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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

Preprints of the IFAC/IFORS/IIASA/TIMS Workshop

Warsaw, Poland

June 24-26, 1992

Editors:

Roman Kulikowski
Zbigniew Nahorski
Jan W.Owsiński
Andrzej Straszak

Systems Research Institute
Polish Academy of Sciences
Warsaw, Poland

VOLUME 1:

Names of first authors: **A-K**

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THE GRAPH MODEL FOR CONFLICTS AS A NEGOTIATION SUPPORT TOOL

D. Marc Kilgour, Keith W. Hipel, and Liping Fang
Department of Systems Design Engineering, University of Waterloo,
Waterloo, Ontario, Canada N2L 3G1

Abstract: The graph model for conflicts is presented as a flexible approach for systematically studying real world disputes. Basic definitions underlying the graph model are reviewed and some representative solution concepts are defined for describing possible human behaviour under conflict. To demonstrate the practical application of the graph model as a negotiation support tool, the modelling and analysis stages are clearly illustrated using an international trading conflict, which arose over the export of Canadian softwood lumber to the United States. Besides showing representative modelling and analysis results, insights gained by carrying out a formal graph model study are pointed out.

Keywords: Conflict analysis, graph model, international trade, negotiation support.

1. Introduction

A conflict is a situation in which two or more decision makers are in dispute over some issue(s). For example, there is an ongoing debate among the United States, Europe and other countries involving subsidies paid to farmers. Conflict analysis techniques and methodologies are specifically designed and developed for systematically studying many types of conflict arising in the real world. In fact, conflict analysis methods capture the key components of strategic conflict in a way that is as independent as possible from the areas of application. Therefore, the same methodology used to analyze a problem in international trade could be employed to study a military dispute.

The objective of this paper is to present a survey of the graph model for conflict analysis, which constitutes a new and flexible approach developed during the past five years for use in negotiation support as well as other areas of conflict management. The graph model methodology is a significant extension of earlier work in conflict analysis carried out by authors such as Fraser and Hipel (1984) and Howard (1971). Within Section 2, the basic methodology for applying the graph model for conflicts (Fang et al., 1988) and its implementation as a decision support system (Kilgour et al. 1990a) are described. Moreover, some basic definitions for the graph model and solution concepts for mathematically modelling possible human behaviour under conflict are outlined in Section 3 (Kilgour et al., 1987; Fang et al., 1989). Subsequently, an international trading dispute over the export of Canadian softwood lumber to the United States (Hipel et al., 1990) is employed in Section 4 to clearly demonstrate how the graph model is applied in practice to an actual conflict.

2. Methodology

2.1 Background to the Canada-U.S. softwood lumber conflict

To illustrate how an actual dispute can be systematically examined using the graph model, the softwood lumber conflict between United States and Canada is employed. The history behind this international conflict is summarized by Hipel et al. (1990), while detailed explanations are provided by Maly and McKinsey (1986) and Foster (1987). As outlined below, the dispute has been studied at two crucial dates in its evolution. The original modelling and analysis of each of the two phases using the graph model approach was accomplished by Hipel et al. (1990). Here, the second stage of the conflict is presented in expanded form in order to explain the theory and application of the graph model in negotiation support.

The domestic lumber industry of the United States suffered an economic decline during the five–year period following the severe recession of 1981-1982. It was common in the U.S. industry to blame imports from Canada for production and sales problems in American wood product industries. Softwood lumber is a major Canadian export to the U.S., amounting to about $2 billion (U.S.) annually; by 1986, Canadian firms had gained about one-third of the American market. Industrial groups and politicians in the United States argued that Canadian lumber enjoyed an unfair competitive advantage over the U.S. product because of subsidies.

On May 19, 1986, the United States Coalition for Fair Canadian Lumber Imports asked the International Trade Commission (ITC) of the U.S. government to rule on a charge of injury against allegedly subsidized softwood lumber imports. The petitioners requested a duty of 27% on Canadian imports to offset the effect of the alleged subsidy.

