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Attitudes of Institutions in Brownfield Redevelopment Projects

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***Abstract*— Systems tools for analyzing the impact of stakeholder attitudes under conflict are utilized to examine the decision of the University of Waterloo to build its new school of pharmacy on a brownfield property in downtown Kitchener, Ontario, Canada. The redevelopment of brownfield properties often has tremendous environmental impacts due to the remediation of the contaminated subsurface. However, there is also a significant increase in the social and financial well-being of the community when a property is redeveloped. Often brownfield redevelopment projects are not undertaken due to the risk of liability that the developer may face. The analysis of this redevelopment project demonstrates the importance of institutional attitudes in the negotiations surrounding brownfield redevelopment projects.**

Keywords—*Attitudes, Graph Model for Conflict Resolution, Decision Support System, Strategy*

I. Introduction

The attitudes of stakeholders have a significant impact on the resolution of conflicts, whether they are interpersonal or professional conflicts. Determining or describing stakeholder attitudes such that they can be applied to a conflict analysis problem while still reflecting what is known about that stakeholder is difficult, at best. To complicate matters further, conflicts in the professional sphere often involve large organizations, such as a government or corporation, which act as a single stakeholder. While methods for dealing with the attitudes of coalitions exist [5], there is currently no literature that prescribes how the attitudes of institutions may be determined and thus applied to gain a better understanding of the conflict. Previous analyses of brownfield redevelopments have been undertaken by Walker et al [9] to better understand how to manage these negotiations.

In the following section, the Graph Model for Conflict Resolution is laid out and explanations are given to detail the way in which state stabilities and equilibria are calculated. In subsequent sections, definitions explaining the function which can be applied within the graph model are examined. A case study of the development of the University of Waterloo, School of Pharmacy [10] will be examined.

II. The Graph Model For Conflict Resolution

The Graph Model for Conflict Resolution (GMCR), developed by Fang et al. [3], is a formal methodology which allows decision analysts to gain strategic insights into the evolution of conflicts by combining concepts from graph theory and metagame analysis. The graph model for a conflict is a set of 4 unique elements $(N, S, (A_i)_{i\in N}, (\succ_i, \sim_i)_{i\in N})$. N is the set of all stakeholders ($|N| \geq 2$), S is the set of all states (outcomes) in the conflict ($|S| \geq 2$), the set (S, A_i) is stakeholder i's graph of the conflict (within this graph of the conflict the set of states, S, becomes the set of all vertices in the graph, A_i is the set of all arcs on the graph connecting two different states in the set S, thus representing a movement by stakeholder i), and $(\succ_i, \sim_i)$ representing stakeholder i's relative preferences between states in the set S.

In order to apply GMCR it is important to know what states in the set S can be reached by an arc A. To do so, it is necessary to determine the reachable list of states from each starting state. Thus, for stakeholder $i\in N$ and state $s\in S$, stakeholder i's reachable list from state s is the set $\{t\in S \mid (s, t)\in A_i\}$, denoted by $R_i(s) \subset S$. The reachable list is a record of all the states that a given stakeholder can reach from a specified starting state in one step. In the graph model, all states that are joined by an arc A_i beginning at state s, are part of the stakeholder i's reachable list from s. When a stakeholder makes a move to a more preferred state, that move is called a unilateral improvement or UI. The list of UI's a decision maker (DM) i has from a state s, $R_i^+(s)$, can thus be defined as the set of states that belong to the DM i`s reachable list from the state s and are more preferred by i to s.

Based on the foregoing types of movements, a range of solution concepts have been defined which can be used to determine which states are stable for specific DMs and which states are overall equilibriums for the conflict. The solution concepts studied in depth here are Nash stability [7], [8] and Sequential stability [4].

