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A conflict model for the international hazardous waste disposal dispute

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ABSTRACT

A multi-stage conflict model is developed to analyze international hazardous waste disposal disputes. More specifically, the ongoing toxic waste conflicts are divided into two stages consisting of the dumping prevention and dispute resolution stages. The modeling and analyses, based on the methodology of graph model for conflict resolution (GMCR), are used in both stages in order to grasp the structure and implications of a given conflict from a strategic viewpoint. Furthermore, a specific case study is investigated for the Ivory Coast hazardous waste conflict. In addition to the stability analysis, sensitivity and attitude analyses are conducted to capture various strategic features of this type of complicated dispute.

1. Introduction

The past century witnessed an increasingly globalized economy. However, people also recognized the dark side of this economic progress: along with the rapid growth of the economy and the development of technology, the global environment was being contaminated and the earth's ecosystems were being ruined. Among these issues, the international dumping of hazardous wastes has become one of the most serious environmental problems and has generated significant concern around the world. Since the second half of the twentieth century, technological innovation has enhanced industrial production capabilities, thereby significantly increasing production and its byproducts. Simultaneously, the abuse of new technologies has caused a depletion of natural resources and an environmental crisis. After having experienced numerous disasters, people finally have come to realize the importance of living in harmony with their natural environment. If hazardous wastes are improperly treated, stored, transported and/or disposed, the outcome can be potentially harmful to human health and the environment [1]. Hence, regulations and laws related to environmental protection came into effect in many countries [2]. As a result, the disposal of hazardous wastes must now be conducted under certain circumstances by meeting regulated standards.

The costs of the disposal of hazardous wastes have dramatically risen as a result of compliance to these laws and regulations. Driven by profit maximization, industrialists began to seek lower cost ways to dispose of toxic wastes [3]. Table 1 shows the increasing tendency to export wastes to developing or less-industrialized regions [4].

Obviously, weakly governed developing countries gradually became the most popular targets for toxic waste dumping and the least costly alternative to solving the toxic waste problem. Unfortunately, numerous toxic waste traders transferred huge volumes of hazardous wastes from richer nations to poorer ones in adherence to the NIMBY (not-in-my-backyard) syndrome [3,5]. Consequently, the transboundary movement of hazardous wastes dramatically escalated throughout the 1980s [6].

As a number of scandals and tragedies began to reveal the scope of this problem, people became cognizant of the situation, and endeavored to find practical solutions to prevent the continuation of this outrage against the environment. After Non-Governmental Organizations (NGOs) campaigned against this illegal trafficking, the United Nations (UN) authorized its United Nations Environment Programme (UNEP) to take practical action. In March of 1989, 118 countries signed the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal, which went into force in May 1992. As of July 1997, 113 countries had ratified the treaty [6].

With the adoption of the Basel Convention, efforts were made to publicize the environmentally sound management of hazardous wastes [3]. The Basel Convention promotes the principles of environmentally sound and efficient management, in order to achieve the ultimate goal of protecting human health and the environment from hazardous wastes [7]. It not only established a legal

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Table 1
Number of schemes proposed for exports bv receiving region and year [4].

Receiving region	Year					Total
	1989	1990	1991	1992	1993	
Baltics and Eastern/Central Europe	32	50	43	113	61	299
Africa	11	4	4	7	4	30
Pacific	1	4	1	2	4	12
East Asia	4	14	22	50	22	112
Southeast Asia	0	10	46		26	84
South Asia	2	3	2	24	12	43
Middle East	0	0	1	12	1	14
Latin America Caribbean	27	42	30	32	16	148
Total	77	120	113	236	146	742

mechanism to control the international transportation of hazardous wastes, but also furnished detailed and practical provisions for managing the transboundary movement between the parties of the Convention. To facilitate the implementation of the Convention, signatories are required to designate competent authorities who will provide prior written notification of any hazardous waste movement. Furthermore, the Convention requires the nation of export to provide prior written notification to the relevant competent authority of the nation of import. All exports may only take place with the prior written consent from the nations of import and transit [6].

Nevertheless, as a voluntary agreement, the Basel Convention applies only to those parties who signed the treaty and, therefore, remains unheeded by those countries that did not sign it. Unfortunately, some heavily industrialized countries, such as the United States, refused to sign the Basel Convention [6]. In addition to this limited jurisdiction, the treaty has an inherently weak control mechanism due to the principle of "Prior Informed Consent", which has led to numerous "legal" transboundary movements of hazardous wastes that are labeled as having "Informed Competent Authority". Moreover, the particular political structure of the UN means the inevitable overlap of the jurisdictional powers between the Multilateral Environmental Agreements (MEA) and the Free Trade Agreements (FTA). This complexity has diminished the strength of international environmental laws [8].

Because of the complex nature of the international toxic waste dumping problem as discussed earlier in this section, a practical and efficient methodology is required to examine the conflict and find possible resolutions. The graph model for conflict resolution [9] constitutes a novel approach to model and analyze strategic conflict. As an expansion of metagame [10] and conflict analysis [11], the graph model for conflict resolution provides an easy-to-use and flexible methodology for strategic conflict analysis, and differs from techniques falling within classical game theory [12]. In this research, by decomposing the toxic waste dumping problems into two main stages, the dispute prevention stage and the dispute resolution stage, complicated conflict situations can be readily investigated, thus realizing better understanding of past events, and forecasting possible outcomes for ongoing conflicts. Furthermore, NGOs are included in the model as a decision maker in order to represent public participation. By taking into account public participation, the model considers a critical part of such controversies [13].

