Attitude-Based
Strategic and Tactical Negotiations
for
Conflict Resolution
in
Construction

by
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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

--Saied Yousefi

Abstract

An innovative negotiation framework for resolving complex construction conflicts and disputes has been developed in this research. The unique feature of the proposed negotiation framework is that it takes into account the attitudes of the decision makers, which is an important human factor in construction negotiation at both the strategic and tactical levels of decision making. At the strategic level, the Graph Model for Conflict Resolution (GMCR) technique has been systematically employed as a method of determining the most beneficial strategic agreement that is possible, given the competing interests and attitudes of the decision makers. At the tactical level, a previously agreed-upon strategic decision has been analyzed in depth using utility functions in order to determine the trade-offs or concessions needed for the decision makers to reach a mutually acceptable resolution of the negotiation issues. A real-life case study of a brownfield construction negotiation has been used to illustrate how the proposed methodology can be applied and to demonstrate the importance and benefits of incorporating the attitudes of the decision makers into the negotiation process to better identify the most feasible resolutions.

The proposed attitude-based negotiation framework constitutes a new systems engineering methodology that will assist managers in tackling real-world controversies, particularly in the construction industry. The negotiation framework has been implemented into a convenient negotiation decision support system that automates the proposed negotiation methodology. The research is expected to improve negotiation methodologies for construction disputes, thereby saving significant amounts of time and resources. The proposed methodology may also assist decision makers in overcoming the challenges of conventional negotiation processes because the incorporation of the attitudes of the decision makers results in a more accurate identification of tradeoffs, greater recognition of the level of satisfaction of the decision makers, and enhanced generation of optimum solutions.

Acknowledgments

I would like first to dedicate my doctoral program to *my mother*, Sedigheh, who has committed her life to me and strongly motivated me with her spiritual prayers throughout my life, particularly during this program. My brave farther, Ali Akbar, and my mother have had profound and undeniable roles in my successes.

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Last but certainly not least, I would like to express my sincerest gratitude to my wife, Hoda, who has supported me throughout this research with her prayers and incredible encouragement. She has concurrently been pursuing her own Master's program and taking care of our baby girl, Golsa, as well as providing an outstanding environment for working at my studies. My wife's endless efforts and help are greatly appreciated.

Dedication

To my mother, Sedigheh, and my father, Ali-Akbar
Who
Have dedicated their lives to me

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CHAPTER 1: Introduction

1.1. Background

The construction industry is one of the largest industries in the world, with members who are expert in planning, design, construction, operation, and administration. Construction projects have become increasingly complex, with the parties involved often having conflicting objectives. For example, the owner would like a project to be inexpensive and quickly completed, while the contractor wants large and income-generating projects with few time restrictions. According to Litigation Trends Survey Findings (LTSF, 2006), construction firms worldwide spend close to 31 million US dollars annually on litigation: the second highest expenditure by type of industry, as shown in Figure 1.1.

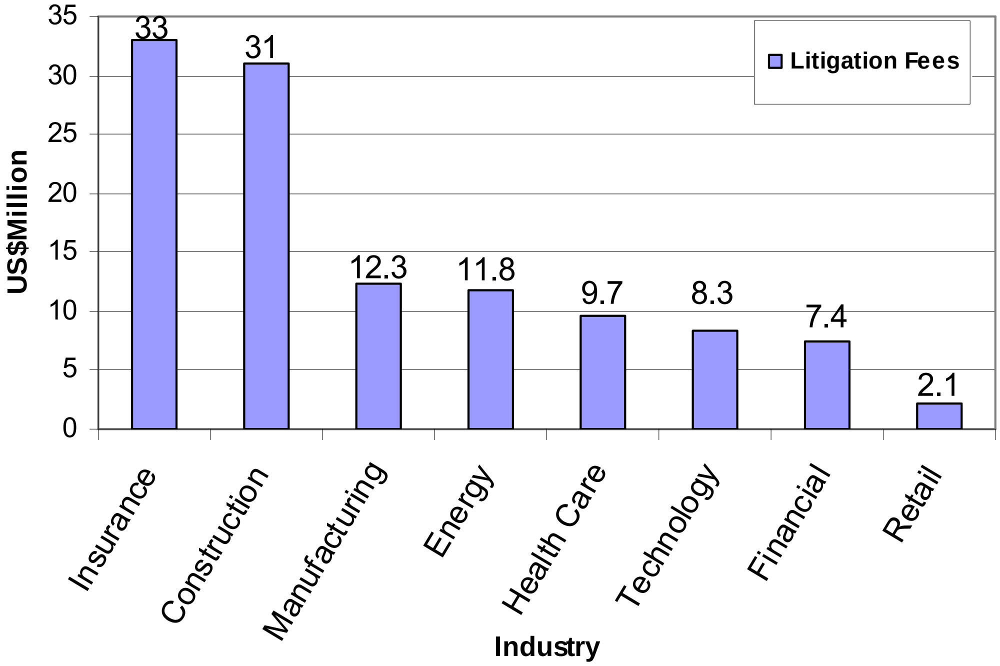


Figure 1.1: Worldwide Litigation Fees for Various Industries (LTSF, 2006)

In the highly competitive multi-party environment of construction, disputes can arise for many reasons, such as the complexity and magnitude of the work, the lack of coordination among the contracting parties, poorly prepared and/or executed contract documents, inadequate planning, financial issues, and disagreements about methods of solving on-the-spot site-related problems. Any one of these factors can derail a project and lead to complicated litigation or arbitration, increased costs, and a breakdown in the communication and relationships between parties (Harmon, 2003).

According to the Department of Justice Canada (1995), construction is the industry that has the highest number of disputes. Moreover, Kumaraswamy (1997) has found that about 75% of construction contracts have been the subject of some types of dispute which represents an enormous expenditure of time, effort, and human resources. In other words, the construction industry has become an adversarial culture prone to conflict and disputes (Brooker and Lavers, 1997; Fenn et al., 1997; Garrett, 2002; Kellogg, 2001; Kumaraswamy, 1997; Mathews, 1997). The adversarial attitude prevalent in many disputes undermines the cooperative environment necessary for the success of a project and is at odds with the collaborative nature required in construction activities. A great deal of research has been devoted to finding ways to reduce the number and magnitude of these conflicts and more effective approaches are needed if sustainable solutions are to be found for the current types of conflicts (Barnett, 1997).

The three major parties traditionally involved in a construction project are the owner, the consultant, and the contractor. Clearly, the successful delivery of a project requires their full cooperation and collaboration: time, costs, resources, and objectives must be coordinated. However, differences in the perceptions of the parties involved in a project make conflicts and disputes inevitable. Therefore, resolving disputes has become an essential component of construction administration and many studies have been conducted with respect to finding effective dispute resolution methods (Barnett, 1997; Cheung et al., 2002; Diekmann and Girard, 1995; Doug, 2006; Rameezdeen and Gunarathna, 2003; and Shen et al., 2007).

The traditional method of resolving construction disputes is litigation, which is usually complicated because of unresolved conflicts or disputes connected with large, complex projects (Pinnell, 1999). The enormous amounts of time and money expended by all parties involved in litigation (Figure 1.1) have led to the emergence of other dispute resolution methods, called Alternative Dispute Resolution (ADR) tactics (Harmon, 2003). The main purpose of ADR tactics is to resolve disputes with the ‘‘least possible intervention by an outside third party’’ (Gillie et al., 1991). As illustrated in Figure 1.2, two groups of ADR tactics are used in construction: formal-binding and informal-nonbinding tactics (Di-Donato, 1993). Formal-binding ADR is predominantly arbitration, while informal-nonbinding ADR tactics include mini-trials, mediation, third-party neutrals, dispute resolution boards, and negotiation (Trantina, 2001).

As shown in Figure 1.2, negotiation is the least hostile approach and is also the fastest and least costly. The objective of sensible dispute management should be to negotiate a settlement as soon as possible. Negotiation can be, and usually is, the most efficient form of dispute resolution with respect to both managing time and costs and to preserving relationships. It should be envisioned as the preferred route in most disputes (Office of Government Commerce, 2002). Its advantages include speed, cost savings, confidentiality, preservation of relationships, a range of possible solutions, and the control of process and outcome.

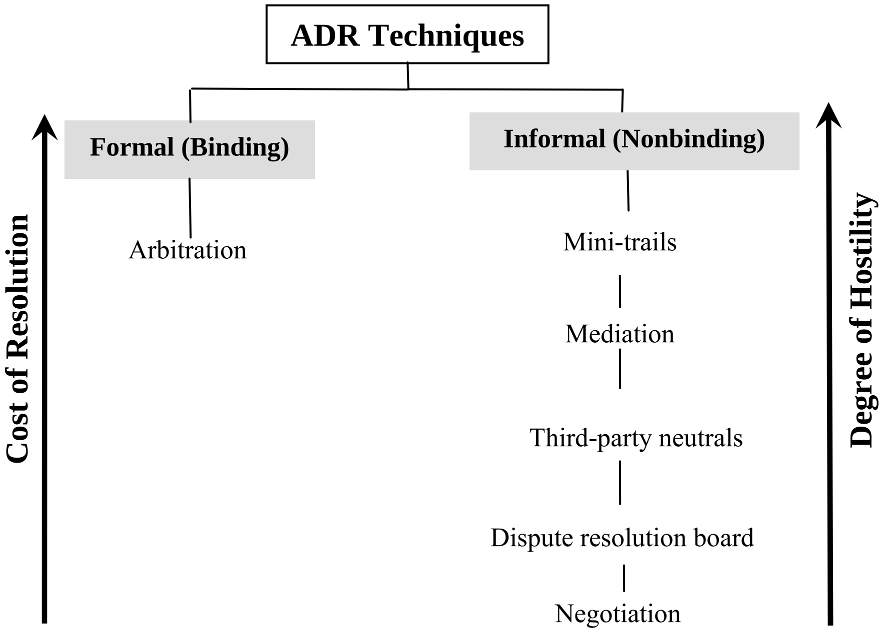


Figure 1.2: ADR Methods in Construction (based on Trantina (2001))

Due to these potential benefits, negotiation has gained the attention of construction project managers. Cheung et al. (2002) mention that those who have been involved in the process view negotiation as the method best suited to preserving or enhancing existing job relationships. Their research also points out that negotiation is effective in reducing costs and opening channels of communication. In addition, according to an official document published by the Office of Government Commerce (OGC) (2002), negotiation is by far the most common form of dispute resolution, with a variety of related systems having been developed for employing it. Despite the importance of negotiation and the availability of formal negotiation techniques, they have not thus far been widely used in the construction industry.

1.2. Research Motivation

The goal of this research is to develop a systematic negotiation methodology, especially suited for complex construction disputes, which incorporates the negotiators' attitudes not only at the strategic level of decision making but also at the tactical (detailed) level of decision making. The research has been motivated by the following considerations.

A) Negotiation is important to the construction industry: Most construction projects involve cost overruns, time extensions, and conflicts among parties. The widespread extent of these problems is generally attributed to two main factors (Hegazy, 2002): the unique and highly uncertain nature of construction projects and the fragmented and highly competitive nature of the construction industry. In this challenging environment, any of the variables that affect a project, such as the weather, the interpretation of the contract, soil conditions, labor, or equipment, can become a problem at any moment. Because each party then strives not to take the blame for the consequences of any difficulties that arise, disputes and conflicts are inevitable. Efficient conflict and dispute management techniques, such as negotiation, thus become key to the success of projects and of the parties involved in the project. It should be mentioned that construction negotiations take place among the parties who are often bounded by a contract. However, there are negotiations among construction parties who are not necessarily bounded by a contract.

B) The construction industry lacks negotiation support: Negotiation is potentially one of the most effective methods of ADR in the construction industry. It provides a process whereby construction disputants can communicate to one another their conflicting interests and resolve differences so that further disputes arising from misperceptions of the current conflict can be prevented. The ability of construction managers to effectively negotiate significantly influences the performance of the project.

In spite of the importance of negotiation, with respect to construction, it has been the subject of little research or education (Dudziak and Hendrickson, 1988). Engineering managers, for example, learn negotiating skills mainly through experience and observation (Smith, 1992). Moreover, negotiation in construction can be difficult since the individuals charged with negotiating the settlement are reluctant to make concessions because of the risk of having to explain them to uninformed senior management. In other words, construction disputants lack organized negotiation support to help them handle complex construction conflicts and disputes. Developing negotiation support tools that can provide assistance for construction managers and administrators is therefore important.

In response to the need for negotiation support tools, several studies have been conducted in the area of negotiation support systems (NSS) (Cheung et al., 2004; Li, 1996; Molenaar et al., 2000; Omoto et al., 2002; Ren et al., 2003; and Yaoyueyong et al., 2005). Such systems, however, seem to suffer from the following restrictions:

- They do not consider the psychological aspects of the decision makers in the negotiation and thus fail to address attitude, which is one of most influential psychological factors in negotiation (Kahneman and Tversky, 2000).
- They are restricted to informing decision makers about the progress of only the current negotiation and cannot provide details about past rounds of negotiation, or about the parties involved, or their preferences.
- They do not consider the characteristics of disputes and disputants in the negotiation methodology.
- They fail to implement suitable negotiation strategies that incorporate changes, since they do not take into account the effect of moves and countermoves by decision makers during interactive strategic decision making.

- They provide decision makers with only cardinal payoff values for conflicting issues and do not suggest to the involved parties any strategic equilibrium state.
- They lack a systematic approach for complementing varying levels of negotiation, such as complementing strategic and tactical levels of decision making to develop a comprehensive negotiation methodology.