Nash stability is defined such that for a DM $i\in N$, a state $s\in S$ is Nash stable for DM i, denoted by $s \in S_i^{Nash}$, if and only if $R_i^+(s) = \phi$. Thus, Nash stability occurs when a DM

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has no UIs from a given state and hence is better off to remain at that state. In order to define sequential stability, it is useful to include the definitions of a unilateral improvement for a coalition and the set of less preferred states.

The unilateral improvement list for coalition $H \subset N$ at states $s \in S$, is defined inductively as the set $R_H^+(s)$ that satisfies the two conditions: (i) if $i \in H$ and $t \in R^+_i(s)$, then $t \in R^+_H(s)$, and (ii) if $i \in H$ and $t \in R^+_H(s)$ and $u \in R^+_i(s)$, then $u \in R^+_H(s)$. The set of less preferred states is defined as follows: For $i \in N$ and $s, x \in S$, the set of all states that are less preferred or equally preferred to state s by DM i is $\phi_i^{\simeq}(s) = \{x \in S \mid s \succeq_i x\}$.

Sequential stability (SEQ) is defined such that for a DM $i \in N$, a state $s \in S$ is SEQ stable for DM i, denoted by $s \in S_i^{SEQ}$, if and only if for all $x \in R^+_i(s)$, $R^+_{N\setminus\{i\}}(x) \cap \phi_i^{\simeq}(s) \neq \phi$. Thus, a state is SEQ stable for DM i if any move away from the state can be sanctioned by a credible move from some other DM in the conflict.

III. Attitudes in GMCR

After the graph model of the conflict is defined according to the DMs' options and preferences, attitudes may be incorporated into the model. Developed by Inohara et al. [5] for determining the impact of attitudes on conflict outcomes, the attitudes framework can be implemented within GMCR. For the sake of simplicity, attitudes are modeled as a threefold set; for DMs $i \in N$, $E_i = \{+, 0, -\}^N$ represents the set of attitudes of DM i. An element $e_i \in E_i$ is called the attitudes of DM i for which $e_i = (e_{ij})$ is the list of attitudes of DM i towards DM j for each $j \in N$. The e_{ij} is referred to as the attitude of DM i to DM j where the values $e_{ij} = +$, $e_{ij} = 0$ and $e_{ij} = -$ indicates that DM i has a positive, neutral and negative attitude towards DM j, respectively.

To operationalize the idea of attitudes, a new preference structure is needed. In particular, a relational preference RP_{ij} defines preferences between two states that takes into account the DM's attitudes. As there are three possible attitudes there are three possible preference structures. For DM i and state s and states t, such that $s \succ_j t$, RP_{ij} can be defined as follows: if $e_{ij} = +$, $s RP_{ij} t$, if $e_{ij} = -$, $t RP_{ij} s$ and if $e_{ij} = 0$, $s RP_{ij} t$ AND $t RP_{ij} s$. Based on these relational preferences an overall preference referred to as the total relational preference, or TRP, is defined. A state v is a TRP_i to state s iff $v RP_{ij} s$ for all $j \in N$. Using the reachable list mentioned in the previous section it is possible to define the equivalent of a UI list, referred to as a total relational reply list (TRR). The TRR list of DM $i \in N$ at e for state $s \in S$ is defined as intersection of the reachable list and the TRP_i set. This is written formally as $\{t \in R_i(s) \bigcup \{s\} \mid t \; TRP(e)_i \; s\} \subset R_i(s) \bigcup \{s\}$, denoted by $TRR(e)_i(s)$.

In order to define solution concepts that accommodate attitudes as they are modelled in GMCR it is necessary to define a set of relationally less or equally preferred states. The symbol $R\phi^{\simeq}(e)_i(s)$ is an analogue of $\phi_i^{\simeq}(s)$ given in the previous section. Formally, $R\phi^{\simeq}(e)_i(s)$ is the set $\{t \in S \mid NE(t \; TRP(e)_i \; s)\}$. This is set is made up of all states which are not relationally preferred to s by DM i under attitude e. Using this definition Nash stability and SEQ stability are altered and given as follows.