On June 26, 1986, the ITC, a semi-judicial body, ruled that softwood lumber imports into the U.S. from Canada were harming the U.S. lumber industry. Following this decision, it was the responsibility of the Department of Commerce to determine whether Canadian exports were actually being subsidized. The U.S. Commerce Department's trade-remedy wing, known as the International Trade Administration (ITA), was scheduled to make a preliminary ruling on the case by October 16, 1986. If it upheld the preliminary finding, the case would return to the ITC for a final injury ruling.

The Commerce Department's preliminary decision imposing a 15% duty was announced on October 16, 1986. Although the Government of Canada first vowed to "fight this all the way" (Foster, 1987), within a month the province of British Columbia became convinced that if the initiative were left to the U.S., Canada would lose.

American trade laws allow a negotiated settlement if all parties agree. Under a negotiated settlement, the amount of any subsidy alleged by the U.S. might be kept in Canada. The province of British Columbia, the major source of softwood lumber exports, therefore had the most to lose from a U.S. duty and the most to gain from a compensating lumber tax increase in Canada. British Columbia announced its intention to implement a compensating tax and Quebec supported its move. At a federal-provincial conference held in Vancouver on November 20, 1986, Prime Minister Mulroney announced an agreement, with nine of the ten provinces, to pursue a negotiated settlement. Ontario alone opposed any attempt at accommodation, which it claimed would diminish Canadian sovereignty. Negotiations were nonetheless undertaken, and produced a dramatic settlement a few minutes before the deadline of midnight, December 30, 1986.

The modelling and analysis of the dispute is divided into two phases; up to the October 16, 1986 ruling, and afterwards. For the study of phase 1, refer to Hipel et al. (1990). Below, phase 2 of the conflict is utilized to explain how a dispute is formally modelled and analyzed.

2.2 Modelling

A game or conflict model is a systematic structure for describing the main characteristics of a conflict which is either taking place now, or happened historically. The three major components to the conflict model are the decision makers, options and preferences.

The *decision makers* and *options* for phase 2 of the softwood lumber conflict are displayed in Table 1, where the options under the control of each decision maker are also shown. The Canadian government can accept the import duty, take legal action and attempt other sanctions, or propose an export tax in lieu of import duty. The U.S. Commerce Department can insist on the duty, drop the import duty provided an equivalent export tax is imposed, or reject the petition. The U.S. Industry can retain or withdraw the petition. A one-word label for each option appears in parentheses in Table 1.

Table 1. Decision Makers and Options for Phase 2 of the Softwood Lumber Conflict

	Decision Makers		Options	Equil.
1.	Canada	(1)	Accept import duty (Duty)	N
		(2)	Take legal action and attempt other sanctions (Legal)	N
		(3)	Impose export tax in lieu of import duty (Tax)	Y
2.	U.S. Commerce Department	(4)	Retain import duty (Retain)	N
		(5)	Drop import duty, accept export tax (Drop)	Y
		(6)	Reject the petition (Reject)	N
3.	U.S. Industry	(7)	Retain petition (Retain)	N

A *strategy* is a selection by a given decision maker of none, some or all of his or her options. To explain this idea, refer to the column of Y's and N's in Table 1. "Y" indicates "yes," the option is taken by the decision maker controlling it, whereas "N" means "no" the option is not selected. In this column of Y's and N's, the strategy for Canada is not to take options (1) and (2), but select option (3). Likewise, the U.S. Commerce Department's strategy is not selecting options (4) and (6), but taking option (5). The N opposite option (7) indicates that the U.S. Industry is not selecting its option, which in this case means that the U.S. Industry is withdrawing its petition.

A *state* is formed after each decision maker selects a strategy. Writing horizontally in text, the vertical state listed in Table 1 (NNY NYN N) is formed by Canada, the U.S. Commerce Department, and U.S. Industry following strategies (NNY), (NYN), and (N), respectively.

