Attitudes and Coalitions within Brownfield Redevelopment Projects

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Abstract—Within the Graph Model for Conflict Resolution, a formal model for attitudes of decision makers is applied to the study of brownfield redevelopment projects. The formation of coalitions is examined in conjunction with attitudes, to illustrate what opportunities for cooperation exist within brownfield redevelopment. Combining attitudes and coalition formation within the graph model allows for a more complete understanding of how cities, developers and the general public affect the success of brownfield renovation projects through their positive and negative interactions.

Keywords—attitudes, coalitions, GMCR, brownfield redevelopment

I. INTRODUCTION

Brownfields, present in almost all post-industrial and industrial nations, are unique for their development potential, their development problems, and the conflicts associated with this development. The USEPA [17], [18] defines brownfields as those properties “abandoned, idled” or those “under-utilised industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived contamination.” This definition illustrates the conceptual ambiguity of a brownfield, in which a site need only be thought of as contaminated in order for it to be deemed a brownfield. Greenberg et al. [7] note that such properties can have a significant impact on not only the environmental wellbeing of a community, but on the financial and social health of a community as well [13], [16]. Abandoned industrial areas may turn into areas of higher crime, deterring developers from investing in brownfield areas. Brownfield areas often have reduced policing, fire and sanitation services due to a loss of commercial and industrial life. DeSousa [1], [2] and Gertler [6] note that often the loss of services in an area blighted with brownfields can cause other companies to leave the area, exacerbating the situation. Private brownfield redevelopment projects are a subset of brownfield projects, in which a private developer purchases contaminated property with the goal of creating a new enterprise. Investors have an interest in these properties due to their low sale prices and the often prime locations while cities benefits from the increase in tax revenue and the revitalization of blighted areas. Despite the important payoffs, there are challenges to overcome in the revitalization of brownfields. The risk of liability and the cost of remediation are the most important financial concerns for private developers [1]. The main concern for cities is that developers will not be able to complete a project or that the outcome of the development will not increase tax revenues or improve the social or environmental status of the city.

Given the significant benefits to enticing private development, it is thus in the best interest of cities to encourage developers to invest in brownfield properties to find a form of reuse that can benefit all involved. In the following sections, the Graph Model for Conflict Resolution will be introduced and applied to the paradigm of private brownfield redevelopment projects.

II. GRAPH MODEL FOR CONFLICT RESOLUTION

The Graph Model for Conflict Resolution (GMCR), developed by Fang, Hipel and Kilgour [3], is used to show how interactions among individual decision makers (DMs) or groups of DMs lead to a particular final outcome. In order to model a conflict, the DMs are first identified. Following this, the options that are available to each of the DMs are included and the full set of potential states based on those DMs and their options is created. Using solution concepts defining potential human behavior under conflict, these states are analyzed to determine which of them are stable.

Definition 1 (The Graph Model for Conflict Resolution): A graph model for conflict resolution is a 4-tuple \((N, S, (A_i)_{i \in N}, (\cdot, \cdot, \cdot)_{i \in N})\), where \(N\): the set of all decision makers (DMs) \(|N| \geq 2\), \(S\): the set of all states in the conflict \(|S| \geq 2\), \((S, A)\): DM \(i\)’s graph \((S): the set of all vertices, \(A_i \subset S \times S\): the set of all
For $s, t \in S$, $s \succ t$ means that DM $i$ prefers state $s$ to $t$, while $s \sim t$ indicates that DM $i$ is indifferent between $s$ and $t$. Relative preferences are assumed to satisfy the following properties:

- $\succ$ is asymmetric; hence, for all $s, t \in S$, $s \succ t$ and $t \succ s$ cannot hold true simultaneously.
- $\sim$ is reflexive; therefore, for any $s \in S$, $s \sim s$.
- $\succ$ is symmetric; hence, for any $s, t \in S$ if $s \sim t$ then $t \sim s$.
- $(\succ, \sim)$ is complete; therefore, for all $s, t \in S$ one of $s \succ t$, $t \succ s$ or $s \sim t$ is true.

