, as it seeks to make the conditions of its share clear.

6.1. Players' Options in the Sensitivity Analysis

Considering the Bonyad-Sazeh report and the new developments in the current state of DBA, the revised players' options are as follows:

NAJA Options

1. Selling its shares at a high price
2. Accepting the DBA dissolution
3. Settling dispute through court action
4. Continuing partnership through establishing two plants, along with maintaining the concession
5. Terminating the provision related to concession
6. Purchasing IDRO's share to extend influence and power
7. Replacing the technology shareholder

TRC Options

1. Transferring technology

2. Taking court action
3. Persuading an approved shareholder to purchase NAJA's share
4. Accepting the DBA dissolution
5. Withdrawing from the partnership and transferring the share

IDRO's Options

1. Transferring the share to the Iranian Privatization Organization
2. Continuing partnership through building two other plants
3. Accepting the DBA dissolution
4. Settling the dispute through court action
5. Replacing the technology shareholder

6.2. Infeasibilities in the Sensitivity Analysis

1. It is impossible for NAJA to sell its share and involvement in the company's decision, such as termination of the concession or TRC replacement.
2. It is not possible for NAJA to sell its share and purchase IDRO's share.
3. If TRC leaves the partnership, it will not transfer the technology.
4. When TRC is replaced, then it will not continue the partnership.
5. In the case of TRC's withdrawal and replacement, persuasion of a new shareholder to purchase NAJA's share and termination of exclusivity clause is meaningless.

With regard to the number of options, there are 2^{17} possible combinations. After removing infeasible combinations, the overall number of possible states is 21. These are shown in Table 6.

Table 6. Feasible States in Sensitivity Analysis

States		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
NAJA	N1	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	N2	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	Y	N	N
	N3	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y
	N4	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	N
	N5	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N	N	N	Y	N	N	N
	N6	N	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N	N
	N7	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y
TRC	T1	N	N	N	N	N	N	Y	Y	N	N	Y	Y	Y	N	N	N	Y	Y	N	N	N
	T2	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y
	T3	N	N	Y	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	T4	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	Y	N	N
	T5	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y
IDRO	I1	N	N	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
	I2	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	N
	I3	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	Y	N	N
	I4	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	Y
	I5	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y

6.3. Players' Preferences in the Sensitivity Analysis

In the sensitivity analysis, some of the changes made in the players' preferences are considered in accordance with the opinions of the parties involved. The overall order of the players' participants is shown in Figure 7.

NAJA's Preferences

NAJA primarily tends to sell its share at a reasonable price. It then is interested in continuing the partnership through building two other plants without terminating the concession clause. If TRC does not transfer its share, NAJA will agree to purchase IDRO's share and push TRC to agree to transfer technology. NAJA also agrees to take court action for the sake of partnership, insisting on not terminating the exclusivity. It is possible that TRC does not agree to continue the partnership. In that case, NAJA seeks to find a new technology shareholder to implement the bioimplant project due to the high expenses spent on cleanroom and industrial shed construction. The other reason for this move is that the suspension of the project's activity for so long might cause the depreciation of assets and equipment and ultimately waste capital. On the other hand, the company's dissolution is not a favorable decision for NAJA, as selling the building and the remained equipment may not make considerable money for this player.

According to the participants interviewed, NAJA does not agree to DBA's dissolution. The worst-case scenario for NAJA is to take part in the court session and, at the same time to witness the dissolution of the company and the project's failure.

TRC Preferences

TRC initially tends to find a new shareholder, compatible with its desire, which purchases NAJA's share. As the next choice, it is interested in continuing the partnership by establishing two plants with the remaining capital. It also demands to terminate the concession provision. Besides, TRC is interested in dissolution, even if it receives no money for its share. If IDRO and NAJA are unwilling to cooperate, this player agrees to leave the partnership and transfer its share. However, the latter option is possible only when the other shareholders agree. TRC is not interested in attending the court unless the court compels all sides to continue the partnership. The worst-case scenario for this player is taking legal action and being found guilty for hesitation in transferring technology and for other accusations raised by IDRO or NAJA. These possible states lead to TRC's withdrawal and replacement.