In the softwood lumber conflict in Table 1, there are 7 options. Because each option can be either selected or rejected, there is a total of $2^7 = 128$ mathematically possible states. However, many of these states are infeasible in the actual conflict for a variety of reasons. Infeasible states can be removed from the game and equivalent states collapsed; the remaining states (13) are listed in Table 4.

In the graph model for conflict analysis, one only has to obtain "relative preference" information for each decision maker. Hence, one has to know only the order of preference (allowing ties) between all pairs of feasible states. The *ordinal preferences* for each decision maker for the second phase of softwood lumber dispute are explained in Section 4. In this case the preferences are transitive for each of the decision makers; nonetheless, the graph model approach can also handle intransitive preferences (Kilgour et al., 1990b).

2.3 Stability analysis

The basic input data needed to calibrate a graph model are the decision makers, their options and their preferences. The graph model is then a basic structure within which one can extensively study the possible strategic interactions among the decision makers. The systematic examination of the possible moves and counter moves by the decision makers during possible evolutions of the conflict, and the calculation of the most likely resolutions, is referred to as *stability analysis*. The results of the stability analysis can be used, for example, to help support decisions made by people having real power in a conflict.

In a *unilaterial move*, a particular decision maker changes his option selection or strategy to cause the conflict to change to another state. Sometimes a unilaterial move by a decision maker is irreversible and can take place only in one direction. For example, after a military attack is made by one nation against another, the effects of the attack cannot be reversed. The graph model systematically accounts for both *irreversible* and *reversible* moves in a conflict.

Sometimes there can be different strategy selections or moves in a conflict which result in the same final state occurring. For instance, there may be a variety of bad management decisions that can result in the same final state – the company goes bankrupt. These *common moves* to the same state can be readily taken care of by the graph model.

In the most general sense, a state is said to be *stable* for a particular decision maker if it is not advantageous for him to move away from the state by unilaterally changing his strategy selection. A *solution concept* is a precise mathematical description of how stability can be calculated and is, therefore, a sociological model of possible human behaviour in a conflict situation. Because human beings can react in different ways in a dispute, a range of solution concepts have been defined for modelling the variety of human behaviour. A list of solution concepts which have been defined within the graph model framework is given later in Table 2.

In a stability analysis, one examines every state for stability from every decision maker's point of view. When a state is stable for each decision maker, it constitutes a possible resolution or *equilibrium*. The state shown on the right in Table 1, for example, constitutes the equilibrium which occurred historically for phase 2 of the softwood lumber conflict. During the *evolution* of a conflict from an unstable status quo position, decision makers may change strategies, causing the conflict to move from one state to another. When an equilibrium is eventually reached, the conflict will stay at that state because no decision maker has an incentive to move away. However, if a basic model parameter changes, such as preference, then one would need to carry out another analysis to ascertain the strategic consequences.

2.4 Method of application

Figure 1 depicts the general procedure for applying the graph model for conflict analysis to an actual dispute. Initially, a real world conflict may seem to be confusing and difficult to comprehend. However, by systematically applying the conflict analysis method according to the two main stages of modelling and analysis, the conflict problem can be better understood in terms of its essential characteristics and potential resolutions.

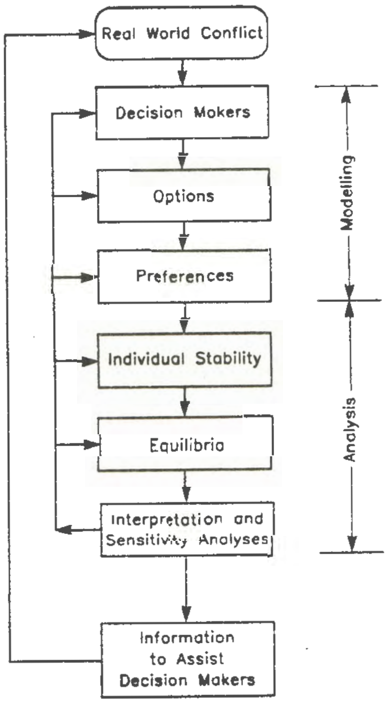


Figure 1. Applying the graph model for conflict analysis.