This paper is organized as follows. After the introductory section, the basic concepts and advantages of the graph model for conflict resolution approach are presented. Then, the generic multi-stage graph model is proposed and discussed in detail. By applying the model to a real world toxic waste dumping case, namely the Ivory Coast toxic waste dumping scandal, the practicality and effectiveness of the graph model approach are illustrated. Finally, the paper is concluded by a brief summary.

2. The graph model for conflict resolution

2.1. Basic concepts

The graph model for conflict resolution is a game theoretic methodology that can be used to analyze conflict existing in the real world [9]. The graph model approach focuses on strategic level conflict analysis with a structure consisting of four main modeling components [9,14,15]:

(1) a set of decision makers (DMs) $N = \{1, 2, \ldots n\}$;
(2) a set of feasible states $S = \{s_1, s_2, \ldots, s_m\}$;
(3) a set of preference relationships among the states $P = \{P_i, i \in N\}$, where P_i denotes the preferences for DM*i*, which is typically expressed as a pair of binary relations, $\{\succ, \sim\}$on S, representing strict preference and indifference, respectively. In other words, $s_1 \succ_i s_2$ denotes that DM*i* prefers s_1 to s_2, and $s_1 \sim_i s_2$ means that DM*i* is indifferent between s_1 and s_2, where $s_1, s_2 \in S$. More specifically, the operator $\succ_i$ is asymmetric (i.e., $s_1 \succ s_2$ and $s_2 \succ s_1$ cannot both be true); and the operator $\sim_i$ is reflexive and symmetric (i.e., if $s \in S$, then $s \sim_i s$ for any $s \in S$; and if $s_1 \sim_i s_2$, then $s_2 \sim_i s_1$). If $\succ_i$ and $\sim_i$ are transitive for DM*i*, the states can be ordered from the most preferred to the least preferred with ties allowed for this DM; and
(4) a set of directed graphs $\{G_i = (S, A_i), i \in N\}$, where G_i indicates the possible moves among the states controlled by DM*i* and A_i is DM*i*'s set of directed arcs in G_i, for which each arc stands for a move DM *i* can make in one step from one state to another.

At the analysis stage of a conflict model, a set of stability definitions or solution concepts and associated algorithms are used to compute possible resolutions. In the graph model for conflict resolution, several specific solution concepts are available to define stability. A state is stable for a DM when he/she has no incentive to move away from the state unilaterally. When a state is stable for all DMs under a certain solution concept, it constitutes an equilibrium and represents a potential resolution for this conflict. Table 2 shows a list of six key solution concepts with their descriptions and associated characteristics. As an important feature, foresight refers to a DM's capacity of foreseeing possible future moves under a particular stability definition. As shown in Table 2, Nash stability has the lowest foresight, while non-myopic (NM) has the highest. The strategic disimprovement in the next column means a DM may move to a less preferred state temporarily in order to reach a more preferred one eventually. The disimprovement by opponents means that other DMs may choose to move to a less preferred state in order to block the focal DM's unilateral improvements. For mathematical definitions, references, and other details, see [9,14,15].

Practically, in order to implement the methodology of the graph model for conflict resolution, a decision support system (DSS), GMCR II, is designed to strategically analyze real-world interactive decision-making problems. Because of its powerful analysis engine and friendly graphical user interface (GUI), GMCR II provides a practical and efficient instrument to assist users in modeling, analyzing, and capturing the essentials of conflicts [16,17]. The procedure for applying GMCR II to a practical problem is explained with an application for model 1 in Section 3, while further comments about GMCR II are made in Section 2.3.

2.2. Attitude analysis

In the area of social psychology, attitude is defined as "an enduring system of positive or negative evaluations, emotional feeling and pro and con action tendencies, with respect to a social object" [18]. As a natural extension of the graph model approach, the consideration of attitudes provides DMs and other interested parties

Table 2
Stability definitions and human behavior [9].

Definition	Description	Foresight	Disimprovements
Nash stability (R)	A DM cannot unilaterally move to a more preferred state.	Low	Never
General mstarationality (GMR)	All of a DM's unilateral improvements are sanctioned by its opponents' subsequent unilateral moves.	Medium	By opponents
Symmetric metarationality [SMR)	All of a DM's unilateral improvements are still sanctioned, even after a possible response by the original DM.		
Sequential stability (SEQ)	All of a DM's unilateral improvements are sanctioned by its opponents' subsequent unilateral improvements.		Never
Limited-move stability (L_h)	A fixed number (h) of state transitions are contemplated; all DMs are assumed to act optimally by backward induction.	Variable	Strategic
Non-myopic stability (NM)	The limiting case of the limited-move stability as the number of state transition approaches ∞.	High	

with the capability of analyzing and understanding a given conflict situation more comprehensively. Inohara et al. [19] introduced attitudes into the graph model for conflict resolution by modifying and expanding the original definitions of preferences, special types of moves among states, and related solution concepts.