Therefore, if current negotiation methodologies are to overcome the above limitations and constraints, they need improvement.

C) The psychological aspects of negotiation need to be considered: Negotiation is considered a decision-making process in which decision makers take into account the social factors (e.g., economic, psychological, financial, and political) that affect their offers and counteroffers during negotiation. Depending on the circumstances surrounding the decision, some of these aspects are more important than others. Psychological factors, such as attitude, often have significant influence on the outcome of the negotiation. For example, when two parties who have negative attitudes toward each other negotiate, the outcome of the negotiation is unlikely to be productive. The attitudes of decision makers toward one another may also change during each round of negotiation. For example, two decision makers may initially have negative attitudes toward each other, but as negotiation continues and they share their concerns and limitations, they may develop more positive attitudes and eventually reach a productive outcome. Therefore, using a negotiation methodology that considers the attitudes of the negotiators is more likely to provide a reliable outcome that can be a stable solution to the conflict.

When parameters are set for conflict situations, the few negotiation models prepared for the construction industry (Cheung et al., 2004; Molenaar et al., 2000; and Omoto et al., 2002) lack consideration of the psychological states of the decision makers. A key goal of this research is therefore to incorporate the attitudes of the decision makers into the modeling of the negotiation process so that more realistic and reliable equilibrium outcomes can be suggested. In other words, a comprehensive negotiation methodology should be capable of including the psychological aspects of negotiation, such as the negotiators' behavior and attitudes, at both the strategic and the tactical levels of the decision making process. Such unified methodology can then suggest the most stable solution.

D) Decision analysis tools should be integrated within the negotiation methodology: Recent research in negotiation has shown the advantage of employing decision-making tools to help produce better negotiation outcomes (Bellucci and Zeleznikow, 1998; Kersten, 2002; Matwin et al., 1989; and Thiessen and McMahon, 2000). Such integration provides the following advantages:

- Effective communication among decision makers,
- The capability of learning from experience,

- Explanations helpful to decision makers,
- The modelling of the dynamic properties of the negotiation, and
- The ability to draw reasonable conclusions and clear strategic guidance.

Negotiation Decision Support Systems (NDSSs) have been used successfully in other domains, such as family counseling (Bellucci and Zeleznikow, 1998); E-commerce and E-negotiations (Kersten, 2002); and manufacturing disputes (Sycara, 1993). In spite of the potential benefits and inherent capabilities of NDSSs, the construction industry has not been sufficiently introduced to these recent developments in negotiation methodologies and support systems. For example, the Graph Model for Conflict Resolution (GMCR) methodology was developed by Fang et al. (1993); the concept of utility theory was explained by Fishrburn (1970); the concept of Efficiency Frontier was introduced by Raiffa et al. (2002); and the concepts of Even Swaps and Value-Focused Thinking were introduced by Hammond et al. (1999) and Keeney (1992), respectively. These concepts have not been widely employed for addressing construction disputes. Moreover, such theories and methodologies have potentially beneficial applications in resolving construction conflicts because they can model the risk attitudes and behaviors of decision makers, and can effectively account for negotiation-related uncertainties.

E) Challenges in brownfield negotiations need to be overcome: As an area of construction in which negotiation can be applied, this research focuses on brownfield negotiations: a growing problem in the Canadian construction industry and elsewhere (De Sousa, 2001 and Ellerbusch, 2006). A brownfield is contaminated land that lies unused and unproductive. Due to the enormous amount of uncertainty and the number of unexpected events involved in brownfield redevelopment, the parties involved (e.g., the current owner and the government) spend tremendous amounts of time in multiple rounds of negotiation in the hope of reaching an agreement about cleaning up the contaminated site (De Sousa, 2000). They must analyze past and current information in order to make effective offers and counteroffers that can lead to an agreement about the transfer of ownership and the decontamination and redevelopment of a brownfield property. The negotiating parties may, however, lack negotiation skills and be unable to handle the negotiation process efficiently, communicate their concerns and preferences, and make suitable decisions about the problem. Although the parties involved are willing to reach a mutual agreement cooperatively, the negotiation process in brownfield projects is complex and often unproductive, particularly when few practical solutions are suggested by any of the parties (Begley, 1997).

A negotiation support system that provides more effective practical guidelines for the parties involved is therefore needed (Hipel et al., 2009). Such brownfield negotiation tools must take into consideration the risk attitudes and behavioral characteristics of the current owner, the government, the stakeholders involved, and possibly the future purchaser.

1.3. Research Objectives

The primary objective of this research is to provide a better understanding of the negotiation processes among the decision makers involved in construction disputes. Accordingly, a systematic negotiation framework has been developed that considers decision makers' attitudes in order to help the negotiating parties reach a stable mutual agreement. The proposed negotiation methodology provides the parties involved with both strategic decision options and tactical (detailed) payoff outcomes. The specific objectives are as follows:

1. To understand how construction negotiators behave and negotiate in practice to reach mutual compromises with respect to conflicting issues;
2. To identify, with respect to construction, the characteristics of both negotiations (e.g., the parties involved, the type and number of conflicting issues, and the type of project) and negotiators (e.g., position, choices);
3. To study the applications of game theory, negotiation analysis, the Graph Model analysis, utility theory to model a construction negotiation process;
4. To develop an attitude-based negotiation methodology at both the strategic and tactical levels of negotiation for addressing and resolving construction disputes when multiple decision makers and multiple conflicting issues are involved;
5. To demonstrate the application of the proposed negotiation methodology in real-life brownfield case studies; and
6. To implement the proposed negotiation methodology into a construction negotiation decision support system.

1.4. Research Methodology

To achieve the above objectives, relevant theories, techniques, and approaches in the literature have been reviewed and appropriately refined and expanded in order to arrive at a novel decision-making methodology for engineering purposes particularly suited to construction decision making (Yousefi et al., 2008). The proposed methodology will systematically incorporate the attitudes of the negotiators into the modeling of the negotiation at the level of strategic decision analysis as well as at the tactical level. The systematic research methodology is depicted in Figure 1.3.

1.5. Summary

The goal of this research is to develop an innovative negotiation methodology that takes into account the attitudes of decision makers at two levels of decision making: strategic and tactical. At the strategic level, the Graph Model for Conflict Resolution is systematically employed as a means of determining a potential overall agreement, or set of resolutions, that is possible given the competing interests of the decision makers involved in the negotiation process. At the tactical level, the new methodology allows a possible strategic solution to be studied in depth using utility functions to determine the detailed trade-offs or concessions needed for the parties to reach a mutually acceptable solution.

This research may help participants facilitate or mediate the negotiation of disputes in construction projects. The proposed methodology may assist decision makers in overcoming the challenges of conventional negotiation through the consideration of the attitudes of the decision makers so that the levels of decision making can be conveniently complemented, tradeoffs can be more accurately identified, the level of decision makers' satisfaction can be recognized, and optimum solutions can be generated.

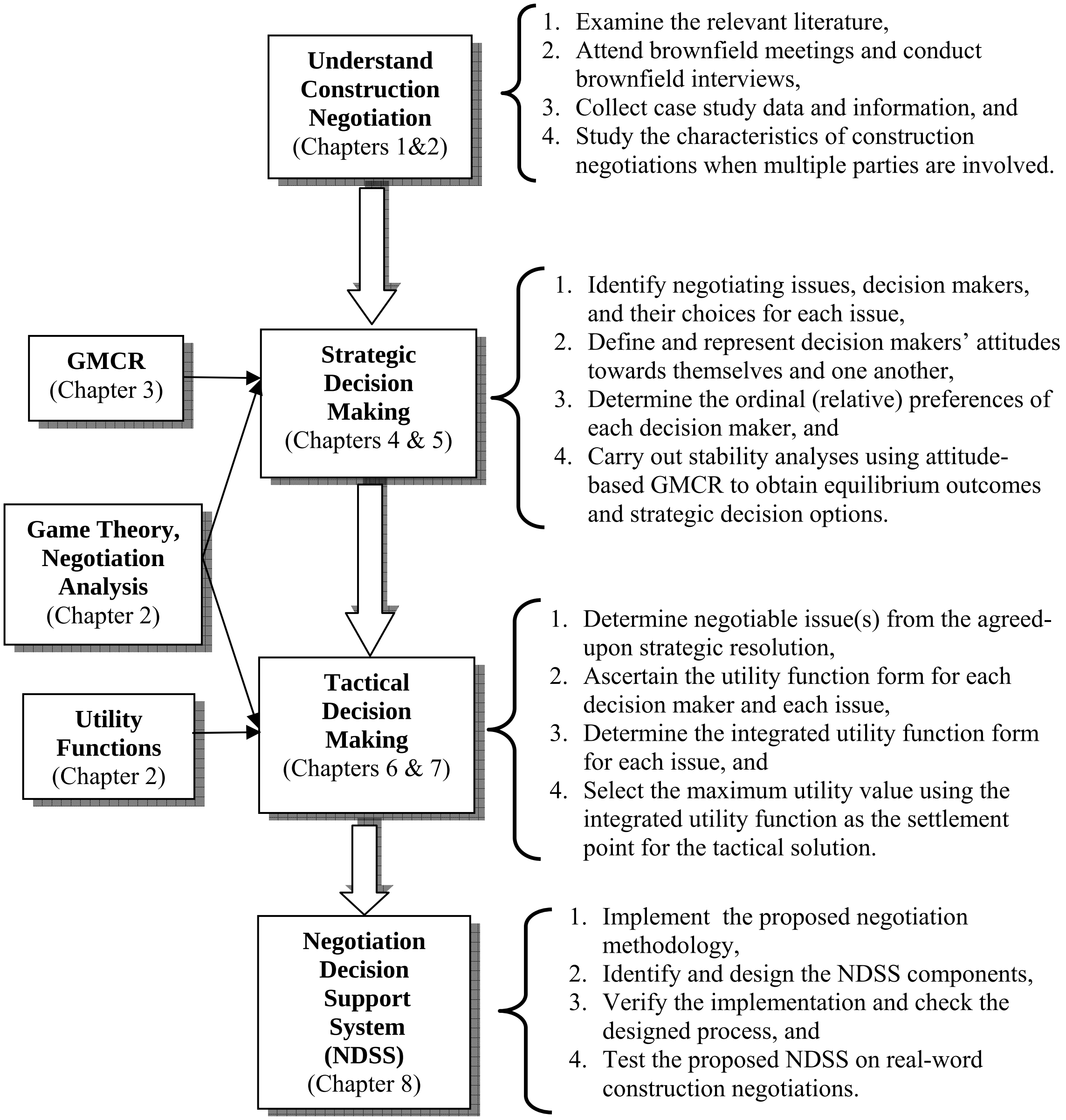


Figure 1.3: Proposed Research Methodology

This chapter has emphasized the need for using negotiation tactic in construction due to their lower cost and less hostile attributes compared with other ADR tactics, such as litigation and arbitration. The motivation for this research has been briefly explained. The objectives of the research have been listed and the proposed research methodology outlined. Chapter 2 provides a comprehensive review of literatures related to conflicts, disputes, negotiation, and decision-making, with respect to the construction industry, followed by Chapter 3, which briefly introduces the Graph Model for Conflict Resolution (GMCR). The development of the new negotiation methodology at the strategic level for both two and multiple decision makers is discussed in Chapters 4 and 5, respectively. The negotiation methodology at the tactical level, again for both two and multiple decision makers, is presented in Chapters 6 and 7, respectively. The implementation of the proposed methodology in the design of a construction negotiation decision support system is explained in Chapter 8, and Chapter 9 contains concluding remarks, research contributions, and suggestions for future work.

CHAPTER 2
Background and Literature Review

2.1. Introduction

An overview of conflict and negotiation in construction projects is provided in this chapter along with concepts, techniques, and methodologies related to decision making that can be used to develop a negotiation methodology for complex construction disputes. The fundamentals of decision making, particularly strategic and tactical decision making, game theory, and negotiation analysis are introduced. The relationship between game theory and negotiation analysis is also explained and approaches used in modeling the negotiation process are reviewed. Finally, computer applications that support negotiation, particularly in the construction domain, are explained and the relevant literature is reviewed and summarized.

2.2. Studying Disputes in the Construction Industry

The construction of a project is an integrated process. Every construction project requires detailed planning and involves parties such as the owner, contractor, and subcontractors, who are contractually integrated but who have different responsibilities and knowledge. In such an environment, conflicts and disputes can arise for many reasons, including the complexity and magnitude of the work, lack of coordination among the contracting parties, poorly prepared and/or executed contract documents, inadequate planning, financial issues, and disagreements about solving many of the on-the-spot site-related problems. Any one of these factors can derail a project and lead to complicated litigation or arbitration, increased costs, and a breakdown in the parties' communication and relationship (Harmon, 2003). While changes in the work on construction projects are not unusual, the manner in which these alternatives are addressed; or not, can potentially affect the successful completion of a project by creating additional unresolved and unproductive conflicts. If the construction conflicts are not adequately addressed and managed, they can evolve into serious disputes among the parties involved and, therefore, not only could the working environment be damaged, but the cost and duration of projects may also be significantly increased (Hartman and Jergeas, 1995).

The parties involved in the construction industry are usually bound contractually and thus, the contract is the essential document used in the submission and evaluation of claims. In the early stages of a project, the owner decides on a contract strategy which takes into account the following aspects, as shown in Figure 2.1 (Hegazy, 2002):

- The project objectives and constraints,
- A proper project delivery method,
- A reasonable design/construction interaction scheme,
- A proper contract form/type, and
- Administration practices.