The graph model for conflict analysis can be conveniently programmed and implemented in practice as a *decision support system (DSS)* within an overall decision making environment in which real decision makers make actual decisions. Because the graph model is meant to be used interactively when programmed within a DSS, it is can be aptly referred to as a methodology for interactive decision making.

3. Definitions

3.1 The graph model for conflicts

A graph model for a conflict consists of a set of directed graphs and a set of payoff functions. Let $N = \{1, 2, ..., n\}$ denote the set of decision makers or players and $U = \{1, 2, ..., u\}$ the set of states of the conflict. A collection of finite directed graphs $D_i = (U, A_i)$, $i \in N$, is used to model the evolution of the conflict. The *vertices* of each graph are the possible states of the conflict and hence the vertex set, U, is common to all graphs. The *arcs* of the directed graphs are defined as follows: if player i can (unilaterally) move (in one step) from state k to state q, there is an arc with orientation from k to q in A_i. For convenience, it is assumed that there is no arc from state k to itself, i.e. there are no loops in any player's graph. For each player $i \in N$, a payoff function P_i: $U \rightarrow R$, where R is the set of real numbers, is defined on the set of states. The payoff functions measure the worths of states to the players. As described below, it is assumed that values of the payoff functions represent only the players' ordinal rankings of the states.

An analytic representation of player i's graph A_i is given by i's reachable lists. For $i \in N$, player i's reachable list for state $k \in U$ is the set $S_i(k)$ of all states to which player i can move (in one step) from state k, or

$$S_i(k) \equiv \{ \ q \in U: \ \textit{if player i can move (in one step) from state k to state q} \ \}. \qquad (1)$$

The *payoff function* for player i, P_i, measures how preferred a state is for i. Thus, if $k, q \in U$, then $P_i(k) \geq P_i(q)$ iff i prefers k to q, or is indifferent between k and q. When this inequality is strict for all pairs of distinct states for every player, the conflict is called *strict ordinal*; in other words, different states have different payoffs for every player in a strict ordinal conflict. Beyond the ordinal information of preference or indifference, nothing can be inferred from the values of P_i. For example, $P_i(k) > P_i(q)$ indicates that i prefers k to q, but the value of $P_i(k)-P_i(q)$ gives no meaningful information about the strength of this preference. For convenience, small positive integers are used as the values of $P_i(\cdot)$.

To represent various stability definitions in the graph form, the concept of unilateral improvement is invaluable. A *unilateral improvement* from a particular state for a player is any preferred state to which that player can unilaterally move. Note that the player must strictly prefer the unilateral improvement to the initial state. To represent unilateral improvements, each player i's reachable list, $S_i(k)$, can be replaced by $S_i^+(k)$, defined by

$$S_i^+(k) \equiv \{ \ q \in S_i(k): \ P_i(q) > P_i(k) \ \}. \qquad (2)$$

Thus, $S_i^+(k)$ denotes the set of player i's unilateral improvements from state k and is called the unilateral improvement list of player i from state k.

3.2 Solution concepts

A solution concept constitutes a mathematical description of a behaviour pattern. Because decision makers can react to conflict situations in many ways, there are many different solution concepts. At the stability analysis stage, solution concepts are used to predict the stable states for each decision maker and the equilibria. Fang et al. (1989) compare mathematically a wide range of solution concepts applicable in the graph model.