For DMs $i, j \in N$, let $E_i = \{+, 0, -\}^N$ represent the set of attitudes of DMi. An element $e_i \in E$ is called the attitudes of DMi for which $e_i = (e_{ij})$ is the list of attitudes of DMi towards DMj for each $j \in N$ where $e_{ij} \in \{+, 0, -\}$. The e_{ij} is referred to as the attitude of DMi to DMj where the values $e_{ij} = +$, $e_{ij} = 0$ and $e_{ij} = -$ indicate that DMi has a positive, neutral and negative attitude towards DMj, respectively.

Table 3 shows how attitude information can be illustrated in matrix form. The entry in the cell for row i and column j represents the attitude of DMi to DMj. Essentially, DMs' preferences are the elements that are mostly impacted by attitudes. Similar to a regular graph model analysis, after applying attitude information to the DMs' preference structures, the stability analyses of the given model can be carried out.

2.3. Applying GMCR

Aiming to better understand conflict situations as well as provide strategic insights and guidance, GMCR constitutes a simple and flexible methodology designed for modeling and analyzing real world conflicts. Because the graph model was purposefully developed for formally studying actual disputes, it possesses many advantages over classical game theory techniques such as requiring much less input information from the user, allowing DMs to move in any order rather than restricting movement to a prespecified order, only requiring relative preference information for each DM rather than cardinal utility values which can be extremely difficult to obtain in practice, and permitting a rich range of behavior to be considered when analyzing potential human interactions in conflict situations. As a direct result of the foregoing and other inherent capabilities, GMCR has been applied to a broad variety of societal controversies such as military, peace keeping, international trade, labor-management negotiations, and both local and international environmental conflicts. In this paper, GMCR is utilized for the first time to formally investigate generic conflict arising over the disposal of hazardous wastes at the international level in Section 3 and a specific case study that took place in the Ivory Coast in Section 4.

Table 3
Attitudes in matrix form.

DM	i	j
i	e_{ii}	e_{ij}
j	e_{ji}	e_{jj}

The DSS GMCR II [16,17] permits the graph model methodology to be conveniently utilized by both practitioners and researchers for formally studying both current and historical disputes as well as generic and hypothetical disputes. As explained by Kilgour and Hipel [15], GMCR II can be gainfully utilized as an analysis and simulation tool for conflict participants; an analysis and communication tool for mediators; and an analysis tool for a third party or a regulator, as is done in this paper in Sections 3 and 4, where the authors constitute an interested third party.

3. Multi-stage modeling and analysis

A multi-stage approach is developed to tackle the complexity of this type of conflict. In this model, four parties are involved in international toxic waste disposal conflicts: the receiving country, the toxic waste trader, the United Nations, and Non-Governmental Organizations. Generally, only poor countries, or developing countries, are potential receiving countries due to the pressure of the financial difficulties they face. "Trash for Food" is a manifestation of their concessions [8]. Since toxic waste trade began in the 1970s, numerous hazardous wastes have been shipped from the USA, European Union (EU) and Australia to poor countries in Africa, Asia, and South America [4]. These highly developed nations are equipped with the most advanced manufacturing facilities in the world, which are able to produce large amounts of products and hazardous wastes. The United Nations (UN), the largest international organization, was created in 1945. There are two main mechanisms that the UN has for settling environmental disputes. The first is negotiation, mediation and conciliation, which is a peaceful procedure where, with the agreement of the disputants, a mediator or conciliator is appointed to conduct fact-finding procedures and seek solutions for a settlement. The other is arbitration, which is a method of legally binding settlement of disputes by the International Court of Justice or Arbitration under the Basel Convention [20]. Non-Governmental Organizations refer to the legal entities that are independent from the control of any government. In this paper, an NGO is defined as an environmental group with a narrow focus on environmental protection and not-for-profit in nature, such as the Greenpeace. In waste disposal conflicts, NGOs can alert the public to dumping scandals and conduct a campaign to press the involved parties to settle their disputes.

The Multi-Stage Graph Model Analysis applied to this dynamic conflict focuses on analyzing uncertain situations and observing the evolution of the conflict from a strategic viewpoint. For the purpose of conflict analysis, this model simplifies the complicated situation occurring in reality. Based upon this consideration, the time dependent event can be divided into two stages: Dumping Prevention Stage and Dispute Resolution Stage, as shown in Fig. 1.