IDRO's Preferences

Initially, IDRO tends to alleviate the current tension and to transfer its share to the Privatization Organization. Continuing partnership and building two plants are highly preferable for this player as its major mission is to invest for the purpose of boosting economic growth. In order to slow down the tensions, IDRO is not willing to replace NAJA with a new shareholder, as TRC desires. In addition, it is not interested in terminating the concession provision of the agreement but is ready to make a deal for the benefit of the company. This player is not interested in proceeding with court action, as it takes remarkable time and capital, which is incompatible with the company's purpose. Dissolution is an option to be considered by IDRO when other options don't work. If the company is not dissolved, it agrees to replace the technology shareholder. The worst-case scenario for this player is to get involved in court action, and no clear conclusion is reached (see Figure 7).

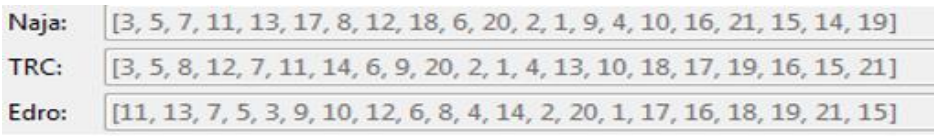

Figure 7. Ordinal Preferences of the Players in the Sensitivity Analysis

6.4. Equilibrium in the Sensitivity Analysis

By inserting all the above data in GMCR+, the states 5, 11, 12, 13, 14, 15, 17, 18, 19, 20, and 21 are shown as the equilibria (see Figure 8). Considering the current state, and whether the players are present in court or not, the following outcome is achieved:

	Ordered		5	11	12	13	14	15	17	18	19	20	21
	Decimal	Filter	4609	1242	1244	1245	1741	3302	4135	4137	5043	6764	10067
1 - Naja	N1	-	Y	N	N	N	N	N	N	N	N	N	N
	N2	-	N	N	N	N	Y	N	N	N	Y	N	N
	N3	-	N	N	N	N	N	Y	Y	Y	Y	N	Y
	N4	-	N	Y	Y	Y	N	N	Y	Y	N	N	N
	N5	-	N	N	Y	N	N	N	N	Y	N	N	N
	N6	-	N	N	N	Y	N	N	N	N	N	N	N
	N7	-	N	N	N	N	N	N	N	N	N	Y	Y
2 - TRC	T1	-	N	Y	Y	Y	N	N	Y	Y	N	N	N
	T2	-	N	N	N	N	N	Y	Y	Y	Y	N	Y
	T3	-	Y	N	N	N	N	N	N	N	N	N	N
	T4	-	N	N	N	N	Y	N	N	N	Y	N	N
	T5	-	N	N	N	N	N	N	N	N	N	Y	Y
3 - Edro	I1	-	Y	Y	Y	Y	N	N	N	N	N	N	N
	I2	-	N	Y	Y	Y	N	N	Y	Y	N	N	N
	I3	-	N	N	N	N	Y	N	N	N	Y	N	N
	I4	-	N	N	N	N	N	Y	Y	Y	Y	N	Y
	I5	-	N	N	N	N	N	N	N	N	N	Y	Y
Payoff For:	Naja	-	20	18	14	17	2	3	16	13	1	11	4
Payoff For:	TRC	-	20	16	18	8	15	2	5	6	4	12	1
Payoff For:	Edro	-	18	21	14	20	10	1	6	4	3	8	2
	Nash	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	GMR	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	SEQ	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	SIM	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	SEQ & SIM	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	SMR	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Figure 8. Equilibria Results in the Sensitivity Analysis