Table 2, taken from Hipel et al. (1990), lists solution concepts that have been defined and developed within the field of conflict analysis. The first column names the solution concepts while the second provides original references. The last two furnish ways for characterizing the solution concepts in a qualitative sense according to the two criteria of "foresight" and "disimprovement." Foresight refers to the ability of a decision maker to think about possible moves that could take place in the future. If the decision maker has high or long foresight, he can imagine many moves and counter moves into the future when evaluating where the conflict will end up after an initial unilateral move on his part. Notice, for example, that in Nash stability the foresight is low whereas it is very high for non-myopic stability. The "strategic" disimprovement appearing in the fourth column means that a decision maker may temporarily move to a worse state in order to reach eventually a more preferred state. Disimprovements "by opponents" indicates that other decision makers may put themselves in worse positions in order to block unilateral improvements by the given decision maker.

Next, the definitions of Nash stability (Nash, 1950) and sequential stability (Fraser and Hipel, 1984) are presented briefly in the graph model context. The original adaptations of these solution concepts to the graph model of conflict can be found in Kilgour et al. (1987) and Fang et al. (1989) for two-player and n-player conflicts.

General definitions

In a two-player conflict, player i's decision problem at initial state k is illustrated in Figure 2. A special convention is used in two-player conflicts: whenever a player $i \in \mathrm{N}$ has been identified, then i's opponent is automatically denoted by j. If player i seizes the initiative and moves to some state $k_1 \in S_i(k)$, then player j, may move from k_1. Depending on what he expects player j might do from each possible $k_1 \in S_i(k)$, player i may prefer to stay at state k. If so, state k is stable for i. If state k is stable for both players, it is an equilibrium.

In an n-player conflict, player i's decision problem at initial state k is more complicated, as illustrated in Figure 3. If player i seizes the initiative and moves, say to state $k_1 \in S_i(k)$, then some other player j, $j \in \mathrm{N}-i$, may move from k_1, say to $k_2 \in S_j(k_1)$. Depending on j's move, yet another player p, $p \in \mathrm{N}-j-i$, may move from k_2, say to $k_3 \in S_p(k_2)$, and so on. Depending on what player i expects the other players $(\mathrm{N}-i)$ to do from each $k_1 \in S_i(k)$, player i may prefer to stay at state k.

Table 2. Solution Concepts and Human Behaviour

Solution Concepts	Original References	Foresight	Disimprovements
Nash stability (R)	Nash (1950); von Neumann and Morgenstern (1944, 1953)	low	never
General metarationality (GMR)	Howard (1971)	medium	by opponents
Symmetric metarationality (SMR)	Howard (1971)	medium	by opponents
Sequential stability (FHQ)	Fraser and Hipel (1984)	medium	never
Limited-move stability (L_h)	Kilgour (1985); Kilgour et al. (1987); Zagare (1984)	variable	strategic
Non-myopic stability (NM)	Brams and Wittman (1981); Kilgour (1984, 1985); Kilgour et al. (1987)	high	strategic

Note that in this sanction sequence the same player may move more than once, but not twice in succession. However, after his initial move the (original) player i does not take part in the sequence.

For any subset of the players, $H \subseteq N$, $S_H(k)$ will denote the set of all states that can result from any sequence of unilateral moves, by some or all of the players in H, starting at state k. In this sequence, the same player may move more than once, but not twice consecutively. If $k_1 \in S_H(k)$, $\Omega_{H,k}(k_1)$ denote the set of all last players in legal sequences from k to k_1.

Definition Let $k \in U$ and $H \subseteq N$, $H \neq \emptyset$. The unilateral moves of H are the states in $S_H(k) \subseteq U$, defined inductively by

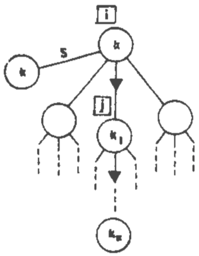
(*i*) *if* $j \in H$ *and* $k_1 \in S_j(k)$, *then* $k_1 \in S_H(k)$ *and* $j \in \Omega_{H,k}(k_1)$ (3a)

(*ii*) *if* $k_1 \in S_H(k)$, $j \in H$, *and* $k_2 \in S_j(k_1)$, *then* (3b)

(*a*) *if* $|\Omega_{H,k}(k_1)| = 1$ *and* $j \notin \Omega_{H,k}(k_1)$, *then* $k_2 \in S_H(k)$ *and* $j \in \Omega_{H,k}(k_2)$

(*b*) *if* $|\Omega_{H,k}(k_1)| > 1$, *then* $k_2 \in S_H(k)$ *and* $j \in \Omega_{H,k}(k_2)$.