In Definition 1, the arcs between states represent the set of unilateral movements that a DM has between those states. Given this mathematical foundation and in order to define solution concepts for analyzing conflicts, the reachable list and unilateral improvement list are defined.

Definition 2 (Reachable list): For $i \in N$ and $s \in S$, DM $i$’s reachable list from state $s$ is the set $\{t \in S | (s, t) \in A_i\}$, denoted by $R_i(s) \subseteq S$. The reachable list is a record of all the states that a given DM 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 DM $i$’s reachable list from $s$.

In a conflict with multiple DMs, it is necessary to consider a subset of DMs with its own reachable list. To accommodate this, Definition 3 expands the reachable list definition for that of DM $i$ to that of a subset of DMs, $H$, using induction.

Definition 3: The reachable list of a subset of DMs $H \subseteq N$ at state $s \in S$, 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 $t \in R_i(s)$ and $u \in R_i(t)$, then $u \in R_H(s)$.

Definition 4 (Set of less or equally preferred states): 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 $\phi^i_s(x) = \{x \in S | s \succ x\}$.

Definition 5 (Unilateral Improvement (UI) list for a DM): For $i \in N$ and $s \in S$, DM $i$’s UI list from state $s$ is the set $\{t \in R_i(s) | t \succ s\}$, denoted by $R^+_i(s) \subseteq S$.

In large multiple conflicts, it is convenient to define unilateral improvement lists for subsets of DMs.

Definition 6: For $H \subseteq N$ and $s \in S$, the strictly unilateral improvement list of coalition $H$ from state $s$ 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 $t \in R^+_i(s)$ and $u \in R^+_i(t)$, then $u \in R^+_H(s)$. The two stability concepts used in this analysis are Nash stability [14, 15] and sequential stability [4, 5]. Nash stability represents the case where a DM will not move from a given state in a conflict as he or she has no unilateral improvements available. This can be defined as follows:

Definition 7: For $i \in N$, state $s \in S$ is Nash stable for DM $i$, denoted by $s \in S^*_i$, if and only if $R^+_i(s) = \phi$.

Sequential sanctioning is a situation in which a DM will avoid moving unilaterally to a more improved state because opposing DMs can sanction the DM, thereby moving the conflict to a less desired state for the particular DM. In this case, the opposing DMs will only sanction the initial DM using a credible move. This means that the move is advantageous to the sanctioning DMs.

Definition 8: For $i \in N$, state $s \in S$ is sequentially stable for DM $i$, denoted by $s \in S^*_i$, if and only if for all $x \in R^+_i(s)$, $R^+_{N \setminus \{i\}}(x) \cap \phi^i_s(x) \neq \phi$.

III. PRIVATE BROWNFIELD REDEVELOPMENT CONFLICTS

In the case of private investment in brownfield properties is in the interest of cities to encourage developers to take on the risk and investment. To examine the way different decision makers (DMs) interact in private brownfield redevelopments, Walker, Hipel and Boullier [19] broke down the development of a brownfield property into three distinct conflicts, as shown in Fig. 1. In each of these conflicts the developer and city government act together while interacting with various other DMs.
In redevelopment projects, the most commonly modeled and analyzed situations are those of brownfield acquisitions.

However, a vast majority of these conflicts have been shown from an environmental or economic perspective. Previous models have focused on the appropriate sharing of remediation costs between buyer, seller and cities while case studies have examined the costs and benefits that potential buyers face when considering the purchase of a brownfield property. In order to determine the best policies to implement to entice redevelopment, acquisition will be analyzed using coalition analysis [9], [10] and attitudes [11] which is defined in the following section.

IV. ACQUISITION CONFLICT

In brownfield renovation projects, the acquisition conflict is where a potential developer looks to purchase the property from the current property owner, who may be a receiver or financial institution. City governments may not be involved at the outset of such negotiations, however as it is in their best interest, local governments may decide to influence the negotiations through the use of incentives. Such incentives may be financial and include tax incremental financing, a reduction in development fees or the waiving of building permit fees. The assistance of a city planner, as is common in the City of Kitchener [19], to aid developers in the completion of all the steps necessary in the approval processes is another incentive to development.