In Case not Attending the Court

In Table 7, the players' total payoffs are placed in the last row. We determine a score for each state according to each decision-maker. This score (payoff) is equal to the number of states which are less preferred plus one. In this case, the payoff for the least preferred state is equal to one, and the payoff for the most preferred state of decision-makers is equal to the number of states. Out of all equilibria, state 5 constitutes the best payoff for all players. In this state, TRC persuades a new shareholder to purchase NAJA's share according to its own criteria. Because NAJA disagrees with the new shareholder's proposed price, the realization of this state seems impossible. Then, state 11 is regarded as the best feasible state for all players, with a total payoff of 55. In this state, NAJA and IDRO jointly set up two plants and transfer the technology there without termination of concession provision. Then, as the project has been implemented, IDRO would leave the project, transferring its share to the Privatization Organization.

In the sensitivity analysis, the analyst's suggestion to players is to sign a new turnkey agreement to construct two new plants in Tehran and Kermanshah. The contractor of this turnkey project, technology shareholder, should catch required international certificates for

DBA, provide a bank guarantee, and implement the project with the remaining capital. Then, IDRO would be able to leave the project.

It is worth mentioning that the termination of the provision related to concession will no longer matter. If TRC were willing to develop the business, it would legally extend its firm by attracting investors. Considering its current trend and its experience in DBA, however, it is clear that the firm has no interest in growing the business through attracting new investors.

In Case of Attending the Court

Presence in court would have a desirable outcome for none of the players. Given the total payoffs of the players, the best state in case of court action is state 17, with a total payoff of 27, which involves continuing partnership without terminating the concession. State 18, with a tiny difference compared to the first state, is ranked as the second-best state, which constitutes a continuing partnership with terminating the concession. The worst states are 21 and 19, which include attending the court, no implementation of the project, DBA's dissolution, and TRC's withdrawal (see Table 8).

In all states, including attending the court, all players experience excessive damage as they lose plenty of time and money without any achievements. Therefore, if the parties attend the court, continuing partnership and implementing the project will be the best scenario ahead.

Table 7. Equilibria in Case not Attending the Court

State		5	11	12	13	14	20
NAJA	N1	Y	N	N	N	N	N
	N2	N	N	N	N	Y	N
	N3	N	N	N	N	N	N
	N4	N	Y	Y	Y	N	N
	N5	N	N	Y	N	N	N
	N6	N	N	N	Y	N	N
	N7	N	N	N	N	N	Y
TRC	T1	N	Y	Y	Y	N	N
	T2	N	N	N	N	N	N
	T3	Y	N	N	N	N	N
	T4	N	N	N	N	Y	N
	T5	N	N	N	N	N	Y
IDRO	I1	Y	Y	Y	Y	N	N
	I2	N	Y	Y	Y	N	N
	I3	N	N	N	N	Y	N
	I4	N	N	N	N	N	N
	I5	N	N	N	N	N	Y
Payoff For	NAJA	20	18	14	17	2	11
	TRC	20	16	18	8	15	12
	IDRO	18	21	14	20	10	8
SUM		**58**	**55**	46	45	27	31

Table 8. Equilibria in Case Attending the Court

State		15	17	18	19	21
NAJA	N1	N	N	N	N	N
	N2	N	N	N	Y	N
	N3	Y	Y	Y	Y	Y
	N4	N	Y	Y	N	N
	N5	N	N	Y	N	N
	N6	N	N	N	N	N
	N7	N	N	N	N	Y
TRC	T1	N	Y	Y	N	N
	T2	Y	Y	Y	Y	Y
	T3	N	N	N	N	N
	T4	N	N	N	Y	N
	T5	N	N	N	N	Y
IDRO	I1	N	N	N	N	N
	I2	N	Y	Y	N	N
	I3	N	N	N	Y	N
	I4	Y	Y	Y	Y	Y
	I5	N	N	N	N	Y
Payoff For	NAJA	3	16	13	1	4
	TRC	2	5	6	4	1
	IDRO	1	6	4	3	2
SUM		6	**27**	23	8	7

6.5. Graphical Representation

Figure 9 demonstrates the graphic model for changing the situation for the sensitivity analysis. Each vertex represents one of the possible states. Any possible Unilateral Move between states is shown as a directional arrow, which is displayed with the player's own unique color, and if the new state is more preferred by DM, it is Unilateral Improvement (UI).