Different considerations of these factors produce different contractual forms, which shape the process by which conflicts are addressed in construction projects.

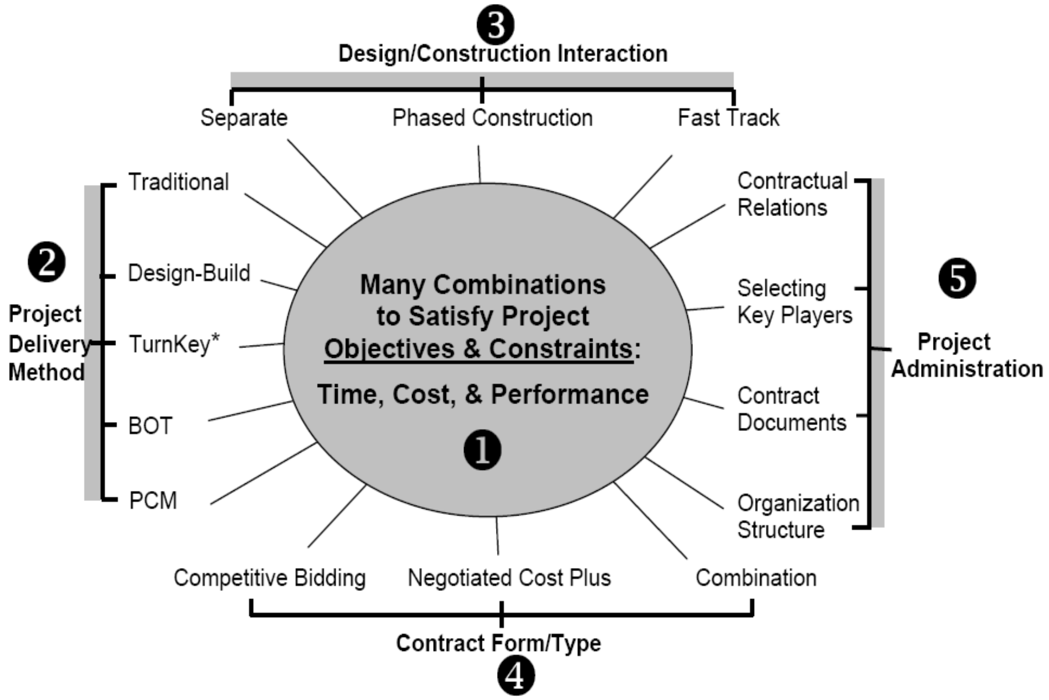


Figure 2.1: Key Considerations in a Contracting Strategy (Hegazy, 2002)

2.2.1. Causes of Conflicts and Disputes in the Construction Industry

Although each construction project is unique, the causes of conflicts are generally similar. They arise from the complexity and magnitude of the work, from multiple parties having different objectives, from unrealistic expectations, from poorly prepared and/or executed contract documents, from financial issues, and from communication problems. A list of the identified causes of disputes in construction is shown in Table 2.1; it represents a compilation from many studies

(Ock and Han, 2003; Loosemore, 1999; Harmon, 2003; Fenn et al., 1997; Cheung et al., 2002).

Table 2.1: Compiled Causes of Disputes in the Construction Industry

Contractual Causes	Organizational Causes	Technical Causes
1. Varied interpretations 2. Unusual weather 3. Delays 4. Accelerations 5. Contract pressures 6. Contract factors 7. Changes in project 8. Increase in scope	1. Deteriorated relationship 2. Owner's failure to act administratively 3. Improper contractor site management 4. Site availability problems 5. Inadequate contractor organization 6. Change in regulations 7. Problems with neighbors 8. Economic conditions 9. Lack of positive attitudes among the involved parties 10. Lack of proper communication: 10.1. In one organization 10.2. Between two involved organizations, and 10.3. Between the involved and the external organizations.	1. Improper planning 2. Technical mistakes 3. Technical negligence 4. Quality of materials 5. Consultant technical problems 6. Defective specifications: 6.1. Improper workmanship 6.2. Improper design 6.3. Technical misperceptions

It should be noted that this list is not comprehensive and other causes of disputes in construction projects may exist. The parties involved in construction projects can significantly influence the number and extent of the causes listed in Table 2.1. When a dispute arises on a project, the disputants behave according to different perceptions, needs, objectives, constraints, aspirations, interests, preferences, and/or levels of reservation (Semple et al., 1994; Harmon, 2003). One of the reasons for these differences is the disputants' varying type of expertise in a construction project. For example, architects have an educational background in aesthetics, whereas engineers have knowledge of the analysis and design of structures and the owner often concentrates on project control and administration. Conflicts and disputes arise when they have to communicate with one another about the project because their background and training are very different and lead to different perspectives on the project (Fenn et al., 1997). None of the parties usually has an in-depth overall view, which may hamper the finding of a common meeting ground.

Although conflicts are an inherent part of every construction project, it is very important that conflict among parties be reduced. Therefore, any viable means of reducing the incidence of conflicts and disputes (e.g., developing positive attitudes among the parties involved) should have a positive effect on the outcome of the project (Jergeas, 2008). The construction participants are themselves aware that unresolved conflicts and their resulting legal and consulting fees add no value to construction projects.

2.2.2. Alternative Dispute Resolution

Traditionally, unresolved conflicts and disputes involving large scales, complex construction projects can be resulted in complex construction litigation (Pinnell, 1999). Litigation is a dispute when it has become the subject of a formal court action or law suit. Anyone who has ever been involved litigation knows that it is expensive, time consuming, emotionally draining and unpredictable. With litigation, until a judge or jury decides who is right and who is wrong, the outcome is not certain. Alternative Dispute Resolution (ADR) tactics, such as mediation, has been gaining popularity as a method to remedy the shortcomings of litigation.

Lengthy and expensive litigation processes have made construction participants less eager to have their day in court, opting instead to resolve their disputes among themselves, as has been done for a long time (Glasner, 2000). In response to the increased cost and duration of litigation, the construction industry has gravitated toward ADR tactics (Mix, 1997; Treacy, 1995). Historically, the construction industry has been seeking innovative and creative ways to resolve conflicts and disputes arising from construction contracts (Henderson, 1996; Mix, 1997). Not only are the costs of court claims avoided, but there are also intangible benefits to avoiding court cases such as maintaining reputation and avoiding emotional stresses (Cheung et al., 2002). For example, arbitration and mediation are similar in that they are alternatives to litigation, or are sometimes used in conjunction with litigation to attempt to avoid litigating a dispute to its conclusion. Both arbitration and mediation employ a neutral third party. Both can be binding; however, it is customary to employ mediation as a non-binding procedure and arbitration as a binding procedure. The characteristics of ADR tactics are summarized in Table 2.2.

As shown in Figure 1.2, ADR techniques can include both binding (formal) and nonbinding (informal) procedures (Kellogg, 2001; Honeyman et al., 2004). Binding ADR is predominantly arbitration, and the binding method sometimes used in construction (Di-Donato, 1993). Nonbinding ADR techniques normally include mini-trials, mediation, third-party neutrals, Dispute Review Boards (DRBs), and negotiation.

Table 2.2: The Characteristics of ADR Techniques (Harmon, 2003)

Tactics	Application	Advantages	Drawbacks
Litigation	Traditional approach for large complex projects. Last preferred tactic.	Appropriate for large complex disputes, formal win-lose method with assigning damage compensations via a court appeal.	Expensive, time consuming, fraught with flaws, affect parties' reputations.
Arbitration	Alternative to litigation with more preference, incorporated into standard contracts.	Very common usage, acceptance of evidences, maintains the confidentiality of the proceedings, more cost-efficient than litigation, preserved business relationship between parties.	More time preparation, no quick and easy answers to resolving the problem, procedural complexities, adversarial approach, lack of the appeal process.
Mediation	A nonbinding, consensual process, a form of distributive justice, a form of assisted or guided negotiation, better to use before arbitration.	Faster, less expensive, more confidential, and more satisfactory way than litigation, minimizing future disputes by maintaining open communication between the parties, creates a win-win outcome that satisfies both parties, very flexible.	Procedural complexities, leading to a compromise settlement, sometimes resulting in subjective outcomes which may confuse parties.
Med./Arb.	A hybrid of mediation and arbitration, binding mediation, considered as a new and enhances tactic.	Encourages the parties to settle rather than lose control of the outcome if arbitration becomes necessary, includes the capabilities of mediation and arbitration.	Creates some dilemmas for either pursue or hold back from mediation part, not so much used in the construction industry.
Mini-trial	A nonbinding hybrid ADR process, it is not a trial, and is held after other alternative dispute mechanisms have failed, but before an actual trial.	Predicts the results of an actual trial, thereby enabling the parties to come to a decision to resolve their dispute before applying for a full scale trial.	Presentations at a mini-trial are time limited, each party must have a relatively good understanding of its issues and the opposing parties' refutations and issues.
ENE * (third-party neutral)	Used early in the litigation process, a court-ordered process, an informal, nonbinding procedure.	Resolves disputes sooner rather than later, thereby circumventing the need for trial preparation, an alternative to expensive discovery and resolving complex technical issues.	Evaluation can be based on predicting the outcome of a trial or arbitration, the procedure is not very straightforward.
Partnering	Seeks to change attitudes about the relationships between parties, establishing trust and open communication, considers as a preventive dispute resolution.	Reduces exposure to litigation, cost overruns, and delays, promotes mutual rather than bifurcated goals, restores the spirit of cooperation.	Not a suitable tactic if the root causes of disputes are not addressed, needs a top-down approach, needs a huge amount of communication among parties.
DRB**	A unique, proactive, non-adversarial project management technique, a panel chosen prior to the start of construction.	Facilitates resolving conflicts before escalating to disputes, has familiarity with the ongoing construction and any important developments on the project.	Its focus is on circumventing disputes rather than merely resolving them, only tries to highlight and identify the root causes of disputes.
Negotiation	Applied for both non-binding and binding ADR as well as a preventive tactic.	Fast growing tactic that is very easy to settle between parties. In any stage of a contract, either before or after, is used officially and/or unofficially.	No positive outcome can be anticipated despite long discussion with the opponents, depends mainly on the opponent's attitude which is unpredictable.

* Early Neutral Evaluation, **Dispute Review Board

Because of its low cost and low degree of hostility (Figure 1.2), negotiation is the tactic most preferred by construction participants. In construction conflicts and disputes, negotiation occurs every time the parties communicate directly with one another about disputed issues. Some negotiators seek agreement that offers the opportunity to avoid the "disruptive consequences of non-settlement" (Colosi, 1999). The honest negotiation of changes and claims helps mitigate disputes before they damage the relationship and become major problems (Zack, 1995). In negotiations, team members often have conflicting goals and values, but when properly performed with cooperative mindsets of decision makers towards one another, negotiation achieves their objectives while maintaining harmony, and reducing time, cost, and hostility.

Richter (2000) illustrates a continuum of ADR procedures, as shown in Figure 2.2, which clarifies that negotiation not only involves the least cost and degree of hostility but also provides the parties involved with the most control over the outcome of the disputes. In other words, negotiation is the best tactic for participants who would like to make their own choices in a conflict situation. In construction, negotiation is sometimes considered a relief from the normal administration of the contract, for it offers both parties involved the opportunity to break from the daily administrative pressures of the contract and thus provides a better environment in which the conflicting issues are discussed in order to reach mutual agreement (Hartman and Jergeas, 1995).

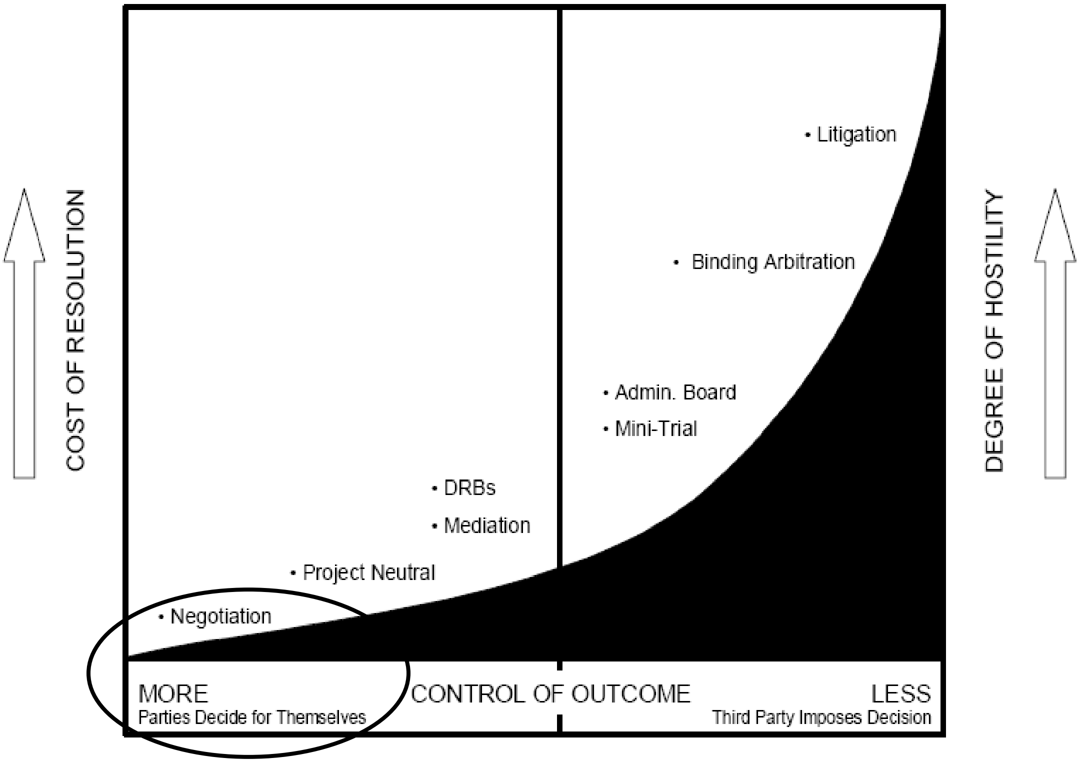


Figure 2.2: Dispute Resolution Continuum (Richter, 2000)

In a negotiation process, effective negotiation skills are a tremendous asset to any successful executive. They are especially significant for construction executives who are continually involved in managing and administering complex contractual relationships involving substantial amounts of money (Jergeas, 2008). However, many individuals often fail in negotiation not because they are unable to reach an agreement, but because they walk away from the table before they achieve the results they are capable of obtaining. Moreover, in spite of the importance of negotiation, proper training in negotiation skills is not provided within the construction industry. Negotiations are an important activity, but they are the subject of little research or education (Dudziak and Hendrickson, 1988).