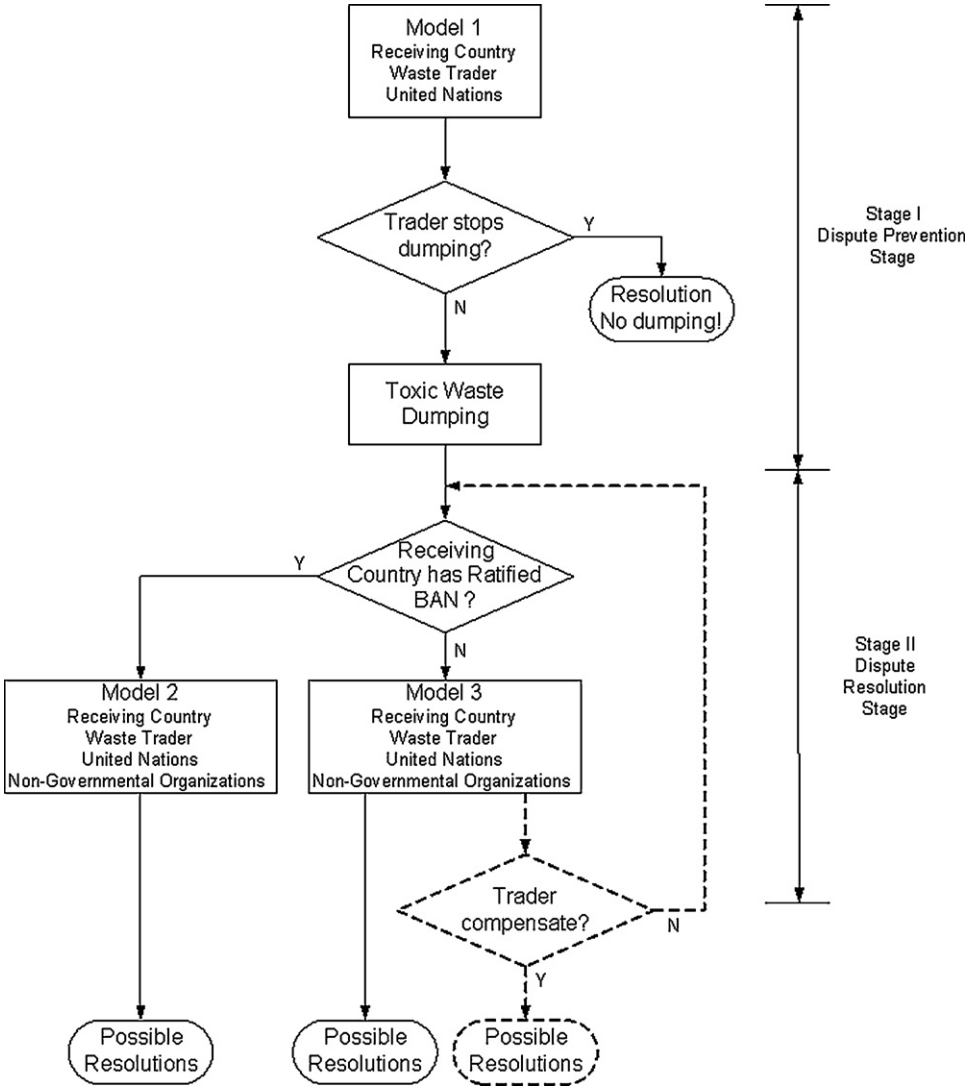

Fig. 1. Flowchart of the multi-stage analysis.

3.1. Stage I—dispute prevention

At this stage, due to the possible illegal waste trafficking, the three DMs involved in the conflict are the Receiving Country (RC), Waste Trader (WT) and United Nations (UN). The receiving country might take a risk in receiving wastes for financial benefit. With rising public consciousness of environmental protection, these poor counties might accept wastes conditionally. They may require proper treatment for toxic wastes or a cleanup offer for taking care of accidental leakage, or they may just ban them completely. Driven by the profit maximization, the toxic trader always attempts to dump the wastes. In order to enforce international environmental law, the UN cooperates with nations and diverse organizations to control the illegal waste trafficking and minimize its negative impacts on the environment. At a chosen time point, the available options of each DM are as listed in Table 4.

For each of the options, DMs may choose the option (Y for yes) or not select the option (N for no). Therefore, there exist $2^8 = 256$ possible combinations. After eliminating infeasible combinations, GMCR II automatically generates a list of 36 feasible states for this model.

Two categories of infeasible states are removed: (1) "mutually exclusive" options, which eliminate the states that contain sets of options for which more than one option from a specified set of options are selected. For each of the DMs Receiving Country and Waste Trader, their options are mutually exclusive. (2) "at least one" option, which is used to specify that, for a specified set of options, at least one option must be selected. In this conflict, Receiving Country must choose at least one from its options, and Waste Trader must also select at least one of its options. Fig. 2 shows how the foregoing types of infeasibilities are specified using GMCR II.

Table 4
Model 1 in stage I—decision makers and options.

DMs	Options
Receiving Country (RC)	1. Import wastes: accept any potential toxic wastes. 2. Require treatment: accept proper disposal or require cleanup. 3. Refuse and ratify: refuse potential toxic wastes and ratify the Convention. 4. Dispose wastes: continue waste dumping.
Waste Trader (WT)	5. Export and treat: export and agree to clean up. 6. Stop: stop all dumping.
United Nations (UN)	7. Press WT: bring pressure on WT to stop waste dumping. 8. Encourage RC: encourage RC to refuse wastes and ratify the Convention.