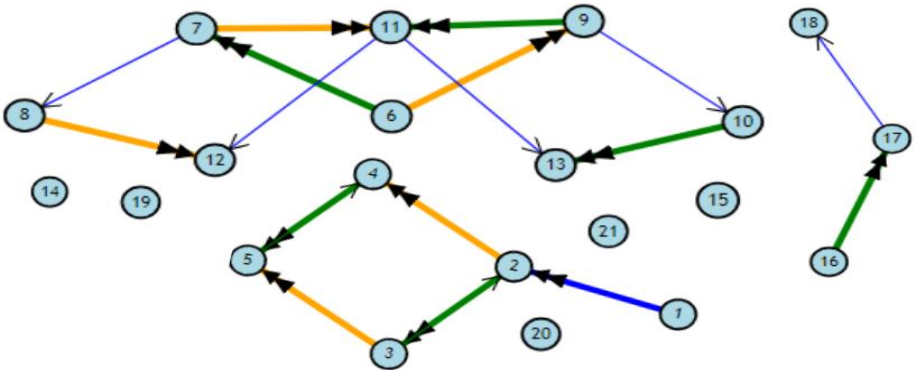

Figure 9. Graph Diagram for the Sensitivity Analysis

7. Steps for Working With GMCR + Software

We now briefly describe how to use GMCR+ as a decision support system. The basic interface, shown in Figure 10, includes a large navigation bar at the top of the screen. This bar displays each of the logical steps in the modeling of a conflict.
Decision-Makers and Options are the first steps in modeling the conflict where the user or analyst defines the DMs and their options in the conflict. There is an information panel at the right edge of the screen.

After defining DMs and options, the program will generate a list of all possible states. There are some infeasible states that must be removed. After removing infeasible conditions and mutually exclusive options, the set of feasible states can be displayed as a complete list of feasible states in YN format or as ordered and decimal state numbers.