Project managers seem to learn negotiating skills only through experience and observation (Smith, 1992). Therefore, negotiation support tools for the construction industry may be useful in enabling the participants in a project to handle negotiation more productively.

2.2.3. Brownfield Negotiation

Brownfield projects are reconstruction projects in which the land has already been contaminated and the site may contain hazardous materials that pose a risk to human health and the environment. In Canada, it is estimated that as much as 25% of the land area in major urban centers is potentially contaminated because of previous industrial activities (Benazon, 1995). Interest on the part of developers and lending institutions in redeveloping contaminated sites has tended to be minimal because such projects may involve high cleanup costs that limit the profit margin. Moreover, developers fear being held liable for any negative environmental effects that could be traced to the redeveloped site. On the other hand, these sites are potentially valuable because they are often located in the core sections of metropolitan areas and thus are prime candidates for urban redevelopment and renewal (Bourne, 1995; Barnett, 1995). Therefore, Canadians municipalities and local governments have established comprehensive programs and incentives in order to facilitate brownfield remediation and redevelopment with the hope of achieving the objectives and benefits listed in Table 2.3. It should be mentioned that the listed objectives can be further completed.

Table 2.3: The Objectives of Brownfield Reconstruction (De Sousa, 2000)

Environmental	Social	Economic
➢ Reduction of development pressure on greenfield sites, ➢ Protection of public health and safety, ➢ Protection of groundwater resources, ➢ Protection and recycling of soil resources, ➢ Restoration of former landscapes, and ➢ Establishment of new areas deemed to have ecological values.	➢ Renewal of urban cores, ➢ Elimination of the negative social stigmas of the affected communities by revitalizing them, and ➢ Reduction of the fear of ill health, environmental deterioration and shrinking property values in these communities.	➢ Attraction of domestic and foreign investment, ➢ Restoration of tax base of government especially at the local level, ➢ Increased utilization of and reinvestment in existing municipal services, and ➢ Development of remediation /decontamination technology

To achieve these objectives, it is essential that government representatives (e.g., municipalities) promote cooperation between the current owner(s) of contaminated sites and potential investor(s) so that the parties may share the cost as well as the benefits of redeveloping brownfield sites. However, because of the challenges associated with brownfield reconstruction (e.g., uncertainty about liability with respect to the chain of title, lender hesitation, the time to occupancy, community support, the proposed land use, the condition of the local infrastructure, the support of local politicians, and the availability of financial incentives), many unexpected events may occur during the remediation process. Such unexpected events may bring the remediation to a temporary halt, resulting in delays, cost overruns, and serious conflicts and complex disputes among the parties involved (Barnett, 1995). In brownfield conflicts, as in many other controversies, a variety of dispute resolution procedures are available, of which, as shown in Figure 2.2, negotiation is the most preferred because the local government, the current owner, and the future purchaser can negotiate a solution in a less costly and less hostile environment. Cooperative negotiation among the parties involved will contribute to a mutual and sustainable agreement among the parties, and such agreements may help achieve the objectives of brownfield reconstruction.

Productive negotiation of the complex conflicting issues in a brownfield project requires that each party has feasible options for each conflicting issue (e.g., cost of remediation, extent of liability) and reasonable attitudes towards the other parties. The parties sitting on the negotiation table must interact with one another in order to find a proper direction in the negotiation process, so they should therefore consider the strategic as well as the tactical levels of decision making. The difficulty is that the negotiation of brownfield issues is complicated and the parties involved, such as the current owner, are most likely not familiar with negotiation skills and methodologies. Thus, it is essential to develop appropriate formal negotiation methodologies for the parties involved in brownfield projects (Yousefi et al., 2009 and Yousefi et al., 2007).

Due to the complexity of brownfield disputes, the proposed brownfield negotiation methodologies should assist the decision makers in providing resolutions at both the strategic and tactical levels of decision making. The strategic level assists the parties to find the proper direction for further negotiations and the tactical level provides the parties with specific compromises for each negotiation issue needed to reach an agreed-upon settlement with respect to each negotiation issue.

2.3. Negotiation Support Systems in the Construction Industry

Several cases in the literature discuss the application of Information Technology and Systems (ITSs) in the construction industry: see, for instance, Aouad and Price (1994), Aouad et al. (1996), Ngee et al. (1997); O'Brien and Al-Soufi (1994), and Shash and Al-Amir (1997). They have found that ITSs enable construction activities to be programmed and executed in a speedy and cost-effective manner. Many applications that have been impossible in the past are now feasible, such as a project information management system that can handle tasks like construction programming and information storage and retrieval.

Spreadsheets were among the earliest information management systems that had a profound effect on the widespread use of support systems among construction participants. They have strong features such as their intuitive cell-based structure and their simple interface that is easy to use even for a first-time user. Underneath the structure and the interface are a host of powerful and versatile features, from data entry and manipulation to a large number of functions, charts, and word processing capabilities (Hegazy, 2002). In order to increase productivity and versatility, programmability options, a number of add-in programs, and features that allow Internet connectivity and workgroup sharing, have been also added to newer spreadsheet versions. Because of their wide uses particularly among construction professionals and participants, spreadsheets have proven suitable as a decision support system for developing computer models that require ease of use, versatility, and productivity, such as those for decision support methodologies. For example, a decision support system for construction conflict resolution is developed by Kassab et al. (2006) that uses Ms Excel spreadsheet as the system platform. It should be mentioned that Ms Excel spreadsheets have been applied successfully in many infrastructure applications such as planning and cost estimation for highway projects (Hegazy and Ayed, 1998), Critical Path Method and time-cost trade-off analysis (Hegazy and Ayed 1999), construction delay analysis (Mbabazi et al., 2005), infrastructure asset management (Hegazy et al., 2004), and cost estimation for reconstruction of educational buildings (Yousefi et al., 2008).

Negotiation support systems have recently gained attention in the construction industry. In particular, construction participants have been motivated to benefit from the continual growth in the development of the internet and computer technologies, which has led to increased numbers of electronic negotiation systems. Electronic negotiations are described as processes that involve computer and communication technologies in one or more negotiation activities (Bichler et al., 2003). These technologies include the use of e-mail, internet, world wide web, multimedia, traditional databases, decision support systems, and knowledge-based systems. Table 2.4 summarizes the applications of negotiation systems in the construction industry and some of these efforts are briefly explained below. It should be mentioned that the research efforts summarized in Table 2.4 are based on the available reviewed literature and other related studies can be added to the list.

Table 2.4: Reviewed Literature of Negotiation Systems in the Construction Industry

Authors	Objective	Method	Factors	Comments
Shen et al. (2007)	Obtaining concession period for BOT-type contracts using game theory.	Bargaining-game theory, utility functions.	Players' utility functions, net profit values, time value, bargaining costs and payoffs.	Feasible applications of game theory in construction in which game theory was used to obtain shorter range of concession time period acceptable by both parties.
Molenaar et al. (2000)	Develop a structural equation model framework for quantifying dispute factors between owners and contractors.	Regression analysis as a statistical tool.	Owner management ability, contractor management ability, project complexity, risk, allocation, and project scope definition.	No basic theoretical concepts; only a case study to identify the dispute factors; thus, not a solid work for future research, but good effort to develop a framework for dispute negotiations.
Cheung et al. (2004) (CoNegO)	Assists parties by providing suggested solution for construction disputes.	'Even Swaps' eliminating approach, and tradeoff methodology.	Disputant's issues, Satisfaction graph and rating, the weight of each issue.	Considerable effort to structure negotiation process, but lacks some basic analytical issues for parties such as defining payoff and utility functions for each issue and party.
Ren et al. (2003) (MASCOT)	Develop a multiagent system for construction claim negotiation (MASCOT).	Probability equations and utility functions.	Rational outcomes, and Risk acceptance to the contractor agent (Pc-max) and engineer agent (Pe-max).	Many problems still need to be addressed (the level of empowerment of the MASCOT, the encoding of claim participants' knowledge, and the qualitative claims negotiation), no potential useful research for construction.
Omoto et al. (2002)	Develop bargaining model for construction dispute resolution.	Game theory principles and bargaining model.	Owner's acceptance and/or rejection, and contractor's acceptance and/or rejection.	There are some possible future developments; the basic concept can be used for future applications.
Gibson and Gebken (2006)	Framework for improving project decision making through dispute identification, assessment, and control.	Regression analysis.	Transactional cost, contract amount, original claim, settlement amount.	Transactional costs of dispute resolution efforts are outlined which is a new aspect investigated in the dispute discussion; the concepts can be considered in developing construction negotiation systems.
Yaoyueyong et al. (2005)	Develop an online multiplayer construction negotiation game.	Computer simulation techniques.	Online user database, real-time multiplayer system, online votes, scoring system.	Applying negotiation concepts to be added to the negotiation games; no theoretical basis and mostly computer programming.
Li (1996) (MEDIATOR)	Develop a computer model (MEDIATOR) for construction negotiation.	AI techniques (CBR).	Negotiation issues and goals of both parties, case negotiation adoption.	The model cannot 'recognize' the 'thrown-away' issues and goals at the start of a negotiation; further research effort is needed to investigate the feasibility of implementing this ability; potential future development to use hybrid AI techniques.
Ngee et al. (1997)	Develop a mechanism for negotiation of BOT-type contracts.	Multiple regression analysis.	Financial and contractual factors such as tariff, concession period, and rate of return.	A practical and well-developed negotiation mechanism that can be further developed and adapted for reconstruction and brownfield projects.
Shin (2000)	Identify critical dispute characteristics during construction operations.	Content analysis (qualitative data), and statistical analysis (quantitative data).	Personnel, organization, cost, schedule, risk, environment, contract, time, and budget.	Very well-developed research in developing a framework for dispute knowledge management by converting precedence disputes into a source of knowledge for current dispute identification; further research to refine dispute knowledge management can be pursued.

1) *Shen et al. (2007)* successfully applied bargaining-game theory to obtain detailed concession periods for construction contracts. Game theory principles were used particularly to determine specific time spans between moves. In other words, game theory was employed as a complementary technique for the methodologies that help decision makers with strategic decisions (i.e., to determine a broader range for the concession period). The paper, however, did not consider all the factors (e.g., political, risk attitude, reputation, and contractor's economic condition) that may influence the outcome of bargaining. Nevertheless, with improvements, the technique used in this research has potential benefits for use in the negotiation of construction disputes.

2) *Molenaar et al. (2000)* developed a systematic framework for quantifying dispute factors. The purpose of the research was to explain how and why contract-related construction problems occur: logistic regression was used to model the likelihood of construction disputes arising. This study provides a methodology for quantifying contract disputes. In game theory, these issues are considered in terms of cardinal and quantified values.

3) *Cheung et al. (2004)* developed a construction negotiation support system, namely CoNegO, which assists parties by providing a suggested solution for a construction dispute. In CoNegO, the communication component is the Internet, and the data accessibility component manages the sharing of information. The negotiators first study the construction dispute case and then formulate the

bargaining ranges for each issue using two cardinal values: the pessimistic value represents the baseline of the negotiator with respect to a particular issue (no further concession will be offered beyond this value) and the optimistic value represents the value that produces the highest satisfaction for the negotiator. Negotiators must also determine other parameters for each issue, such as relative importance and satisfaction rating. Although the research provides a valuable approach to a negotiation methodology, it is based on the subjective evaluation of the negotiators. For example, a negotiator may exaggerate his or her position to provide a better negotiation position, or either or both parties may inflate their opening demands, misrepresent their positions or interests, withhold sensitive or potentially damaging information, or use threatening behavior. These issues need to be addressed.

4) *Ren et al. (2003)* developed a system specifically for construction claims called MASCOT that utilizes utility theory. Each party is assigned a linear utility function which can be determined by two points: the optimum point and the reservation point. Each party can then estimate the opponent's utility function based on these two critical points. The proposed methodology was developed based on many constraints and idealized assumptions, including quantitative negotiation, rationality, and fixed utility function. These assumptions decrease the accuracy of the outcomes produced by this system. The research also provides some future work to improve the system.