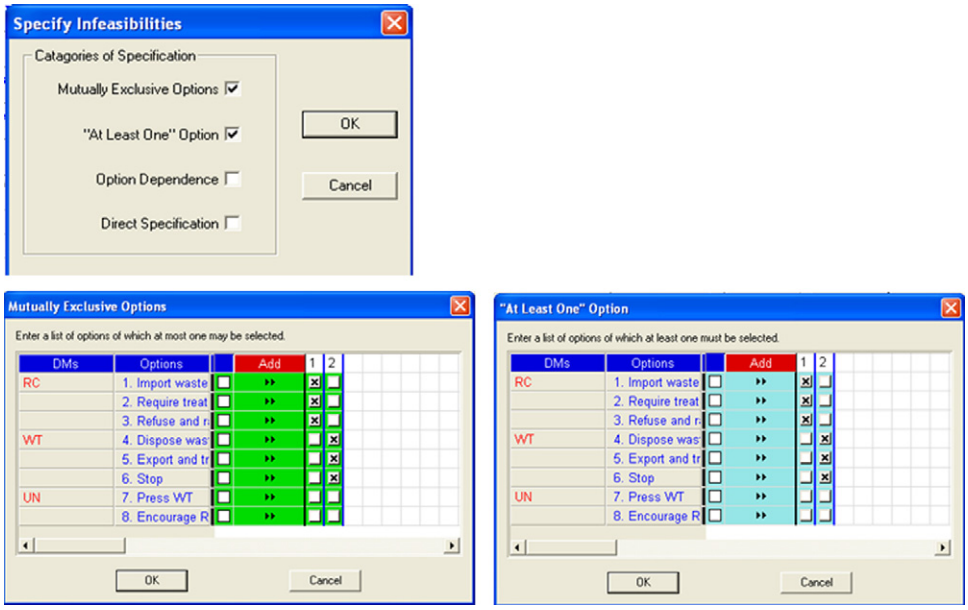

Fig. 2. Model in stage I—remove infeasible states using GMCR II.

There are three techniques in GMCR II to specify relative preferences for each DM: Option Prioritizing, Option Weighting, and Direct Ranking. Table 5 demonstrates how the Option Prioritizing, a flexible approach to specify relative preferences for each DM, works. In the column for each DM, the numbers from top down represent preference statements ordered from most to least important. For instance, from the Receiving Country's point of view (column of RC), "−4" denotes that the Receiving Country most prefers that Waste Trader stop dumping (−4 means "do not take option 4"); "2" denotes that the Receiving Country accepts conditional dumping; "3 IF 8" represents that the Receiving Country would refuse dumping and ratify the Convention if UN encourages it; "7 IF 4" represents that the UN would press the Waste Trader to stop if the Waste Trader continued dumping. Similarly, the preferences of the Waste Trader and the UN are given by the preference statements in the corresponding columns. Using the preference statements in Table 5 for each DM and under the assumption of preference transitivity, GMCR II has an algorithm which ranks the states from most to least preferred.

With the completion of the initialization process, the model is created and the conflict analysis is carried out by using the analysis engine in the decision support system GMCR II. Fig. 3 lists which states are equilibria, or stable for all of the DMs as indicated by check marks opposite the solution concepts for which an explanation is given in Table 2.

Table 6 lists two strong equilibria, which are equilibria according to all of the solution concepts. For each of these equilibria, the Receiving Country will conditionally accept the toxic waste dumping and require the Waste Trader to properly treat or clean up spilled wastes. The Waste Trader will continue to trade or dispose of toxic wastes conditionally. As usual, the UN will press the Waste Trader to stop dumping and call for ratification of the Convention by the Receiving Country. The results of the prevention stage analyses indicate the possibility of a dumping dispute taking place. Once the disposal happens, the disposal conflict analysis will move to the next stage as shown in Fig. 1.

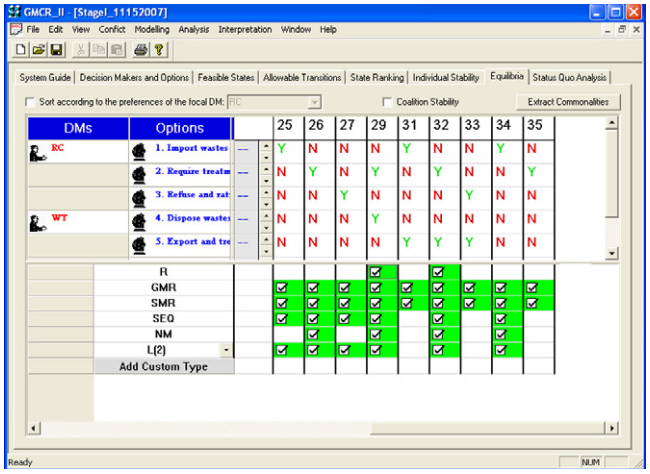

Fig. 3. Model in stage I—equilibria in GMCR II.

Table 5
Model 1 in stage I—preferences.

DMs	Receiving Country (RC)	Waste Trader (WT)	United Nations (UN)
Preference statements	−4	1	6
	2	2	3
	3 IF 8	−7	8
	7 IF 4	−3	7
		−6	5

Table 6
Summary of equilibria in model 1 of stage I.