For a DM $i \in N$, state $s \in S$ is relational Nash stable (RNash) at e for DM i, denoted by $s \in S_i^{RNash(e)}$, if and only if $TRR(e)_i(s) = \{s\}$. That is, the state is RNash stable iff the only state in i's TRR list from a state is the state itself. Relational SEQ stability (RSEQ) is defined such that for DM $i \in N$, state $s \in S$ is relational general metarational at e for DM i, denoted by $s \in S_i^{RSEQ(e)}$, if and only if for all $x \in TRR(e)_i(s) \setminus \{s\}$, $TRR(e)_{N\setminus\{i\}}(x) \cap R\phi^{\simeq}(e)_i(s) \neq \phi$. Simply put a state x is RSEQ stable if for every TRR away from x some other DM in the conflict can make a TRR from the new state to a state less relationally preferred by i to state x.

The total relational reply list of coalition $H \subset N$ at e for state $s \in S$ is defined inductively as the set $\mathbf{TRR}(e)_H(s)$ that satisfies the next two conditions: (i) if $i \in H$ and $t \in \mathbf{TRR}(e)_i(s)$, then $t \in \mathbf{TRR}(e)_H(s)$, and (ii) if $i \in H$ and $t \in \mathbf{TRR}(e)_H(s)$ and $u \in \mathbf{TRR}(e)_i(t)$, then $u \in \mathbf{TRR}(e)_H(s)$.

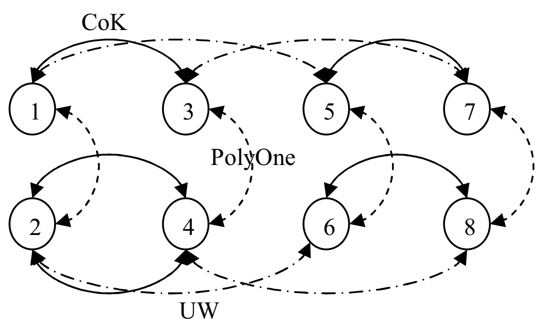
The authors have applied these concepts to the redevelopment of a brownfield property in Kitchener, Ontario which now serves as home to the University of Waterloo's school of pharmacy. The model of this conflict and how attitudes play a role in the analysis of the conflict is illustrated in the next section.

IV. School of Pharmacy Redevelopment

In this section GMCR and the attitudes methodology have been implemented to better understand the negotiations that occurred between the property's original owner, Poly One, and the City of Kitchener (CoK) and the University of Waterloo (UW). In Table I the conflict is shown in option form with the DMs listed on the left and their available options one column over. The combinations of 'Y' and 'N', meaning to choose or not choose an option, generate the full set of conflict states. The model shown in Table I is a simpler one which ignores the very real possibility of City of Kitchener taking legal recourse against Poly One. Thus the options in this construction conflict are 1) PolyOne must decide whether to remediate, 2) City of Kitchener must decide whether to offer incentives to PolyOne to promote remediation and 3) UW must decide whether to construct the project on the contaminated land. The combination of these three possible options is a total of $2^3 = 8$ states.

TABLE I. SCHOOL OF PHARMACY REDEVELOPMENT CONFLICT: STAKEHOLDERS, OPTIONS AND OUTCOMES

Stakeholder									
PolyOne	Remediate?	N	Y	N	Y	N	Y	N	Y
CoK	Incentives?	N	N	Y	Y	N	N	Y	Y
UW	Construct?	N	N	N	N	Y	Y	Y	Y
STATE IDS		1	2	3	4	5	6	7	8



$P_{CoK} = \{6, 2, 8, 4, 1, 5, 3, 7\}$
$P_{UW} = \{(6, 8), 3, 1, 4, 5, 7, 2\}$
$P_{PO} = \{7, 5, 8, 6, 1, 4, 3, 2\}$

Figure 1. Graph Model of Pharmacy Conflict

From the sets of states listed in Table I it is possible to create a graph model of the conflict that illustrates how the DMs could move from state to state whilst providing information about the DM's preferences, as illustrated in Figure 1. The individual preferences of each DM were arrived upon using a simple multiple criteria decision analysis (MCDA) approach whereby states that are seen to fulfill more of a DM's perceived goals are seen as more preferred. For example, state 6 is the most preferred state for CoK as UW agrees to build, the PO agrees to remediate the property and CoK does not need to offer any costly incentives to entice either party.