5) *Yaoyueyong et al. (2005)* developed an online multiplayer construction negotiation game called Virtual Construction Negotiation Game (VCON), as an innovative tool for negotiation training in the construction industry. In their research, the procedure for developing an Internet-based negotiation system is clearly explained, and the ideas can be used in the development of future computer support systems. Development of the VCON game can be classified into four major phases: the identification of game requirements, system design, software development, and system testing. The drawback of this system, as with many other developed systems, is that the behavioral aspects of decision making (negotiating), particularly the changes in the attitudes of the negotiators during the negotiation, are not taken into account.

6) *Li (1999)* designed MEDIATOR a computer system for construction negotiation, which employs a Case-Based Reasoning (CBR) technique to provide intelligent support for construction negotiations. CBR uses previous cases as a basis for addressing new problems. In contrast to conventional expert systems (ESs) that use compiled knowledge in problem solving, the system selects similar cases to help solve a given negotiation problem. The selected cases are then modified and adapted to generate proposals that should move negotiators towards a settlement. The system uses three techniques to modify and transform selected cases in an attempt to generate new proposals: modify the reservation values, introduce new issues and goals, and select additional cases. Although the research tried to use Artificial Intelligence techniques (e.g.,

CBR) in developing a negotiation methodology, there are significant difficulties in using CBR, for example, in collecting previous negotiation cases. Direct collection is difficult because negotiation history is seldom recorded and documented. Hence, it is very difficult to reconstruct and understand how the results of the negotiation were arrived at. Another difficulty in using CBR lies in capturing the original context of a negotiation. In other words, in special economic and political conditions, negotiators may make concessions at any cost in order to win with respect to specific issues. When a negotiation case for a problem is reused in a different economic climate, it is necessary to know the initial context so that it can be adapted consistently. Therefore, one should be cautious in using CBR or other AI techniques that use historical data as input to the model.

The above studies provide important insights into the application of negotiation support systems in the construction industry. A variety of decision-making techniques have been used, and many studies have been carried out in order to make sure that the decision-making models are as accurate as possible. However, the study of available negotiation systems reveals that other aspects of decision making need to be considered. For example, the behavioral characteristics of the involved parties are not formally considered in the dispute negotiation process when many of the negotiation support tools are developed. The attributes of each party play a significant role in modeling a negotiation process since the attitude of decision makers is the most influential psychological aspect that can change the outcome of negotiation. For example, it is vital to consider each party’s attitudes toward risk in order to assign a utility function to the player. Decision-making systems can also be enhanced by integrating the strategic level of decision making with the detailed (tactical) level of negotiation. As Fisher et al. (1991) emphasize, any negotiation takes place at two levels. The first level involves “negotiation of the substantive issues” (e.g., contract price). The next level of negotiation refers to “the procedure for dealing with the substantive issues”. This “upper” level dictates how each side plays the game of negotiation. For instance, one can negotiate by hard positional bargaining, by a cooperative approach, or by another method (Fisher et al., 1991).

The objective for the research in this thesis is the development of a systematic, reliable, and sustainable negotiation methodology that is suitable for application to complex construction disputes and that incorporates the behavioral aspects of construction professionals and participants not only at the strategic level of decision making but also at the tactical level. Because negotiation is an important aspect of decision making, it is, therefore, essential to review decision-making concepts, techniques, approaches, and methodologies in some depth as shown in the remainders of this chapter.

2.4. Decision Making

Decision making is the process of choosing a preferred option or course of action from among a set of alternatives (Raiffa et al., 2002). Decision making permeates all aspects of life: people must decide what to buy, whom to vote for, what job to take, and so on. Decisions often involve uncertainty about the external world (e.g., What will the weather be like?), as well as conflict regarding one's own preferences (e.g., Should I opt for a higher salary or for more leisure?). The decision-making process often begins at the information-gathering stage and proceeds through likelihood estimation and deliberation, until the final act of choosing (Bell et al., 1988).

Engineering decision making can also be grouped into two extreme levels: the strategic level and the tactical level, as shown in Figure 2.3. The flowchart on the left side of Figure 2.3 contains the main factors that must be considered in the selection of a suitable model for an engineering problem. In addition to proper engineering modeling, any alternative solution must be assessed with respect to environmental, economical and financial, and political and social feasibility (Hipel and Fang, 2005). Appropriate techniques from systems engineering and operational research can assist with these evaluations throughout the decision-making process. The top cell on the left in Figure 2.3 indicates that output from all of the analyses provides information to assist decision makers in making an eventual overall decision (Hipel et al., 2007).

The right-hand portion of Figure 2.3 depicts the characteristics that are embodied in the hierarchical framework of the engineering decision-making process. It should be noted that as one moves from the tactical level of decision making to the strategic level, the problem changes from being highly structured and quantitative to being unstructured and qualitative. Hence, the overall problem contains both hard and soft system components.

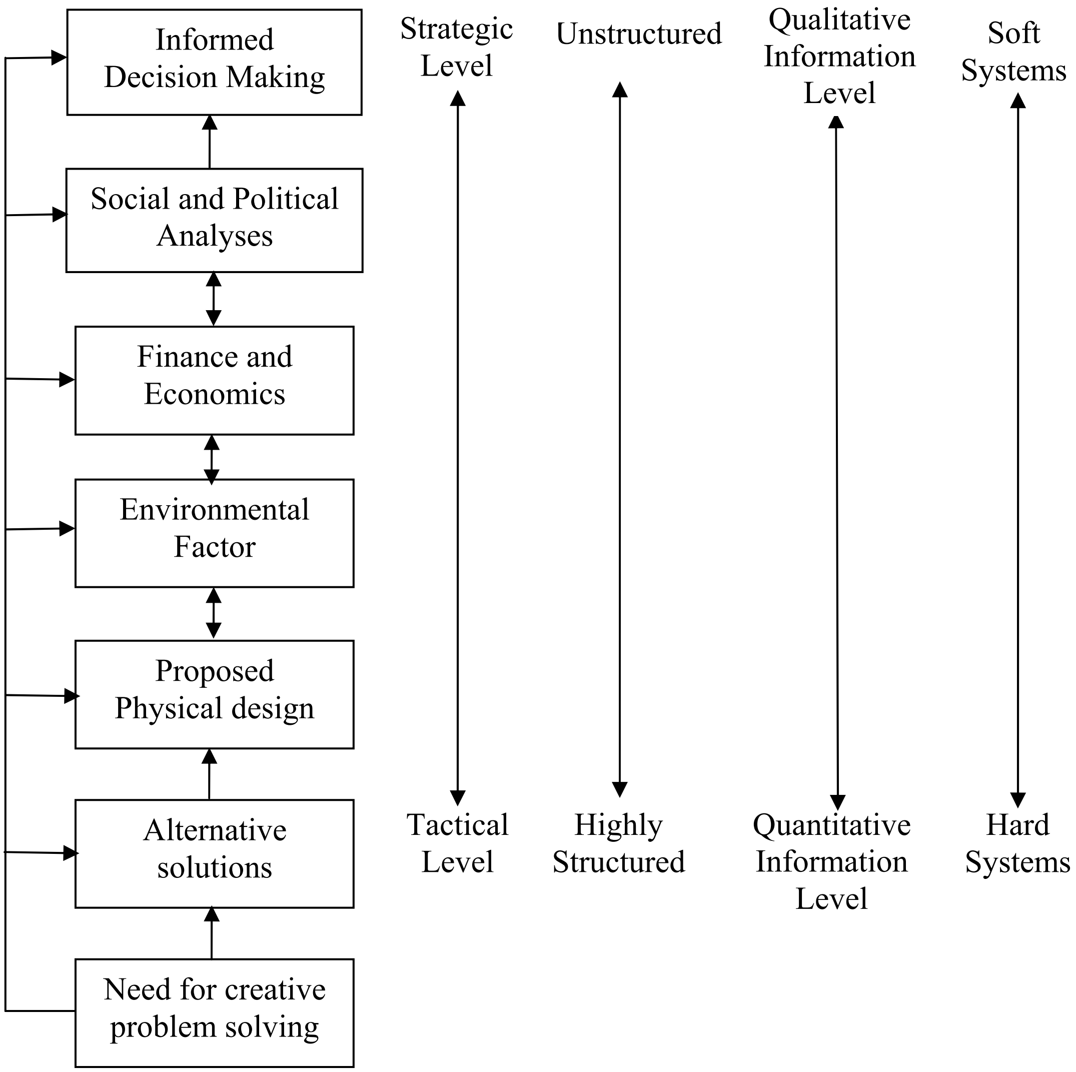


Figure 2.3: Engineering Decision Making (Hipel et al., 2007)

Because of these and other factors, an appropriate set of systems tools must be selected in order to investigate all relevant aspects of the system, or system of systems, being studied. When modeling strategic interactions among decision makers, and information tends to be unstructured and more qualitative, one can employ the Graph Model for Conflict Resolution (Fang et al., 1993).

Another perspective in engineering decision making is the number of decision makers involved in the process of decision making. Raiffa et al. (2002) categorized decision making into plural and individual decision making. Individual decision making includes descriptive, normative, and prescriptive approaches whereas plural decision making consists of “separate and interactive” decision making, known as game theory, and joint decision making which is known as negotiation theory. The categories of decision making are shown in Figure 2.4. It should be noted that in plural decision making, as in individual decision making, descriptive, normative, and prescriptive approaches are all considered.

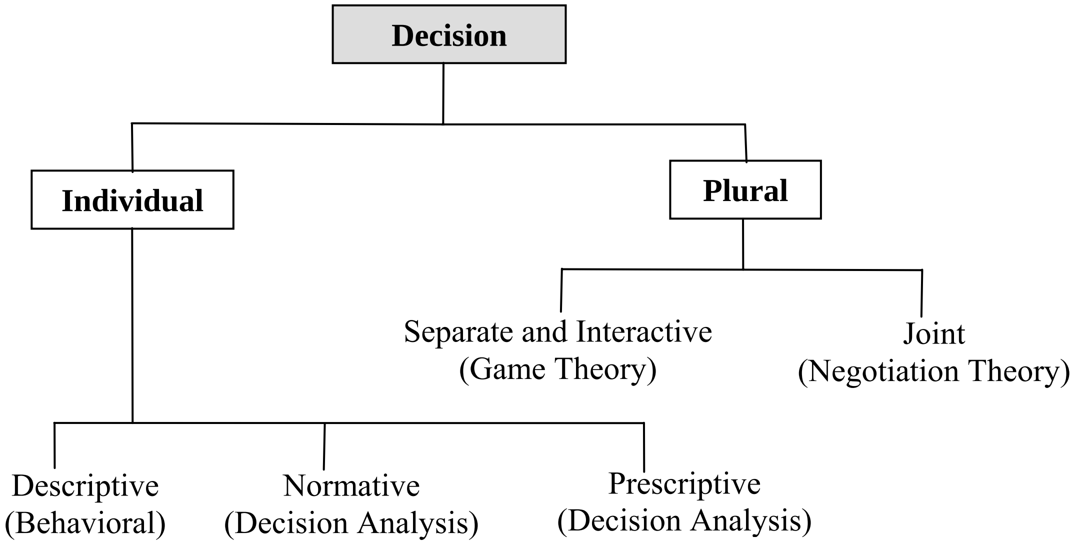


Figure 2.4: Perspectives on Decision Making (Raiffa et al., 2002)

As shown in Figure 2.4, the individual approach to decision making focuses on only one decision maker who is faced with two or more choices whereas in group decision making, two or more decision makers interact to some degree to make their decisions. In both methods, the decision maker strives to make the best decision by using decision analysis tools, techniques, and methods. There are three approaches to a decision making context: descriptive, normative, and prescriptive (Raiffa et al., 2002). Each approach is briefly explained as follows.

1. **Descriptive decision making:** The focus of this approach is how decisions *are* made. The descriptive approach to decision making is based on empirical observation and on experimental studies of choice behavior. It is concerned primarily with the psychological factors that guide behavior in decision-making situations. Experimental evidence indicates that people's choices are often at odds with the normative assumptions of the rational theory (Von Winterfeld and Edwards, 1986). The psychological aspects of decision making are discussed in details in Subsection 2.4.1.
2. **Normative decision making:** This approach concerns how decisions *should be* made, and suggests how idealized and rational people should make decisions. Such analyses do not consider the known cognitive concerns of real people, such as their shifting values, their inability to perform intricate calculations, and their limited attention span. The distinctive characteristics of such normative analyses are coherence and rationality, which are usually captured in terms of precisely specified axioms (Raiffa et al., 2002).

3. **Prescriptive decision making:** This approach focuses on how decisions *could be* made better. The question the prescriptive analyses ask is what a real person can actually do to make better decisions. In seeking to craft useful theory, prescriptive analyses do not take into consideration conceptual ideas and techniques that are useful for idealized, mythical, and super-rational people. Instead, prescriptive proposals must be useful for real people. Because real people are different, good advice has to be tuned to the different needs, capabilities, and emotional makeup of the individuals for whom the prescriptive advice is intended (Bell et al., 1988). Prescriptive advice should be evaluated based on its pragmatic value and its ability to help people make better decision. Advice should also promote an understanding of the problems, confidence in the decisions, justification for the decisions, and satisfaction with the consequences. Prescriptive analysis should be informed by descriptive and normative theories (Raiffa et al., 2002).