The acquisition conflict can be seen as a three DM conflict involving the buyer (B), seller (S) and local government (LG). The buyers options are to either buy (b) or not, the seller’s options are to either sell low (L), high (H) or not at all and the city’s options are to offer incentives ($) or not. Both B and S have the option to end negotiations, denoted by an E.

As the selection of this option by either DM would result in the same outcome regardless of the other DM’s actions, the states where either or both B and S choose option E have been merged into one state, state 8. This conflict can be written in option form, as seen in Table I in order to illustrate all the potential outcomes to the conflict.

<table>
<thead>
<tr>
<th>Preference Information for Acquisition Conflict</th>
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<tr>
<td><strong>DM</strong></td>
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<tr>
<td><strong>Preference Information</strong></td>
</tr>
<tr>
<td><strong>E</strong></td>
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<td><strong>NOT S</strong></td>
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</tbody>
</table>

Using the preferences statements in Table II, the preference rankings are determined in written below it. From this information a stability analysis can be undertaken using the solution concepts from Definitions 1 through 8. In tableau form, as developed by Fraser and Hipel [4], the analysis is shown in Table III.

The equilibrium state is state 8, which corresponds to the state where B, S or both parties end negotiations. Due to the need for S to sell and the potential loss of investment in the community, State 8 is a less preferred state for B and LG, however, it is important to determine if there is a path in the Graph Model from the status quo state(s) to this outcome. If the conflict is started under the assumption of S selling at a higher price, there are two possible starting states: 1 and 5. In Fig. 2, the potential evolutions from states 1 and 5 are shown.

Fig. 2. Potential evolutions of states in acquisition conflict
In Fig. 2. a) S offers a high selling price in the presence of LG incentives. B either leaves the negotiation immediately, moving the conflict to state S or considers it, state 0, and then rejects it. In b) S offers a high selling price in the absence of incentive and B immediately ends the negotiations. In order to determine what actions and movements might lead to better outcomes, coalitions and attitudes will be applied to this problem. In Section V, both of those methodologies shall be defined.

V. COALITIONS AND ATTITUDES IN THE GRAPH MODEL

The framework for analyzing temporary coalitions was first developed by Kilgour, et al. [12] and expanded by Inohara and Hipel [9], [10]. In temporary coalitions, two or more DMs work together making unilateral and coalition movements to reach an improved outcome that they could not reach on their own. The following definitions outline how coalition analysis can be applied to conflicts within GMCR.

Definition 9: The coalition improvement list of a coalition H ⊂ N, with states s, t ∈ S, RH(s) is defined as the set {t ∈ RH(s)} ∀ t ∈ H, t ≠ s.

Definition 10: The class improvement list of a subclass C of P(N) from state s ∈ S is defined inductively as the set RC++(s), where the values eij = φ for all i, j. Testing conditions (i) if H ∈ C and t ∈ RH(s), then t ∈ RC++(s), and (ii) if H ∈ C and t ∈ RC++(s) and u ∈ RH(t), then u ∈ RC++(s).

Definition 11: A state s ∈ S is coalition Nash stable for coalition H ∈ P(N), denoted by s ∈ SNash(CH), if and only if RH(s) = φ[12].

Definition 12: A state s ∈ S is coalition sequentially stable for coalition H ∈ P(N), denoted by s ∈ SNash(CH), if and only if for all x ∈ RH(s), RH++(x) ∩ φH(s) = φ.[9], [10].

Attitudes, developed by Inohara, et al. [11], examine how different DMs may act towards each other based on their devotion or aggression, regardless of their preferences. This allows decision analysts to examine a myriad of potential conflict cases without needing to reevaluate DM preferences. Definitions 13 through 22 detail the framework of attitudes within the Graph Model.

Definition 13 (Attitudes): For DMs i, j ∈ N, let Ei = {+, 0, −} represent the set of attitudes of DM i. An element ei ∈ Ei is called the attitude of DM i for which ei = (ei) is the list of attitudes of DM j towards DM i. The values ei = +, ei = 0, and ei = − indicates that DM i has a positive, neutral and negative attitude towards DM j, respectively.