DMs and options	29	32
Receiving Country		
1. Import wastes	N	N
2. Require treatment	Y	Y
3. Refuse and ratify	N	N
Waste Trader		
4. Dispose wastes	Y	N
5. Export and treat	N	Y
6. Stop	N	N
United Nations		
7. Press WT	Y	Y
8. Encourage RC	Y	Y

3.2. Stage II—dispute resolution

As shown in Fig. 1, at this stage, the dispute has already occurred. The DM, Non-Governmental Organizations (NGOs), is now considered to be involved in the dispute. NGOs cooperate with the UN and interact with governments to pursue their goals related to environmental protection. Due to their work, NGOs have a wide base of support and strong connections to developing countries. Hence, NGOs can garner public attention to the dumping scandal, and conduct a campaign to press the involved parties to settle their disputes.

The conflict analyses are classified into two models based on the Receiving Country's status of ratification of the Basel Convention. If the RC has ratified the Convention, then the dispute falls under the jurisdiction of the Basel Convention and its Amendments. The RC can file a claim by submitting the dispute to the UN for obtaining a settlement. If the RC has not ratified the Convention, then the RC has a less powerful option than in the previous case. As well, the RC can decide to ratify the Basel Convention instead of filing a claim according to the Convention. One can then execute a conflict modeling and analysis study by using GMCR II to determine the possible resolutions for these two models. A detailed explanation for the case study provides a better understanding of the conflict at this stage of dispute resolution. Furthermore, the consideration of the influence of attitudes provides a different perspective to gaining strategic insights into this dispute.

4. Case study: stability analysis and attitude analysis

The Multi-Stage Conflict Model analysis is now used to investigate the serious conflict arising over the illegal dumping of toxic waste in Abidjan, the former capital of Ivory Coast, in August 2006 [21–25]. Both a regular stability analysis and an attitude analysis are carried out. In this hazardous waste trafficking scandal, the Waste Trader dumped 400 tons of toxic chemical mixture in at least 10 open sites around the city, which caused 10 deaths and more than 85,000 people required medical treatments [22–24]. The case of the Ivory Coast toxic waste dumpling reveals the complexity of a conflict that entangles different parties (local government, toxic waste trader and the United Nations) and different areas (finance, law and environment).

4.1. Conflict modeling

The time point of the strategic study is the beginning of November 2006. At this point, the dumping has already occurred, and the receiving country, Ivory Coast, has not ratified the 1995 Ban Amendment yet. Therefore, this model is classified as Model 3 of Stage II, Dispute Resolution Stage, in Fig. 1. The DMs involved and corresponding options are listed in Table 7.

Table 7
Decision makers and option.

DMs	Options
Ivory Coast (IC)	1. Refuse waste: refuse future toxic waste dumping. 2. Demand compensation: insist that the trader compensate, including cleaning up and paying penalty. 3. Enforce: ratify the 1995 Ban Amendment.
Toxic waste trader (TR)	4. Compensate: agree to compensate and accept punishment.
United Nations (UN)	5. Press Ivory Coast: put pressure on Ivory Coast to ratify the 1995 Ban Amendment.
Non-Governmental Organizations (NGOs)	6. Campaign: call for public attention to trader and press it to stop dumping.

Table 8
Ivory Coast conflict—preference statements for option prioritization.

DMs	Ivory Coast (IC)	Toxic waste trader (TR)	United Nations (UN)	Non-Government Organizations (NGOs)
Preference statements	4	−2	4	4
	6	−4 IF 2	3 IF 5	2
	1	−1	1	1
	2	−3 IF 5	6	3 IF 5
	3 IF 5	−6		6

Note that, in this case, toxic waste trader refers to the international waste trader, a Dutch-based oil trading company named Trafigura Beheer BV. The local company, Tommy Company, and the related shipping agent are omitted in the analysis. The reason for this omission is that the focus of this multi-stage model is on investigating and understanding the conflict from the international rather than local level. As discussed previously, international waste trading activities are rarely restricted or regulated due to the huge savings in cost, and most importantly, the lack of international governance. International traders can take advantage of the issues arising from the jurisdictional gap between the supranational treaties and state laws, and thus attempt to avoid being accused of dumping. However, on the other hand, the local parties are totally under the control of state laws and could be sentenced when any illegal activities are committed. Therefore, they are not considered in this case study. Of course, anyone having special knowledge about the situation may wish to employ GMCR and its associated DSS GMCR II to execute their own investigation.

Moreover, since Ivory Coast has not ratified the Convention at this time point, the UN cannot put pressure on the Waste Trader directly, but may press the receiving country, Ivory Coast in this case, to ratify the Convention. Once the ratification is made, the conflict would fall into another model of this stage, Model 2. In Model 2, the victim country could file claim to the UN, and the UN would conduct further actions, such as conciliation talks or arbitration, between Ivory Coast and the Waste Trader. The move of the conflict situation from model to model is shown in Fig. 1.

4.2. Stability analysis

As illustrated in Fig. 4, among the four techniques of GMCR II to remove infeasible states, only the technique of Option Dependence is employed in this study. It is intuitive that the Trader will compensate only if Ivory Coast asks the Trader to do so. After removing all infeasible states, 48 feasible states are retained.

Option Prioritizing is used to determine the ranking of states for each DM in this conflict. Table 8 lists the prioritized preference statements for each DM. As can be seen in the column for IC, this DM most prefers that the Trader agrees to compensate and accept punishment (option 4). Next, the NGOs alert the public to what the Trader is doing and thereby pressures the Trader to stop dumping (6). Next, Ivory Coast itself prefers not to accept any more dumping (1), followed by demanding compensation (2), and ratifying the 1995 Amendment when requested to do so by the UN (3 IF 5).