2.4.1. The Psychological Aspects of Decision Making

Psychological factors such as human perception, emotion, attention, attitude, and effort are certain to influence decision making. Despite economists' assumptions about the perfect rationality of people when they make decisions, the fact is that people often have faulty intuition about their own motives and behaviors, and they often act to bring about outcomes that they themselves judge to be bad (Kahneman and Tversky, 2000). Psychologically, people experience conflict and behave differently when they face decision making. They often approach decisions as they would problem-solving tasks, trying to gauge the various attributes and come up with compelling arguments for choosing one option over another. At times, a comparison of the alternatives yields compelling reasons to choose one option. At other times, the conflict between the available alternatives is hard to resolve, which can lead the decision maker to seek additional options or to maintain the status quo. This behavior has implications that are not readily apparent: people sometimes need to decide whether to opt for an available option or to search for additional alternatives (Camerer, 1995). Psychological studies of decisional conflict (e.g., Kagel and Roth, 1995; Morley, 1981; Yousefi, et al., 2008; Rabin, 1998) suggest that people are more likely to opt for an available option when they have a compelling reason that makes the decision easy, and that they are tempted to delay the decision and search further when a compelling reason is not readily available and the decision is hard to make. Conflict, on the other hand, plays no role in the classical analysis, according to which a person is expected to search for additional alternatives if the expected value of searching exceeds that of the best option currently available. Important psychological aspects of decision making are summarized in Table 2.5

2.4.2. Attitudes and Utility Theory in Decision Making

Attitude is defined by Krech et al. (1962) as “an enduring system of positive or negative evaluations, emotional feelings and pro and con action tendencies, with respect to a social object”. In other words, the attitude is a preparation in advance of the actual response, and therefore, constitutes an important determination of the ensuing behavior. The attitudes of people significantly influence the outcome of a decision-making process particularly with respect to attitude toward risk. Risk is an uncertainty that matters in which different things matter to different people to a different extent in different circumstances. Risk attitude is the chosen response of an individual or group to uncertainty that matters, influenced by perception. Understanding risk attitude is a critical success factor that promotes effective decision-making in risky situations.

Table 2.5: Major Psychological Aspects of Decision Making

Aspect	Comments
Risk attitudes	The psychological carriers of value are gains and losses, rather than final wealth (Kahneman and Tversky, 1979; Tversky and Kahneman, 1986); diminishing sensitivity yields risk aversion for gains and risk seeking for losses, but this can reverse in the case of very low probabilities, which generally have a non-linear impact on decision (Kahneman and Tversky, 1979; Prelec, 2000).
Loss aversion	People are loss averse. i.e., the loss of utility associated with giving up a good is greater than the utility associated with obtaining it (Tversky and Kahneman, 1991).
Money and mental accounting	People divide wealth and spending into distinct budget categories, such as savings, rent, and into separate mental accounts, such as current income, assets, and future income (Thaler, 1988); also, people find themselves willing to save and borrow (at a higher interest rate) at the same time (Ausubel, 1991).
Emotion	Negative mood increases the perceived frequency of undesirable events (Johnson and Tversky, 1983), and positive mood can lead to greater risk-aversion (Isen and Geva, 1987). People are less sensitive to the probability of occurrence of emotionally powerful stimuli (Rottenstreich and Hsee, 2001), and are willing to pay more to insure emotionally meaningful items (Hsee and Kunreuther, 2000).
Fairness	People care about fairness and cooperation, even in dealing with unknown others when long-term strategy and reputation are irrelevant (Rabin, 1998), and they care about procedural justice often more than about the outcome (Tyler, 2000).

A decision maker who prefers to receive an expected value for certain rather than an uncertain alternative is called *risk averse*, while someone who finds receiving the expected value for certain to be equally preferred to the alternative is called *risk neutral*, and someone who prefers to receive the uncertain alternative rather than the expected value for certain is called *risk seeking*. In order to manage risk attitude, four steps can be considered (Kahneman and Tversky, 1979; Tversky and Kahneman, 1986):

1. *Awareness*: Of how perception of a risky situation will shape risk attitude and behaviour,
2. *Appreciation*: More than understanding, respect for differing views as a basis for engaging and changing if necessary,
3. *Assertion*: Needs and issues will need to be articulated if risk attitude is to change, and
4. *Action*: Willingness to take action and be resilient in the pursuit of goals, beyond ‘good intentions’

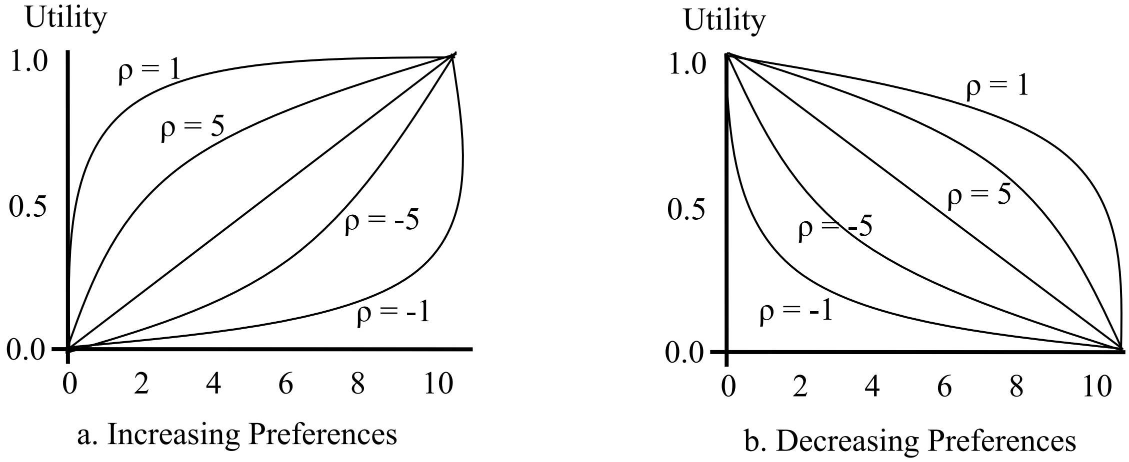
Utility theory is an attempt to infer subjective value, or utility, from choices. Utility theory can be used in both decision making under risk (where the probabilities are explicitly given) and in decision making under uncertainty (where the probabilities are not explicitly given). Extensions of utility theory include subjective probability as well as distortions of probability (Bell et al., 1988). Because utility theory is dealing with preferences, it is often convenient to represent preferences with a utility function and reason indirectly about preferences with utility functions. Therefore, many types of utility functions have been proposed and more discussion in this regard is provided in Chapter 6.

A decision maker's attitude toward risk taking determines the shape of his or her utility function. Knowing that a decision maker is risk averse can substantially restrict the shape of a utility function (Kirkwood, 1997). These varying levels of attitude toward risk can be expressed as exponential functions. The exponential utility function can be expressed as follows (Kirkwood, 1997).

$$u(x) = \frac{\exp[-(x - Low)/\rho] - 1}{\exp[-(High - Low)/\rho] - 1} \text{.............} If \text{...} \rho \neq Infinity$$

$$u(x) = \frac{x - Low}{High - Low} \text{..................................} Otherwise,$$

In the above equations, “Low” is the lowest level of “x” that is of interest, “High” is the highest level of “x”, and “ρ” is the risk tolerance for the utility function. Figure 2.5 shows examples of exponential utility functions for different risk tolerances (ρ). In both parts of this figure, the range of values for the evaluation measure is from Low = 0 to High = 10. Part “a” of the figure shows functions with increasing preferences (e.g., reconstruction profit for a contractor), and part “b” shows functions with decreasing preferences (e.g., cost sharing for the involved parties) (Kirkwood, 1997). In Figure 2.5a, for example, the function shape with ρ = 1 represents a very risk-averse decision maker, whereas the function shape with ρ = -1 represents a very risk-taking decision maker. The unlabeled straight line in the center of each part of the figure corresponds to the case when ρ = Infinity, which means that a decision maker is risk-neutral. Figure 2.5 also shows that as the magnitude of the risk tolerance increases, the utility function becomes more linear.



a. Increasing Preferences

b. Decreasing Preferences

Figure 2.5: Exponential Utility Functions (Kirkwood, 1997)

The above concepts have been also used to develop decision-making support systems. In a research attempt to incorporate the attitude of decision makers to a negotiation system using utility function, Ji et al. (2007) developed an attitude-adaptation negotiation model that assigned a utility function to each negotiator when they interactively negotiate one or several issues in an electric market. To enable agents to adapt their attitudes according to negotiation duration, utility function was constructed on the basis of a history-adaptation strategy and the fixed-attitude strategies were compared by simulation. Also, in another research effort, Zhang et al. (2005) used multi-dimensional utility function to develop a cooperative negotiation mechanism for multi-agent systems. This mechanism uses marginal utility gain and marginal utility cost to structure the negotiation process. The idea of multi-dimensional utility function allows decision makers to negotiate over multiple attributes of the commitments which make it more likely for decision makers to find a solution that increases the global utility by producing more options.

With respect to analyzing and modeling, group decision making is more complicated than individual decision making because decision makers possess different interests, attitudes, goals, and preferences, and each party tries to achieve his or her own interests and objectives. The process of group decision making consists of offers and counteroffers by decision makers in a specific manner which constitutes the dynamics of decision making. Therefore, the study of interactions among decision makers is of key importance in analyzing group decision making. Two broadly defined methodologies have been developed for studying group decision making: game theory and negotiation analysis.

2.5. Game Theory

Game theory is the mathematical study of interactions among decision makers, or players. Known as interactive decision making, game theory is an approach to study how to construct different kinds of games as models of real-world decision problems and how to analyze and interpret them. It has been applied to a broad range of fields, including economics, political science, biology, psychology, linguistics, systems engineering, and computer science (Hipel, 2008 a, b; Hipel and Ben-Haim, 1999; Sage and Rouse, 1999). It should be remembered that in games, as in other models, some details are inevitably missing; however, games are useful since they facilitate the study of some aspects of interactive decisions, while ignoring others. Of course, the model is not the real situation, so what is learned is limited, but often studying the models provides players with surprising insights (Kilgour, 2006). Game theory was initially introduced by Von Neumann and Morgenstern in their book *Theory of Game and Economic Behavior* (Von Neumann and Morgenstern, 1944 and 1953). This section introduces basic game theory, which is referred to in the remainder of this thesis.

2.5.1. Game Theory in Conflict Analysis

Game theory contributes significantly to the study of the various types of conflicts. The application of game theory in conflict resolution is explained in an overview paper by Hipel (2003) and in a series of articles about Conflict Resolution in the Encyclopedia of Life Support Systems (EOLSS) (2002), as well as in two edited books by Hipel (2008 a, b). Figure 2.6 shows the genealogy of formal models for analyzing conflict which are based on a number of underlying assumptions. As shown in Figure 2.6, in the quantitative approach, cardinal preferences are to be determined whereas in the non-quantitative approach, only relative preference information is required. It is very hard sometimes to obtain cardinal preferences for the disputants involved in societal disputes. Therefore, non-quantitative approaches are especially useful for formally studying social and environmental conflicts and disputes because of their inherent qualitative nature. Both quantitative and non-quantitative approaches are described in the following subsections.

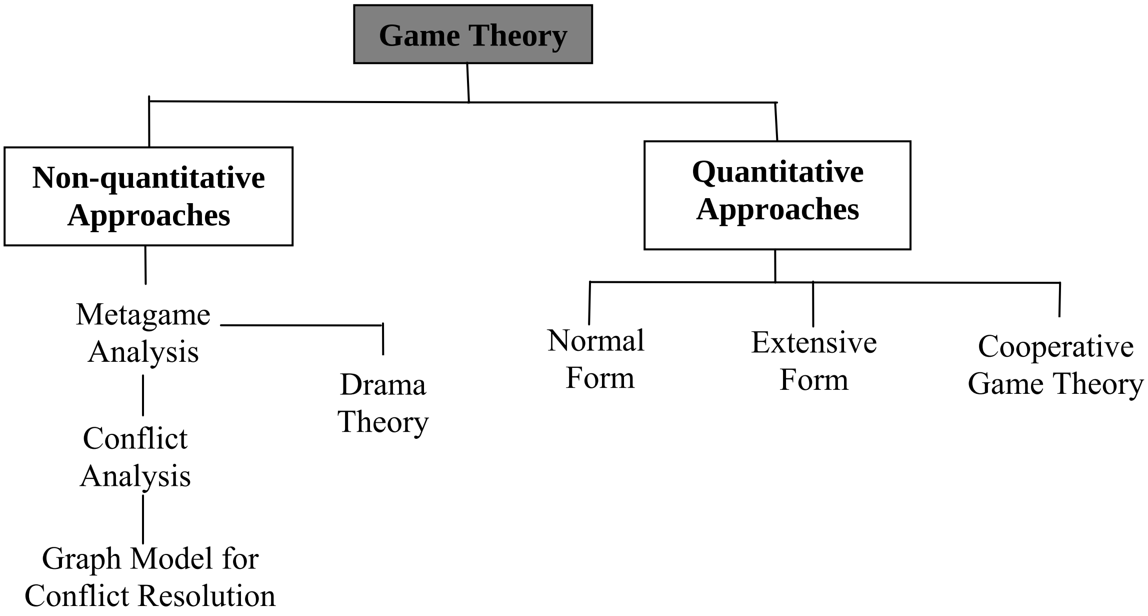


Figure 2.6: Genealogy of Formal Conflict Models (Based on Hipel and Fang, 2005)

2.5.2. Quantitative Approach to Game Theory

Quantitative game theory is broadly divided into two distinct classes: non-cooperative and cooperative games, as shown in Table 2.6. The distinction has to do with the kinds of interacting choices the players make. In non-cooperative games, the general principle is that only those aspects of the players' interaction that are explicitly included in the model are to be taken into account, and players act in their own best interests. In cooperative games on the other hand, not only can players communicate, but they also have access to a reliable and cost-free mechanism, that enables them to make binding agreements at no cost. In other words, the question in cooperative games is not so much whether the players will cooperate, but how they will share the benefits of cooperation (Kilgour, 2006; Von Neumann and Morgenstern, 1953).