The arrows represent the movements between states for different DMs; the arrows are two sided meaning that the moves are reversible. The solid lines represent the movements of CoK, the dashed lines represent the moves of PolyOne and the dotted/dashed lines the moves of UW.

In order to perform an analysis of the conflict, it is necessary to utilize the preference rankings and movements of the states for each DM as they are given in Figure 1. When an analysis using Nash and SEQ stability is undertaken, it can be found that five equilibriums occur: states 1, 3, 4, 6 and 8, as can be seen in Table II. Of these equilibria only two occur at states where UW constructs the project: 6 and 8. Across the top row x and E are used to represent non-equilibrium and equilibrium states, respectively. Equilibrium states occur, of course, when the state is stable for all DMs. To the right of each DM's name the states are listed from most to least positive. Below each state in the preference row the unilateral improvements from the state are given. Using this set up, both Nash and Sequential stabilities, described in the previous section, are applied. States which are Nash or Rational stable are marked with an 'r' while states that are sequentially stable are marked with an 's.' States that are neither Nash nor Sequentially stable are marked with a 'u' to denote that the state is unstable for that DM. When a state is stable for all three DMs the state is an equilibrium and marked with an 'E', as mentioned previously.

TABLE II. STATIC ANALYSIS

	x	x	E	E	E	E	E	x
	r	r	s	s	r	r	s	u
PO	7	5	8	6	1	4	3	2
			7	5			4	1
	r	r	r	r	s	u	u	u
UW	(6	8)	3	1	4	5	7	2
					8	1	3	6
	r	r	s	s	r	r	u	u
CoK	6	2	8	4	1	5	3	7
			6	2			1	5

r-Nash stable, s – Sequentially stable, u-unstable, E – equilibrim state, X-nonequilibrium state

For example, state 4 is stable for all three DMs and is thus an equilibrium state. For PO, state 4 is Nash stable as there are no UIs away from 4. UW can make a UI from state 4 to state 8 and thus is not Nash stable. From state 8, however, PO can move the conflict to state 7; as $4 >_{PO} 7$, the sanction moves the conflict to a less preferred state for UW and thus the state is sequentially stable, denoted by 's.' Similarly CoK can move from state 4 to state 2, from which PO can move to state 1. Systematically applying the solution concepts in this manner yields the stability and equilibrium information, mentioned earlier, and this allows for greater insight into the conflict.

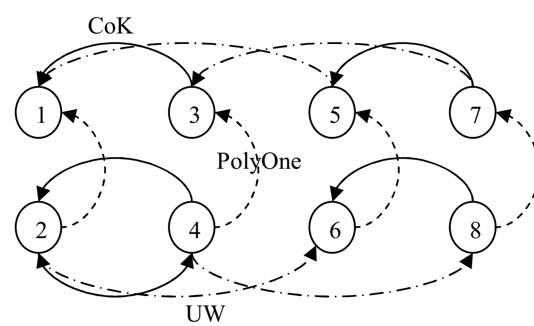


Figure 2. UIs for each DM

However, as illustrated in Figure 3, if it is assumed that the conflict starts at the status quo state 1, there are no UIs for any of the DMs from that state. Thus, the state is a Nash equilibrium – an extremely stable point that none of the parties have the incentive to leave. However, in reality, the negotiations proceeded, ultimately benefitting all three DMs. Thus, the use of frameworks which further examine the nature of the negotiations parties is needed.