In a similar manner, one can define $S_H^+(k)$ which denotes the set of states that can result from any sequence of unilateral improvements by some or all of the players in the set H starting from state k. $S_H(k)$ and $S_H^+(k)$ can be thought of as H's reachable list and unilateral improvement list, respectively. In particular, the sets $S_{N-i}(k)$ and $S_{N-i}^+(k)$ represent the possible states of "response sequences" of i's opponents against a move by i to k. Note that for two-player conflicts, $N = \{i, j\}$ and $N - i = j$, so that $S_{N-i}(k)$ is $S_j(k)$.



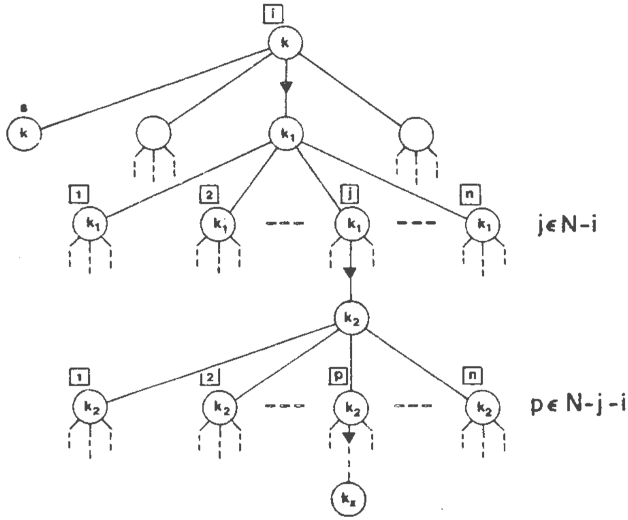


Figure 2

Figure 3

Figure 2. Player i's decision problem at initial state k in a two-player conflict, where player j is i's opponent; k, k_1, k_x are states; and s means stay.

Figure 3. Player i's decision problem at initial state k in an n-player conflict.

Nash stability

State k is Nash stable, or individually rational (R), for player i iff $S_i^+(k) = \varnothing$. Under Nash stability, player i expects that player j will stay at any state i moves to; in other words, any state that i moves to will be the final state. The state k is therefore stable for i iff i cannot move from k to any state i prefers to k.

Sequential stability

State k is sequentially stable (FHQ) for player i iff for every $k_1 \in S_i^+(k)$ there exists $k_x \in S_{N-i}^+(k_1)$ with $P_i(k_x) \leq P_i(k)$. Thus, player i expects that the other players, N$-i$, will respond by hurting i if it is possible for them to do so. Note that i anticipates that the conflict will end after the players of N$-i$ have responded. As well, it is assumed that i's opponents will make "credible sanctions" [$k_x \in S_{N-i}^+(k_1)$ is required, rather than merely $k_x \in S_{N-i}(k_1)$].

4. Applications

4.1 Case studies

As summarized in Table 3, the graph model for conflicts has been successfully applied to a variety of challenging real world disputes. To show how the graph model can be utilized in practice, phase 2 of the softwood lumber trading conflict discussed in Section 2 is a representative example.