Using Definition 13 devoting and aggressive preferences are defined in order to create new sets of relational moves.

Definition 14 (Devoting preference (DP)): The devoting preference of DM i ∈ N with respect to DM j ∈ N is D(i, j), denoted by DPij, such that for s, t ∈ S, s DPij t if and only if s ⊂ t.

Definition 15 (Aggressive preference (AP)): The aggressive preference of DM i ∈ N with respect to DM j ∈ N is NE(i, j), denoted by APij, such that for s, t ∈ S, s NE(i, j) t if and only if s ⊂ t. That is, for s, t ∈ S, s APij t if and only if s NE(i, j) t (if and only if t ⊂ s) under completeness of ⊂.

Relational preferences (Def. 16), combine the attitudes of Def. 13 and the preference definitions of Defs. 14 and 15 to create a general preference structure that is analogous to regular preferences in regular analyses.

Definition 16 (Relational preference): The relational preference RP(e)i of DM i ∈ N with respect to DM j ∈ N at e is defined as follows:

\[
RP(e)_i = \begin{cases} 
DP_j & \text{if } e_{ij} = + \\
AP_j & \text{if } e_{ij} = - \\
I & \text{if } e_{ij} = 0,
\end{cases}
\]

where I denotes that DM i is indifferent with respect to j’s preference and, hence, s I s means that DM i’s preferences between state s and x are not influenced by DM j’s preference.

The types of preferences are matched with the three different attitudes. Thus, if DM i has a positive attitude about DM j, DM i will have a devoting preference with respect to DM j. If DM i has a negative attitude towards DM j, DM i will have an aggressive preference with respect to DM j. Thus, a DM behaves according to his or her attitudes.

Definition 17 (Total relational preference(TRP)): The total relational preference of DM i ∈ N at e is defined as the ordering TRP(e)i such that for s, t ∈ S, s TRP(e)i t if and only if s is preferred to t for all j ∈ N.

A state satisfies a total relational preference for the situation in which it is a relational preference for DM i according to the attitudes of DM i towards all of the DMs in the conflict. Thus, if a state s is a total relational preference by DM i to state t with respect to himself and DM j, and there are only the two DMs in the conflict, then state s is a total relational preference by DM i relative to state t.

Definition 18 (Total relational reply (TRR)): The total relational reply list of DM i ∈ N at e for state s ∈ S is defined as the set \{t ∈ R(s) \bigcup \{s\} | t TRP(e)i s \subseteq R(s) \bigcup \{s\}\}, denoted by TRR(e)i(s).
Definition 19 (Total relational reply list of a coalition): The total relational reply list of coalition \( H \subseteq N \) at \( e \) for state \( s \in S \) is defined inductively as the set \( \text{TRR}(e)_H(s) \) that satisfies the next two conditions: (i) if \( i \in H \) and \( t \in \text{TRR}(e)_i(s) \), then \( t \in \text{TRR}(e)_H(s) \), and (ii) if \( i \notin H \) and \( t \in \text{TRR}(e)_i(s) \) and \( u \in \text{TRR}(e)(t) \), then \( u \in \text{TRR}(e)_H(s) \).

Definition 20 (Relational less preferred or equally preferred states): The symbol \( R \phi^*(e)_i(s) \) is an analogue of \( \phi^*(s) \) given in Chapter 2. Hence, \( R \phi^*(e)_i(s) \) is the set of all states which are not relationally preferred to \( s \) by \( DM_i \) (under attitude \( e \)). Note that \( NE(x \text{ TRP}(e), s) \) means that \( "x \text{ TRP}(e), s" \) is not true.

Employing the foregoing definitions, relational solution concepts can now be defined as an extension of rational solution concepts when attitudes are taken into account.

Definition 21 (Relational Nash stability (RNash)): For \( i \in N \), state \( s \in S \) is relational Nash stable at \( e \) for DM \( i \), denoted by \( s \in \text{RNash}_i(e) \), if and only if \( \text{TRR}(e)_i(s) = \{s\} \).