The application of attitudes to this conflict may be one such methodology that helps to explain what moves and countermoves are taken by the involved players to progress towards a new conflict outcome. There are many attitude orientations that suit themselves to the manner in which attitudes are modeled in GMCR. Darling and Mumpower [1] define eight attitude orientations that describe how people interact. In fact, these eight simplified attitude orientations fit well with the concept of attitudes within GMCR and give the decision analyst a wide range of scenarios for modeling attitudes. For instance, the attitude orientation of cooperative mentioned by Darling and Mumpower [1] is the situation within GMCR in which a given DM has a devoting attitude towards himself or herself as well as devoting attitudes with respect to all of the other DMs.

Due to the nature of the conflict being studied, it is wise not to include attitudes where CoK acts negatively towards others. Herein, two common sets of attitudes for positive negotiations are examined: altruism and cooperation. Individualistic attitudes, shown in the top right corner of Figure 4 represent the assumed pattern for standard conflict analyses where DMs are indifferent to the needs of others and positive towards themselves. In Table III, the manner in which altruism and cooperation appear in terms of the attitudes framework are given. In the first column, the general form of attitudes in GMCR is given while in the second and third columns the altruistic and cooperative attitudes situations are given.

TABLE III. STATIC ANALYSIS

Attitudes			**Altruistic i → j**			**Cooperative i → j**		
DM	i	j	DM	i	j	DM	i	j
i	e_{ii}	e_{ij}	i	0	+	i	+	+
j	e_{ji}	e_{jj}	j	0	+	j	0	+

By applying these attitude structures to the school of pharmacy negotiation where CoK = *i* and UW = *j,* new moves are created and new conflict results are found. The application of cooperative attitudes yields the exact same five equilibrium states with still no movements from state 1, the status quo state. The tableau form of this conflict model is shown in Table IV below. As mentioned, in the case where no attitudes were applied there are no UIs for any of the three stakeholders away from state 1. Thus again, state 1 is a Nash Equilibrium state and it is unlikely that any participant will move the conflict from that state.

TABLE IV. STATIC ANALYSIS – COOPERATIVE COK

Cooperative	**x**	**x**	**E**	**E**	**E**	**E**	**E**	**x**
	r	r	s	s	r	s	r	u
PO	7	5	8	6	3	4	1	2
			7	5		3		1
	r	r	r	r	s	u	u	u
UW	(6	8)	3	1	4	5	7	2
					8	1	3	6
	r	r	s	r	r	r	r	u
CoK	6	2	8	4	1	5	3	7
			6					5

r-Nash stable, s – Sequentially stable, u-unstable, E – equilibrim state, X-nonequilibrium state

To attempt to discern how to move past this state, the altruistic attitude set was applied. In Table V the tableau form of the conflict where CoK acts altruistically is shown. Again each of the states are listed in order of preference from left to right. Below the row of states are the unilateral improvements where they exist for PO and UW who are acting in an individualistic manner. CoK, however, is behaving altruistically and thus the states below its preference rankings are total relational replies (TRRs). According to CoK's altruistic attitude towards UW every move that they make must benefit UW. For example, from state 2 CoK can move the conflict to state 4 which is preferred by UW and not CoK. As CoK's altruistic attitudes now no longer restrict this movement, CoK moves to 4 from 2. Using this information, the solution concepts were applied. The same basic Nash and Sequential stabilities were used to examine the stability of states for PO and UW. Clearly, CoK's altruistic attitudes are beneficial to all three DMs by facilitating the movement from state 1 to state 8, an improvement for all of the involved parties.