Table 2.6: Game Theory Classification (based on Kilgour, 2006)

	Non-Cooperative		Cooperative
	Complete Information	Incomplete Information	
Static	Strategic-Form Games	Strategic-Form Games	Cooperative Games
Dynamic	Extensive-Form Games	Extensive-Form Games	

It is noted that, in the real world, most human interactions lie somewhere between non-cooperative and cooperative, and are usually not at either extreme. However, to analyze and model real-world problems using game theory approaches, it is important to know both extremes, not only because they are relatively easy to formulate and study, but also because the behavior observed, predicted, or recommended at the two extremes is a kind of benchmark for what can be expected in the real world.

2.5.2.1. Concepts and components of quantitative game theory

Conceptually, game theory is in essence interactive decision making that involves a set of individual players who have a specified set of choices and the payoff (utility) to each player depends on the totality of the choices made by all players. Each player must choose, sometimes not knowing the choices of the others. Each player must consider what the others might do and realize that the others are, in turn, considering what the others are thinking. The essence of this perspective is that although the individual players make their choices separately from each other, the payoffs they receive are a function of all players' choices. The expected utility hypothesis is widely accepted in the field of game theory. The hypothesis states that when faced with uncertainty about which outcomes he or she will receive, the player prefers outcomes that maximize his or her expected utility.

Each game is played by a finite set of players. Players may be an entity or a group of people who are economically rational. That is, players can assess outcomes, calculate path(s) to outcomes, and choose actions that yield their most preferred outcomes (Morris, 1994). After the game ends, each player receives a numerical payoff. This number may be negative, in which case it is represented as a loss of the absolute value of the number. To study a game that has psychological payoffs (e.g., happiness, satisfaction, prestige), it is necessary to replace the non-quantitative payoffs with numerical ones (Morris, 1994). A strategy is also a predetermined logic that tells a player which actions to take in response to every possible strategy other players might use and which action should not be taken. Each player in the game faces a choice of two or more possible strategies that must be selected by the player who seeks maximum level of satisfaction for his or her chosen strategy.

2.5.2.2. Cooperative game theory

Cooperative game theory describes only the outcomes that result when the players come together in different combinations. In cooperative games, players can and do communicate and, moreover, have a reliable and cost-free enforcement mechanism that enables them to make binding agreements at no cost. The enforcement mechanism is external to the game (i.e., not explicitly modeled). In cooperative games, the question is not whether the players will cooperate in their common interest, but how they will share the gains of cooperation (Kilgour, 2006).

A game theory approach to bargaining was first introduced by Nash (1950) and Nash (1951), who developed a cooperative and static game model. In a two-person bargaining problem, two players have access to a set of alternatives, which is called the feasible set. It is assumed that each player has preferences over the alternatives and that the preferences are represented by two functions, u_1 and u_2. In the original approach by Nash, as in many later developments, it has been assumed that these utility functions are Von Neumann-Morgenstern utilities. The utility functions, u_1 and u_2, define a subset S of R^2, which is the image of the set of feasible alternatives. Each point of S represents a solution for the bargaining problem that is an agreement between the players. Within the feasible set there is also a point called the threat point or disagreement point (d), which is the point at which the game ends and no agreement can be reached. Therefore, a two-person bargaining problem is a pair (S, d) such that S is convex, closed (i.e., it contains its boundary), and a comprehensive subset of R^2; and $d \in S$, and there exists at least one $x \in S$ such that $x > d$. There are also two main bargaining solutions: the Nash solution and the Kalai-Smorodinski (K-S) solution, which are further explained by Kilgour (2006).

2.5.3. Non-quantitative Approach to Game Theory

Because social conflicts tend to be non-quantitative in nature, many studies have been carried out using techniques listed in the left branch in Figure 2.6. For example, Howard published a pioneering book on metagame analysis (Howard, 1971). Metagame analysis provides a theoretical basis for modeling the dynamic aspects of conflict based on the metaphor of a drama, which is another useful non-quantitative methodology (Howard, 1999; Bryant, 2003). Fraser and Hipel (1984) explain the scope of metagame analysis further in a systematic process called conflict analysis, which provides an analytical and formal platform for developing graph model for conflict resolution (Fang et al., 1993). It should be mentioned that the Graph Model for Conflict Resolution (GMCR) is completely discussed in Chapter 3.

2.6. Negotiation Overview

Negotiation is a process by which two or more parties conduct communications or conferences with a view to resolving differences between them (Cohen, 2002). Negotiation analysis is known as joint decision making. In contrast with cooperative game theory in which the players should achieve mutual benefits and decide how their gains are to be split up, the negotiation analysis involves multiple individuals cooperating to arrive at one joint decision (Kilgour, 2006).

The joint decision entails joint consequences, or payoffs, for each individual. It should be noted that underlying every negotiation structure is a game-like component, and the more one studies negotiations, the more one realizes the artificiality of the borders between the two perspectives (Raiffa et al., 2002). Raiffa also believed that negotiation is considered to be both art and ability. On one hand, negotiation is an art which requires the deliberate application of techniques and strategies aimed at a specific goal. This goal is expressed as the equitable adjustment of an impacted contract based on time and cost. On the other hand, the ability of engineers and managers to negotiate effectively is crucial to the success or failure of the project.

2.6.1. Bargaining and Negotiation

Bargaining is a type of negotiation in which two or more decision makers usually negotiate over only one issue. For example, the buyer and seller of goods or services bargain over the price that will be paid and the exact nature of the transaction that will take place, and eventually come to an agreement. Bargaining thus is an alternative pricing strategy to fixed prices. Decision makers in a bargaining problem can bargain over the objective (e.g., project duration) as a whole at any precise moment in time. The problem can also be divided so that parts of the whole objective become subject to bargaining during different stages. In a bargaining problem, the result is either an agreement between the interested parties or the status quo of the problem. It is clear that studying how individual parties make bargaining decisions is insufficient for predicting which agreement will be reached.

Bargaining can be either cooperative or non-cooperative. Cooperative bargaining refers to the cooperative character of the strategic interaction that takes place in the decision-making process. Most definitions and conceptualizations of cooperation in bargaining are focused on the reaching of an agreement (Myerson, 1991; Young, 1991). In other words, cooperative bargaining is defined as working or acting together willingly for a common purpose or benefit in the presence of conflicting interests (Fearon, 1995; Muthoo, 1999). Therefore, cooperatively bargaining over one issue is one of the important topics in the study of negotiation (Sebenius, 1992). Dunlop (1984) presented four approaches to bargaining:

1. Seek to explain bargaining generally and collective bargaining negotiations in particular.
2. Use experimental or simulated bargaining games in order to determine the bargaining outcomes.
3. Use econometric methods to measure aspects of arbitration or collective bargaining. Public-sector bargaining has been used most often because of the availability of data.
4. Use a word-by-word account of the exchanges from the earliest stages of negotiation to the achievement of a settlement.

2.6.2. Aspects of Negotiation

Negotiation has been studied from different perspectives by many researchers. A summary of aspects of negotiation analysis, investigated by several researchers, is highlighted in Figure 2.7. The arrows in the figure show the relationship between the aspects. For instance, the positional concept of negotiation analysis is related to the hard method of negotiation. These aspects of negotiation analysis are briefly explained below.

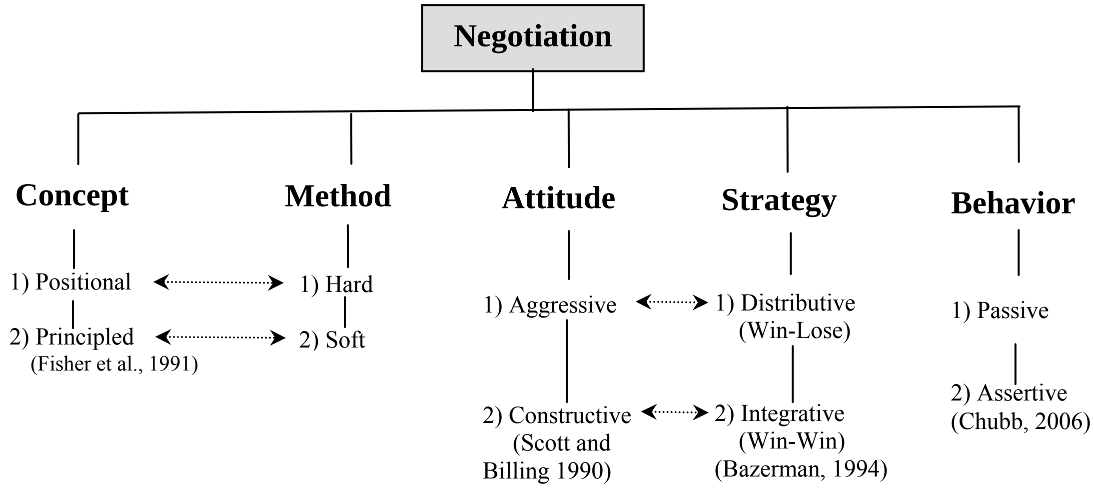


Figure 2.7: Aspects of Negotiation Analysis

Concepts: Negotiation can be explained conceptually as either positional negotiation or principled negotiation. Positional negotiation is essentially adversarial. The negotiators see the process as "win-lose," in which any gains by the opponent are losses on the part of the others. A classic example of this type of negotiation is contract negotiations in the automobile industry. A union tactic in recent years has been to identify one of the "big three" manufacturers, one which is particularly vulnerable to the effects of a strike. This company is then targeted for hard negotiations around a key issue. When neither side yields on the issue, a strike ensues and persists until an agreement is reached or one side collapses under the cost of the strike. Although there might be definite winners and losers in this type of negotiation, it may consequently be beneficial for the parties involved. Principled negotiation, on the other hand, emphasizes that the parties involved look for mutual gains. The theory relies on separating the people from the problem, in an attempt to avoid the human issues that can bias a negotiation (Fisher et al., 1991). Hence, principled negotiation implies a level of disputant rationality. Principled negotiation, as suggested by its title, focuses on the underlying values (or interests) that justify disputants' positions, as opposed to attempting negotiation solely from their positions. Keeney (1992) supported the idea of principled negotiation by proposing value-based negotiation. Value-based negotiation is an alternative negotiation strategy that challenges positional negotiation by proposing that understanding the values disputants place on issues is more important in making decisions than staking out the positions (Keeney, 1992). In value-based negotiation, negotiators try to increase the number of alternatives for resolving the disputing issues and start negotiation by isolating several alternatives to be considered. Fall-back bargaining, for example, is an alternative-based negotiation that focuses on negotiation that produces a prediction about the negotiation outcome (Brams and Kilgour, 2001). Negotiators are begun by insisting on their most preferred alternatives, then falling back, in lockstep, to less and less preferred alternatives until there is an alternative with sufficient support. The outcome of fallback bargaining is a subset of alternatives called the compromise set. This set may be compared to the product of a social choice rule. Another alternative-based algorithm is the Even Swaps method (Hammond et al., 1999), in which disputants commence negotiations by isolating several alternatives under consideration. During negotiation, the preferences of the parties move towards one or a combination of the alternatives. At this stage, it is assumed that the disputants have agreed on an alternative or a group of alternatives to form the basis of a settlement.

Methods: Two methods of negotiation can be distinguished: hard and soft. Hard negotiation strategies emphasize results over relationships. Hard negotiators insist that their demands be completely agreed to and accepted before any agreement is possible. While this approach avoids the need to make concessions, it also reduces the likelihood of successfully negotiating an agreement and usually harms the relationship with the other party as well. Soft negotiation on the other hand, seeks agreement at almost any cost, with the parties offering concessions easily in the interests of preserving (or creating) a good relationship with the other side. Soft negotiators trust the other side and are open and honest about their bottom line. This strategy however, leaves the soft negotiators vulnerable to the hard negotiators who act competitively (Lax and Sebenius, 1992). However, two hard negotiators competing against each other may both lose; hence, the advice to negotiate hard in all cases is not wise. Fisher et al. (1991) suggested that principled negotiation, which negotiates interests rather than positions, is a better alternative than either hard or soft negotiation.

Attitudes: Negotiators' attitudes play an unavoidable role in the outcome of negotiation. Negotiators with aggressive (i.e., negative) attitudes toward other negotiators usually believe in the hard method of negotiation in which concessions are almost non-existent. On the other hand, negotiators who possess constructive (i.e., positive) attitudes are encouraged to follow the soft method of negotiation by making concessions with respect to disputing issues. With constructive attitudes, negotiators share their concerns and interests positively and try to agree on a win-win and mutual solution which would be better than leaving the negotiation table with no resolution of the conflict (Scott and Billing, 1990). In aggressive negotiation, the parties involved often have negative attitudes toward one another and they consider any concession made as a positive improvement for their opponents.