Definition 22 (Relational sequential stability (RSEQ)): For \( i \in N \), state \( s \in S \) is relational sequential stable at \( e \) for DM \( i \), denoted by \( s \in \text{RSEQ}_i(e) \), if and only if for all \( x \in \text{TRR}(e)_i(s) \setminus \{s\} \), \( \text{TRR}(e)_{N \setminus \{i\}}(x) \subseteq \{x/\phi^*(x) \} \).

VI. COALITIONS IN BROWNFIELD CONFLICTS

Using Definitions 8 through 22, the acquisition conflict analyzed in Section I is reevaluated using coalitions and attitudes to determine the impact on conflict outcomes. Due to the close working relationship between LG and B in most cities, they make a natural coalition. Sellers are often not working as closely with the local government as they likely will not have any role with the future of the property in question. Using definitions 9 through 12, coalition movements and improvements are determined for \( H \), a coalition made up of B and LG, and shown in Table IV.

![Graph model](image)

Fig. 3. Potential coalition evolution of states in acquisition conflict

In this evolution of states, the conflict moves away from the state with an offer of incentives and high selling price to purchase by the buyer. This outcome is more preferred by the buyer, seller, and local government and is a win-win solution for all involved DMs. By using attitudes, it will next be determined the nature of the relationship that is necessary to achieve such an outcome without forming a coalition.

VII. ATTITUDES IN ACQUISITION CONFLICT

Applying attitudes to the acquisition conflict reveals how the interactions between the DMs can impact the final conflict outcome. In Table VI is a matrix representing both regular attitudes, as were analyzed in section IV and a new set of attitudes that reflect the cooperative nature that LG and B hold whilst in a temporary coalition.

![Matrix](image)

TABLE VI

<table>
<thead>
<tr>
<th>Attributions in Regular and Modified Analysis of Acquisition</th>
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<tr>
<td>Regular Analysis</td>
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<tr>
<td>B</td>
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<td>B</td>
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<td>S</td>
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<td>LG</td>
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<td>Modified Analysis</td>
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<td>S</td>
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<td>LG</td>
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Using the attitudes prescribed to the modified analysis from Table VI and applying the relational preferences and moves, as defined in Definitions 13 to 22 of Section V, a new set of equilibrium outcomes is determined. Here, states 0 and 8 are equilibrium states with state 0 representing B purchasing at a high sale price from S with incentives from LG. It is worth nothing that when B and LG hold devoting attitudes towards each other, there are no relational improvements for LG. This occurs as LG’s movements can either please itself or B, but not both of them. B’s purchase of the property, at the right price and with incentives, is advantageous to both B and LG not both of them. B’s purchase of the property, at the right price and with incentives, is advantageous to both B and LG and thus B has unilateral relational movements under the price and with incentives. This occurs as LG’s movements can either please itself or B, but not both of them. B’s purchase of the property, at the right price and with incentives, is advantageous to both B and LG and thus B has unilateral relational movements under the attitudes in Table VI.

<table>
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<th>Table VII</th>
<th>Acquisition Conflict</th>
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<tr>
<td>Ed</td>
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<tr>
<td>B</td>
<td>2</td>
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<tr>
<td>B</td>
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<tr>
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<td>LG</td>
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</tr>
<tr>
<td>LG</td>
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</tbody>
</table>

Fig. 4. Potential relational evolution of states in acquisition conflict

This outcome is the same as occurred through the use of coalitions in Section VI, however no coalition movements were made. In place of these coalition movements were relational movements which illustrate how these DMs move cooperatively without forming a coalition.

VIII. CONCLUSIONS

As can be seen in the application of attitudes and coalitions to the problem of brownfield acquisition, positive attitudes and collaboration can move the situation to a beneficial resolution for all involved. Furthermore, the use of attitudes, particularly those analyzed here, illustrates how positive attitudes can give rise to outcomes that also appear through the formation of coalitions suggesting that positive coalition-like outcomes can occur in the presence of positive attitudes.