TABLE V. STATIC ANALYSIS – ALTRUISTIC COK

Altruistic	**x**	**x**	**E**	**E**	**x**	**x**	**x**	**x**
	r	r	s	s	r	u	u	u
PO	7	5	8	6	1	4	3	2
			7	5			4	1
	r	r	r	r	s	u	u	u
UW	(6	8)	3	1	4	5	7	2
					8	1	3	6
	rr	u	rr	rr	u	rr	rr	u
CoK	6	2	8	4	1	5	3	7
		4			3			5

r-Nash stable, s – Sequentially stable, rr-RNash stability, u-unstable, E – equilibrim state, X- nonequilibrium state

Now that state 1 is no longer an equilibrium state it is possible for the conflict to evolve to a new final outcome. Considering state 1 as the status quo state, the following progression can occur. CoK can move the conflict to state 3, next PO can move the conflict unilaterally to state 4 and finally UW can move the conflict from 4 to 8, an outcome in the top half of all three DMs' preference rankings, as shown in Figure 5.

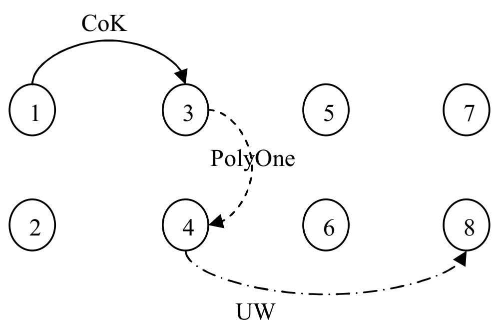


Figure 4. Evolution of Conflict – Altruistic Attitudes on the Part of CoK.

Thus, the application of attitudes to the GMCR model of the conflict gave insight into how CoK was able to positively impact the negotiation to complete the project. In the following section insights gained from the previous analyses and their relationships to institutional attitudes are discussed.

V. Institutional Attitudes

With this simple illustration the relatively logical idea that positive attitudes yield more mutually beneficial results is detailed. What is more difficult to determine is how to incorporate this into the overall strategic plan of institutions and organizations. In this particular case study, CoK had the most to lose from the possible failure to lure UW to the property and then have the property redeveloped by some other party. Thus it was certainly in CoK's best interests to behave cooperatively. A social sciences perspective on negotiation also supports this conclusion; Druckman and Olekalns [2] note that although it was thought that emotions and attitudes were only negative factors when examining negotiations, it has recently been reestablished that indeed attitudes can have a positive impact on negotiations.

McIntosh [6] notes that strong emotions such as happiness and anger tend to be socially-induced and thus are a product of the types of interactions in which people engage. This trend gives an advantage to parties who negotiate on a continuous basis, a fact working against brownfield negotiators. Thus, what is more difficult about a negotiation such as this is that the attitudes DMs possess towards each other will depend entirely on preconceived notions or rumors. Therefore it is up to at least one DM to show an ability to act altruistically in order to settle the conflict objectives and move the process forward. In the UW School of Pharmacy negotiation, CoK was able to be the altruistic negotiator that moved the conflict to a win-win resolution. From a strategic standpoint, however, it may be incorrect to label CoK as truly altruistic. Although CoK's movements were made against their own short-term gain, they secured an outcome that benefitted themselves also. Similarly, DMs may make strategic disimprovements to secure outcomes which are beneficial and stable. Thus, these particular altruistic attitudes may be viewed as *strategically altruistic* as CoK acts altruistically to satisfy its own strategy. CoK's strategic altruism can be seen in the calculation of limited move stability where DMs view *n* steps into the future allowing them to make short term strategic disimprovements in order to move towards beneficial long term outcomes [3]

VI. Conclusions

Using GMCR, a simplified model of the negotiations surrounding the redevelopment of a Kitchener, Ontario brownfield and the subsequent building of the UW School of Pharmacy was analyzed. It was through the use of attitudes, however, that insight into how the City of Kitchener needed to act was revealed. By acting altruistically to satisfy the needs of the University of Waterloo, the City was able to meet its own goals as well and thus was able to maintain a responsible, strategically altruistic approach. By applying GMCR and the attitudes framework, important insights, such as those determined in the analysis of the School of Pharmacy development, may be gained and applied to the resolution of brownfield redevelopment negotiations.

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