From the Trader's point of view, the most preferred option is that Ivory Coast does not demand any compensation at all (−2). Secondly, the Trader would like to refuse to provide any compensation if requested by Ivory Coast (−4 IF 2) and does not want Ivory Coast to refuse future dumping (−1) or to ratify the Amendment even if the UN puts pressure on the country (−3 IF 5). It is also preferred by the Trader that the NGOs not seek publicity to pressure the Trader to stop dumping (−6).

For the UN, its first preference is that the Trader accepts the compensation and punishment (4). It would then prefer to see Ivory

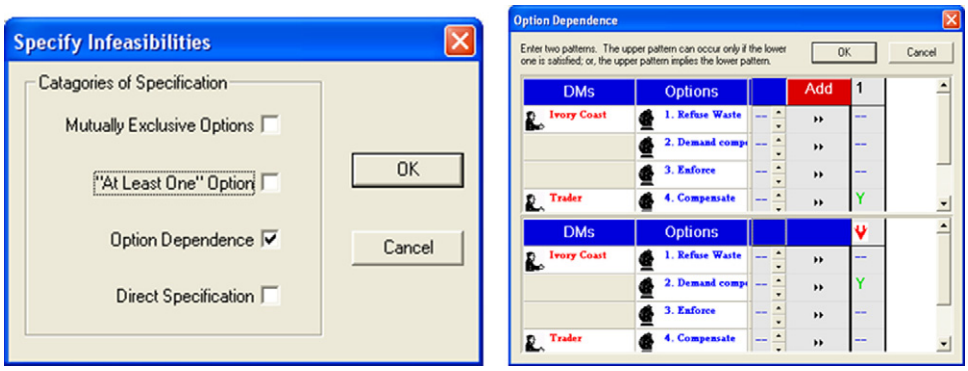

Fig. 4. GMCR II—specify infeasibilities.

Coast ratify the Amendment if pressured in order that Ivory Coast may enjoy protection from any further toxic dumping through the protection offered by international law (3 IF 5). Finally, the UN wants Ivory Coast to refuse dumping (1) and the NGOs to seek publicity to pressure the Trader to stop dumping (6).

As for the NGOs, it most prefers that the Trader agrees to compensate and accept punishment (4). Secondly, it prefers that Ivory Coast demands compensation (2), refuse future dumping (1), and ratify the Amendment if the UN asks it to do so (3 IF 5). Finally, the NGOs definitely want to alert the public and thereby pressure the Trader to stop dumping (6).

Once the preference profiles for all DMs are determined, GMCR II is ready to determine the stability and equilibrium results for this conflict. The calculated equilibria are shown as the screenshot in Fig. 5. Only state 44 is strongly stable under all stability definitions. As shown for the strong equilibrium given as state 44, Ivory Coast will refuse future waste dumping, demand the Trader to compensate, and ratify the 1995 Amendment. The Trader will try to refuse to compensate. The United Nations will put pressure on Ivory Coast and request it to ratify the Amendment for future protection. The Non-Governmental Organizations will definitely call for public attention to be focused on the Trader and thereby pressuring it to stop dumping.

4.3. Attitude analysis

As introduced previously, the attitudes of DMs may have significant impacts on the conflict's outcomes. Therefore, considering the attitudes of DMs along with the regular stability analysis can be useful for better understanding a given conflict situation. In order to further investigate and interpret the Ivory Coast waste dumping dispute, the attitude information for the receiving country, Ivory Coast, and the Trader needs to be taken into account.

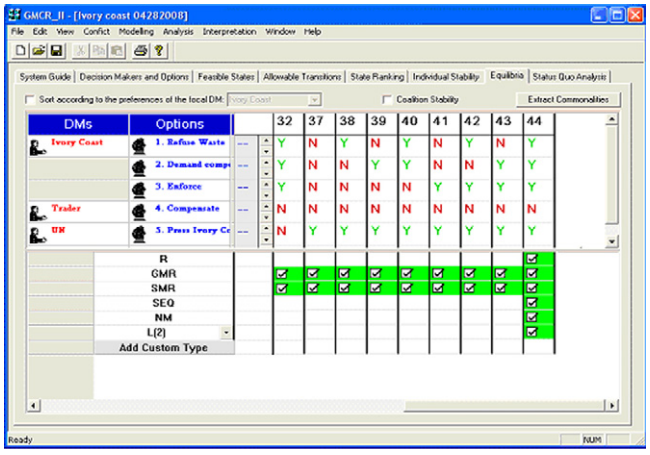

Fig. 5. Equilibria for the Ivory Coast waste dumping dispute found using GMCR II.

Table 9 shows the attitude information of this conflict situation. Each entry of this table stands for the attitude of the row DM towards the column DM. For example, as illustrated in the first row, Ivory Coast has a negative attitude towards the Trader, while it is indifferent with respect to itself and other DMs. Similarly, the Trader is negative against Ivory Coast and indifferent with respect to itself and other DMs. The United Nations and Non-Governmental Organizations are indifferent to all DMs.