Table 3. Real World Applications of the Graph Model for Conflict Analysis

Conflict	Application Area	Reference
Garrison Diversion Unit	International, environmental	Fang et al. (1988)
Softwood Lumber	International, economics, trade	Hipel et al. (1990)
Labour-Management Negotiations	Contract negotiation	Kilgour et al. (1991a)
Rafferty-Alameda Dams	Environmental groups, governments	Hipel et al. (1991)
Flathead River Resources Development	Environmental groups, governments, industry	Kilgour et al. (1991b)

4.2 Softwood lumber dispute

Modelling

The history of the softwood lumber dispute is outlined in Section 2.1, and the decision makers and options for phase 2 of the conflict are given in Table 1. After removing the infeasible states, 18 feasible states are left in the model. However, all states at which the U.S. Commerce Department rejects the petition can be considered to be the same and are represented by state 13, where a dash means that an entry can be either N or Y. As shown in Table 4, a total of thirteen states remain in the conflict.

Table 4. States for Phase 2 of the Softwood Lumber Conflict

1. Canada													
(1) Duty	Y	N	N	Y	N	N	Y	N	N	Y	N	N	-
(2) Legal	N	Y	N	N	Y	N	N	Y	N	N	Y	N	-
(3) Tax	N	N	Y	N	N	Y	N	N	Y	N	N	Y	-
2. U.S. Commerce													
(4) Retain	Y	Y	Y	N	N	N	Y	Y	Y	N	N	N	-
(5) Drop	N	N	N	Y	Y	Y	N	N	N	Y	Y	Y	-
(6) Reject	N	N	N	N	N	N	N	N	N	N	N	N	Y
3. U.S. Industry													
(7) Retain	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	-
Number	1	2	3	4	5	6	7	8	9	10	11	12	13

The reachable lists for this phase of the dispute are given in Table 5. As can be seen, there are some irreversible moves for Canada and the U.S. Industry. For example, Canada can move from state 1 to state 2 or 3 but cannot return from 2 or 3 to 1. However, all of the Commerce Department's moves are irreversible. This is because after the Commerce Department has decided to drop the import duty and accept an export tax, or reject the petition altogether, it cannot change its decision. The feasible movements of the three decision makers are shown graphically in Figure 4.

Table 5. Reachable Lists (S) and Payoffs (P)
for Phase 2 of the Softwood Lumber Conflict

k	Canada		Commerce Dept.		U.S. Industry		Comment
	S	P	S	P	S	P	
1	2, 3	6	4, 13	10	7	13	status quo
2	3	7	5, 13	10	8	4	retain
3	2	5	6, 13	10	9	12	retain
4	5, 6	4		3	10	7	drop
5	6	3		3	11	2	drop
6	5	8		3	12	6	drop
7	8, 9	10	10, 13	6		11	retain
8	9	11	11, 13	6		5	retain
9	8	9	12, 13	6		10	retain
10	11, 12	2		13		9	drop
11	12	1		13		3	drop
12	11	12		13		9	drop
13		13		7		1	rejection

Note: k = State Number; S = Reachable List; P = Ordinal Payoff.

In this dispute, Canada most prefers that the U.S. Industry withdraw its petition. If this occurs, Canada would not like to accept the duty or to pursue legal action, so that states 10 and 11 are least preferred by Canada. Whether the U.S. Industry retains or withdraws its petition, the Commerce Department prefers to do likewise. The U.S. Industry always prefers some kind of economic measure – either duty or tax. After detailed study, the payoff functions for this conflict were determined to be as given in Table 5.

Analysis: Stability analysis and prediction

All of the states in Table 5 were analyzed for each stability type for each of the three decision makers. All equilibria are presented in Table 6.

States 12 and 13 are equilibria for all the solution concepts listed in Table 2, while states 1, 2, 3, and 6 are equilibria for some solution concepts. State 12 occurred historically, which confirms the predictive power of the methodology.