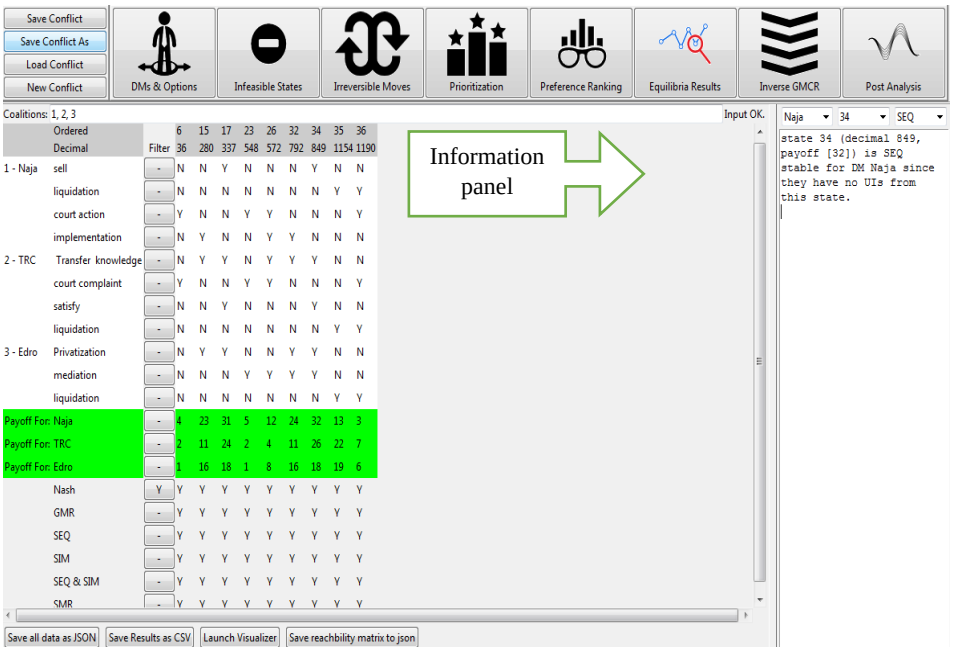

Figure 10. Equilibria Results Screen in GMCR+

The next step is Irreversible Moves (IM), where an analyst can define the reversibility of each option. Preferences for DMs can be specified through preferred conditions or the direct ranking of states. The states are ordered according to their ranking for the active DM. One table also displays the payoff value of each state according to the active DM. States are listed

using their ordered numbers. Equally preferred states can be indicated by being enclosed in square brackets.

Figure 10 illustrates the equilibria results screen. The top of the screen shows the results of equilibria calculations for all states and solution concepts in an option for the conflict model.

In addition, inverse GMCR is a useful addition allowing analysts to perform extensive sensitivity analysis on preferences. There is another choice for an analyst, choosing a specific state to act as a status quo for the post-analysis in the last step and carry out the analysis from it. Possible evolutions of the conflict from the status quo to equilibria will be determined, consequently.

8. Conclusion and Managerial Insights

This research examined applying a useful tool to find settlement strategies in conflicts. The paper illustrated a case study for this approach. The conflict over Danesh-Baft Alborz Company was investigated by employing the Graph Model for Conflict Resolution (GMCR+).

In this conflict, there were 11 options that could be carried out by players. Hence, 2^{11} combinations of strategies were generated. However, considering the infeasibilities, only 36 feasible states remained. Based on this calculation, state 34 had the best outcome for all players. This state included TRC's attempt to persuade a new shareholder to purchase NAJA's share, seeking to build trust by making sure of technology transfer. Thereby, it prepared the ground to sell NAJA's share at a favorable price. This stable situation would let IDRO accomplish its mission at this stage. We also traced the evolution of the conflict from the current state to equilibria in status quo analysis.

In the sensitivity analysis, IDRO was thought to be no longer an inactive shareholder. Given the attitudes of individuals involved in the conflict, it was likely that the technology shareholder would get replaced, and the partnership would continue with the remaining capital. NAJA would also agree to sell its share in case of a favorable price.

Due to the higher number of player's options in the sensitivity analysis, 2^{17} combinations of strategies were generated. Then, the number was reduced to 21 states after eliminating the implausible combinations. In case of not attending the court, the state with the highest payoff would be when TRC persuades a new shareholder to purchase NAJA's share. Given the fact that NAJA has not agreed with the prices offered so far, the possibility of this state occurring is quite low. Another favorable state that involves the best payoffs is that NAJA and IDRO would set up two plants with transferring the technology without the concession's termination. By implementing the project, IDRO would exit the game, transferring its share to the Privatization Organization. Attending the court would not result in favorable outcomes for any of the players. Therefore, considering the sensitivity analysis, our recommendation is to reach a new turnkey agreement in setting up two plants in Tehran and Kermanshah. The contractor of this turnkey project, TRC, is liable to obtain an international certificate. It should provide a bank guarantee and launch the project with the remaining capital. By obtaining the international certification, transferring the technology in an operational situation, and implementing the project, IDRO would leave the project.

There were some limitations and complications in this research. First, the case was very complicated and required lots of information. For example, understanding the ordinal preferences of decision-makers was difficult and time-consuming. The other problem was related to extracting different types of infeasibilities, which were complicated and required strong logic.

For future research, it would be interesting to extend the model, considering risk-based multi-criteria decision analysis. Another alternative would be applying system dynamics, one of the methods that help researchers comprehend this conflict's cause and effect relationships. In addition, mechanism design is another analysis that could be carried out in future. In the mechanism design, the game structure, including the player's preferences, is determined such that a desirable outcome appears at the end as the equilibrium.

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