When considering the attitude information, the preferences for each corresponding DM need to be modified to relational preferences. More specifically, as the Trader has a negative attitude towards Ivory Coast, Ivory Coast's preferences must be examined to determine the Trader's relational reply with respect to Ivory Coast, and vice versa. Once the relational preference information has been attained, all feasible states are listed in a tableau form. Then, similar to the regular stability analysis, each of these states' possible moves and sanctions are investigated individually based on four fundamental relational stability definitions: relational Nash stability (RNash), relational general metarationality (RGMR), relational symmetric metarationality (RSMR), and relational sequential stability (RSEQ). By integrating the stability information for all of the DMs, the overall equilibria of this conflict can be obtained.

As it turns out, the equilibrium is exactly the same as the previous calculation without taking the attitude information into account. With the negative attitude towards the Trader, Ivory Coast will do whatever it can against the Trader: refuse any future waste dumping, demand the Trader to compensate, and, for further protection, ratify the 1995 Amendment. In the mean time, the Trader will take the opposite stance to Ivory Coast: try its best to refuse to pay compensation. This result confirms the consistency of our calculations and the robustness of this analytical model.

4.4. Status quo analysis

As another important analysis tool in the graph model for conflict resolution, status quo analysis is used to track the moves and countermoves of conflict problems starting from the status quo, passing through transitional states and finally reaching the outcomes or equilibria [26].

Table 9
Attitudes in the Ivory Coast waste dumping dispute.

	IC	TR	UN	NGO
IC	$e_{IC,IC} = 0$	$e_{IC,TR} = 0$	$e_{IC,UN} = 0$	$e_{IC,NGO} = 0$
TR	$e_{TR,IC} = -$	$e_{TR,TR} = 0$	$e_{TR,UN} = 0$	$e_{TR,NGO} = 0$
UN	$e_{UN,IC} = 0$	$e_{UN,TR} = 0$	$e_{UN,UN} = 0$	$e_{UN,NGO} = 0$
NGO	$e_{NGO,IC} = 0$	$e_{NGO,TR} = 0$	$e_{NGO,UN} = 0$	$e_{NGO,NGO} = 0$

Table 10
State transition from the status quo to the equilibrium.

	Status Quo	Transitional states		Equilibrium
	1	13	37	44
IC				
Refuse waste	N	N	N	→ Y
Demand compensation	N	N	N	→ Y
Enforce	N	N	N	→ Y
TR				
Compensate	N	N	N	N
UN				
Press IC	N	→ Y	Y	Y
NGOs				
Campaign	N	N	→ Y	Y

Table 10 shows the state transition from the status quo to the equilibrium of the Ivory Coast waste dumping case. At the status quo, the waste dumping just happens. No DM chooses any option yet. Then, UN makes the first move by putting pressure on Ivory Coast to ratify the 1995 Ban Amendment. Next, NGOs start to call for public attention to Trader and press it to stop dumping. Finally, Ivory Coast takes actions by ratifying the 1995 Ban Amendment, insisting that the Trader compensate, and refusing any future waste dumping.

5. Conclusions

In this paper, a multi-stage generic graph model for international toxic waste disposal conflicts is developed and illustrated. More specifically, the model divides toxic waste disputes into two stages consisting of the dumping prevention and dispute resolution stages. Then, a practical conflict analysis methodology, the graph model for conflict resolution, is employed at both stages to carry out in-depth investigations from a strategic viewpoint.

At the problem resolution stage, two graph models are built corresponding to the different status of the waste receiving countries, which are the most important participants in the international toxic waste disposal conflict. Some receiving countries have already ratified the Basel Convention, while others have not. Due to this difference, these countries and the United Nations would have dissimilar options and preferences. Therefore, two models are proposed in order to solve this problem. Note that feedback is allowed when a resolution is obtained for one model.

Attitude issues are taken into account along with the regular graph model analysis. Attitudes may have significant impacts on any conflict situations. Employing a regular graph model study along with attitude analysis assists DMs and other interested parties to more thoroughly understand the given situation and ascertain the sensitivity of the predicted equilibria or resolutions. The investigation further confirms the appropriateness of the predicted resolutions and the robustness of the proposed model and associated equilibria.

A case study of the Ivory Coast toxic waste dumping problem is analyzed to demonstrate how to implement this generic multi-stage model in practice. Moreover, by employing an in-depth attitude analysis, valuable insights into this recent real-world scandal are provided.

In addition to this research, the consideration of nations from which toxic wastes originate or in which toxic waste traders are based could be a factor in some particular cases. Because these nations may have enacted legislations for controlling toxic waste trading, their governments may be able to take action. For those particular cases, the government could be included as a DM in a conflict model.

Besides the conflict existing among the DMs analyzed in this paper, there are other related environmental conflicts occurring worldwide. For example, as an international law, the Basel Convention is actually an environmental agreement. In many cases, there are debates concerning the jurisdiction and scope of the Basel Convention. It is inevitable that conflicts exist due to the overlap between agreements falling under an environmental treaty and economic agreements negotiated among member states of the World Trade Organization. Hipel and Obeidi [27] discuss many serious disputes that have taken place in the ongoing conflict over trade versus the environment at the local, national and international levels, and they carry out strategic analyses in order to suggest how responsible resolutions can be achieved.

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