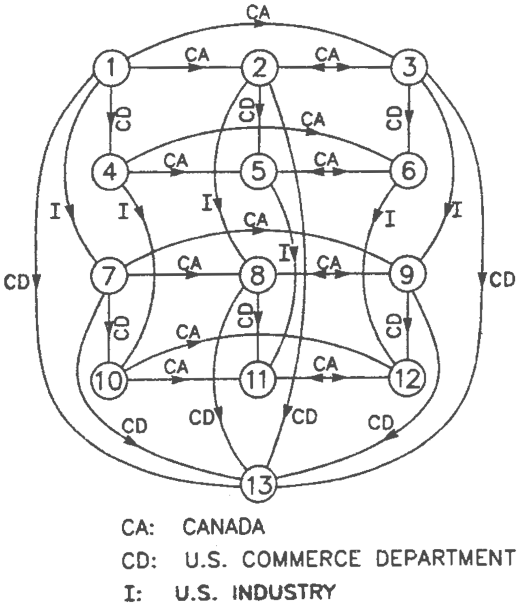


Figure 4. State transition graphs: Phase 2 of the softwood lumber conflict.

Table 6. Equilibria for Phase 2 of the Softwood Lumber Conflict

k	Equilibrium Solution Concepts
1	GMR, FHQ
2	GMR, SMR, FHQ, L_2
3	GMR, FHQ, L_3
6	GMR, SMR
12	R, GMR, SMR, FHQ, L_1, L_2, L_3, L_4, L_h ($h > 4$), NM
13	R, GMR, SMR, FHQ, L_1, L_2, L_3, L_4, L_h ($h > 4$), NM

Interpretation of results.

The status quo at the time of analysis was state 1, at which Canada accepts the import duty, the Commerce Department confirms it, and the U.S. Industry retains its petition. At one of the two equilibria forecasted by all the solution concepts, state 12, Canada imposes an export tax in lieu of import duty, the Commerce Department drops the import duty and the U.S. Industry withdraws its petition. At the other main equilibrium (state 13), the Commerce Department rejects the petition and the dispute is over.

It is not surprising that 13 is an equilibrium since no decision maker can move away from it. Note that 13 can be reached only by action of the Commerce Department, and the Commerce Department prefers the equilibrium at 12 over 13. Furthermore, there is no other strong equilibrium that Canada can threaten the Commerce Department with in order to induce it to move to 13. Thus, even though Canada most prefers the equilibrium at 13, there is no reasonable hope of achieving it. Finally, the equilibrium at 13 is the least preferred state for the U.S. Industry, suggesting that 12 is a "compromise" for all sides.

As shown in Table 7, the actual sequence of events is easy to trace in this model. The arrows connecting the status quo to the equilibrium result show the main option changes required to reach a resolution in phase 2. Canada moves from the status quo (state 1) to state 3 by proposing an export tax in lieu of the import duty. Next, the Commerce Department moves from state 3 to state 6 by dropping the import duty and accepting the export tax. Finally, from state 6, the U.S. Industry reaches state 12 by withdrawing the petition. Since state 12 is an equilibrium having strong stability properties, no participant is motivated to move away from it, and the dispute is over.

Table 7. Progression from Status Quo to Equilibrium State

1. Canada							
(1) Duty	Y	→	N		N		N
(2) Legal	N		N		N		N
(3) Tax	N	→	Y		Y		Y
2. U.S. Commerce							
(4) Retain	Y		Y	→	N		N
(5) Drop	N		N	→	Y		Y
(6) Reject	N		N		N		N
3. U.S. Industry							
(7) Retain	Y		Y		Y	→	N
State	1		3		6		12

5. Conclusions

As demonstrated by the international trading conflict as well as other applications referenced in Section 4, the graph model for conflicts can be used as a DSS in negotiations. In fact, the dispute in Section 4 was analyzed by the authors acting as an interested third party that was not taking part in the conflict. However, the graph model methodology can be employed in other situations including:

1. Analysis by a decision maker of a conflict in which he or she is a participant.
2. Analysis by a consultant advising a decision maker who is actually taking part in a conflict.

3. Tool to coordinate communication and mediation among decision makers in a conflict. Moreover, the graph model could also be employed by an arbitrator.

4. Simulation studies in which interested parties play the roles of decision makers. For instance, prior to contract negotiation sessions with employees, management can simulate what could take place so that it can bargain in the best way possible.

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