Strategies: Negotiation strategies are divided into two categories: distributive (claiming the pie) and integrative (enlarging the pie of available resources), according to Bazerman (1994). The distributive strategy of negotiation is a zero-sum game; that is, one party's gain results in the other's loss. The strategy for such a negotiation is to predict the bottom line of the other and present an offer that will maximize one's own benefit. Such negotiation usually results in a lower satisfaction level. On the other hand, the integrative strategy promotes cooperation between the negotiators. Because each negotiator has different preferences for each negotiable issue and option, the strategy is not to win on all issues, but to realize which issues the negotiators care most about and make tradeoffs. Such negotiation usually results in a higher satisfaction level (Churchman, 1993; Raiffa et al., 2002).

Behaviors: From the behavioral point of view, there are two types of negotiation: passive and assertive. The characteristics of each type are listed in Table 2.7.

Table 2.7: Characteristics of Behavioral Negotiation (Chubb, 2006)

Passive	Assertive
➢ Energy wasted, ➢ Poor body language, ➢ Apologizing a great deal, ➢ Placing too much emphasis on feelings of others, ➢ Stressed, ➢ Avoiding conflict, and ➢ Considering short-term goals	➢ High energy levels, ➢ Respecting yourself, ➢ High self-awareness, ➢ Ability to make choices, ➢ Confident communication and body language, ➢ Internal integrity, and ➢ Healthy stress

There have been some limited attempts to present negotiation process in complementary elements. For example, Lukas and Lukas (2008) explained that a negotiation process consists of three phases: pre-meeting, meeting, and post meeting. They believed that the pre-meeting phase should include three planning elements as follows.

1. *Strategic planning*: negotiator should identify her/his goals for the negotiation along with information about the opponent’s needs. The negotiator should conduct fact finding and financial analysis;
2. *Tactical planning*: the negotiator should determine the approaches and techniques to use during the negotiation to obtain the best

possible result, help achieve the goals and defend negotiation positions; and

3. *Administrative planning*: the negotiator should ensure that the necessary information is gathered and logistics are resolved before the negotiation begins.

It should be noted that negotiation is only a tool and is useful for resolving some but not all disputes that occur in construction operations. If parties have nothing in common, it is useless to try motivating them to settle their differences and irrelevant if there are no differences to settle. Therefore, negotiation is often a process in which proposals are put forward for the purpose of resolving specific disagreements among two or more parties who have both conflicting and common interests. It should be mentioned that there are situations in construction operations in which negotiations are conducted between involved parties who have no conflict or disputes among one another and they only intend to negotiate over non-disputing issues. These negotiations are not the subject of this research which focuses on developing negotiation methodology for resolving complex disputes in the construction industry.

2.6.3. Modeling Negotiation Processes

There are three approaches to modeling the negotiation process (Kersten, 2005):

1) The outcome-based approach: This type of modeling negotiation can be characterized by the well-known quotation, “Not ‘How?’ but ‘What?’”. Three models are usually considered:

- Game theoretic models in which rationality and known preferences are assumed to be available. All alternatives are known explicitly and the focus is on equilibria (i.e., positions from which no party wants to move).
- Multiple Criteria Multiple Decision (MCMD) models in which multiple outcomes, the representation of preferences, and the aggregation of preferences and outcomes lead to a search for non-dominated solutions with regard to distance measures.
- Negotiation analysis in which prescriptive and descriptive are two common approaches to modeling the problem. Known and fixed utility is also assumed as well as intelligent and goal-seeking action by the other parties. What distinguishes negotiation models from game-theoretic models is that the decision makers are not assumed to be fully rational.

2) Process-based approach: The main question in this approach is how concessions are or should be made. The following scenarios can be modeled using a process-based approach:

- War and political models: history, tradition, successful strategies and tactics rooted in culture;
- Models of human and organizational behavior: reciprocity, fulfillment, attitude;
- Analytical models accounting for time, power, pressure, and cost of the process;
- Simulation models: simulation of parties' behaviors;
- Heuristics and rule-of thumb models; and

- Qualitative process theory: the ability to reason with incomplete information, a framework for the application of more detailed qualitative and quantitative models.

When each of the above scenarios is modeled, several aspects must be considered in the development of the model, including aspiration levels, distributive and integrative bargaining, power, hostility, relationships, opposition, knowledge, foresight, strategies, the formation of tactics, and evolution.

3) Attitude-based approach: The main concern is how to influence or strengthen attitudes. To model a negotiation problem, the following criteria must be considered:

- Cooperation, hostility, relationships, responsibility, and
- Reward systems.

Wertheim et al. (1992) conceptualized negotiation into a step-by-step iterative process, as displayed in Figure 2.8. The flowchart shown in Figure 2.8 helps negotiators choose the most appropriate methods for modeling the negotiation process, as discussed in the preceding paragraph. This diagram however, does not allow issues to be re-evaluated during the negotiation process. It should be noticed that although game theory-based negotiation strategy is still the main branch of the research on strategy, its assumptions about full knowledge of the other parties' preferences are untenable in real life situations (Ji et al., 2007).

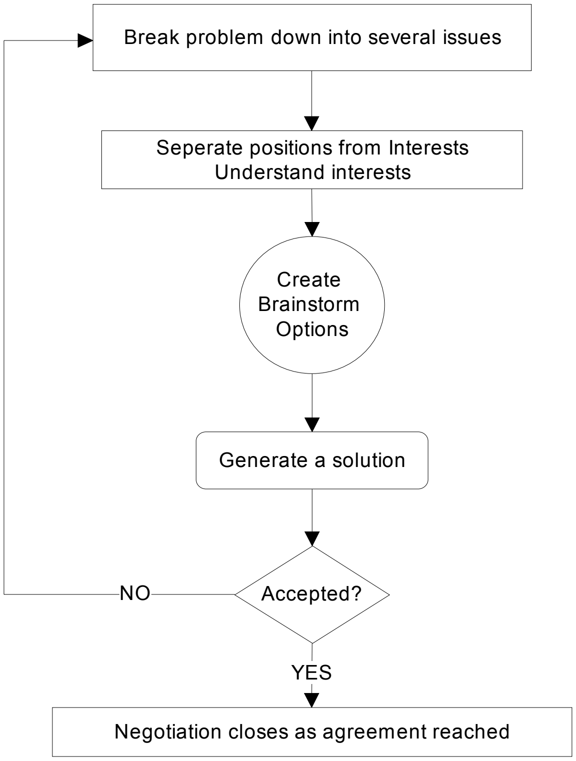


Figure 2.8: Negotiation Process Flowchart (Wertheim et al., 1992)

2.7. Computer Applications to Support Negotiation

Computers and internet have been significantly involved in the development of automated negotiation systems, such as web-based negotiation, E-negotiation, and online dispute resolution systems. These systems allow parties located at a distance to conduct negotiations. A review of current negotiation systems (e.g., Molenaar et al., 2000; Cheung et al., 2004; Ren et al., 2003; Omoto, 2002; Gibson and Gebken, 2006; Yaoyueyong et al., 2005; Li, 1996; Zeleznikow, 2002) reveals that two groups of negotiation systems can be identified:

1) Early Negotiation Support Systems (NSSs), which have been restricted to informing parties about past rounds of negotiation, parties, preferences, and the progress of current negotiation; and
2) Recently-developed Negotiation Decision Support Systems (NDSSs), which have the advantage of incorporating decision-making aspects into negotiation support systems to help decision makers arrive at better negotiation outcomes. They help decision makers overcome the challenges of conventional negotiation through a range of analytical tools that can clarify interests, identify tradeoffs, recognize party satisfaction, and generate optimal solutions (Thiessen and McMahon, 2000). Their aim is to better prepare decision makers for negotiation or to support them during the negotiation process.

2.7.1. Review of Existing Negotiation Support Systems

There have been many research efforts conducted in the area of negotiation support systems due to their important role in facilitating dispute resolution in different communities. The developed negotiation support systems are proposed for resolving disputes in various industries such as manufacturing, financial, and Information Technology (IT). There are also a few negotiation support system developed for resolving family disputes which have different characteristics than of those disputes in the construction industry. The reviewed studies are summarized in Table 2.8.

Table 2.8: A Summary of the Literature about Negotiation Support Systems

Authors	Objective	Method	Factors	Comments
Bellucci and Zeleznikow, 1998 (Family-Winner)	Develop Negotiation Decision Support System (NDSS) for family disputes.	Artificial intelligence techniques.	Types of negotiation strategies, the degree of interdependency of strategies.	Potential benefits for adopting the procedures and developing a new NDSS for the construction industry.
Thiessen, 2000 www.SmartSettle.com	Assists in the preparation and planning stages of negotiation.	Decision process, efficiency frontier graph for each party, even swap approach in eliminating alternatives.	DM's objectives and preferences.	Try to maximize the minimum gain. A valuable source of information in NDSS which uses Smart Choice to arrive at optimal solutions. Commercialized systems and software.
Cheung et al. 2006	Identify relationships between negotiation styles and outcomes.	Multiple regression analysis.	Five styles and seven negotiation outcomes.	A good effort to show which negotiation styles have less influence in achieving functional negotiation outcomes. However, there is no potential for future development.
Kersten, 2002	Provide specifications for E-negotiation systems design and development.	Theoretical-based development, integration of E-negotiation components.	Behavioral, scientific, and engineering aspects of E-negotiation.	No mathematical background, but great analytical integrations which have provided useful contributions for future E-negotiation development, potential use to develop E-NDSS for construction industry.
Kersten, 2001	Internet-based bi-lateral negotiation system using E-mail and web browser (INSPIRE).	uses utility functions to evaluate proposals determined to be Pareto-optimal.	User's preferences, trade-off values, utility graph functions.	Provide valuable insights for designing an online negotiation support system using E-mail, and also applying utility theory in developing the model.
Yuan et al. 1998 (CBSS)	Assists in the preparation and planning stages of negotiation.	Text-based communication, message exchange and editing of common documents.	The objectives and preferences of decision makers.	A fully operational negotiation system which uses text-based for communication.
Bellucci and Zeleznikow, 1998 (AdjustWinner)	Support decision making as its focus is in providing a fair solution.	mathematical manipulation of numeric preferences.	Negotiator's preferences and dispute characteristics.	Can only support a single input stage, developed for family disputes and potentially can be considered for further application in construction projects.
Jarke et al. 1987 (Mediator)	Proposes qualitative solutions.	Artificial intelligent techniques.	Party's objectives and preferences.	Represents a third party in negotiation to offer solutions to both conflicting parties.
Sycara, 1993 (Persuader)	Propose solutions for industrial disputes and disputants.	Artificial intelligent tools, decision theoretic techniques.	Negotiators' characteristics as inputs and predicted solution as outputs of the model.	Carefully applied the AI techniques to develop a negotiation model which can be improved, adjusted, and used in the construction industry.
Matwin et al. 1989 (NEGOPLAN)	labour/contract management negotiations.	Artificial intelligent tools, rule-based method.	Priorities and preferences of each party.	As a commercial software, it can be studied for use in the construction industry; Limitations of AI techniques must be considered.

2.8. Summary

In this chapter, conflict-resolution and decision-making systems and models are reviewed and the concepts, theories, requirements, constraints, methodologies, and techniques in the modeling of decision-making processes were extensively discussed. Conflicts and causes of disputes in construction were briefly explained, and various dispute resolution methods (e.g., arbitration, negotiation, mediation) were presented. Negotiation was presented as the most preferred method for construction participants due to its low cost and low hostility as well as the fact that it provides the parties with more control over their options and outcomes. Group decision-making approaches, such as game theory and negotiation analysis, were explained, and negotiation decision support systems were listed and the characteristics of each system were summarized.

The contents of this chapter will be used and addressed in the development of a negotiation methodology for construction disputes proposed in Chapters 4, 5, 6, and 7. The proposed methodology takes into account the attitudes of negotiators and combines the strategic level of decision analysis with the tactical level of negotiation outcomes. Chapter 3 presents the Graph Model for Conflict Resolution (GMCR) and overviews its modeling and analysis stages. GMCR is used to develop the strategic level of attitude-based negotiation methodology proposed in Chapters 4 and 5.

CHAPTER 3
Graph Model for Conflict Resolution

3.1. Introduction

Finding suitable tools for resolving social and environmental disputes such as brownfield disputes is the objective of many researchers worldwide. They have developed many formal modeling techniques and methodologies for systematically studying conflicts that have two or more decision makers, each of whom can have multiple objectives and interests. In particular, the Graph Model for Conflict Resolution (GMCR) (Fang et al., 1993) is a methodology for modeling and analyzing decision makers' interactions in a conflict in order to find stable states for all decision makers (DMs) which represent feasible resolutions of the conflict at the strategic level. GMCR was originated from conflict analysis (Fraser and Hipel, 1984) which in turn is an expansion of metagame theory (Howard, 1971). The Graph Model utilizes concepts and definitions from graph theory, set theory, and game theory. Each DM's possible moves from one state to other states are captured using a directed graph in which nodes represent states and arcs indicate state transitions controlled by the DM (Hipel et al., 1999). A state is a potential outcome, or scenario, of the conflict. It should be mentioned that most of the contents of this Chapter are taken from Fraser and Hipel (1984), Hipel (2005, 2008 a, b), and Fang et al. (1993).

The associated decision support system GMCR II conveniently implements the Graph Model for conflict resolution and provides speedy, cost-efficient, and accurate advice for the DMs involved in conflict resolution process (Fang et al., 2003a and b). It incorporates the option form for conflict modeling and determines the stability of every state for each DM under a broad range of stability types (Hipel et al., 1997). GMCR II is generally able to predict a variety of equilibrium information, which enhances the analyst's understanding of the conflict and results in useful advice to DMs about whether possible outcomes are strategically stable.

3.2. GMCR Overview

The systematic procedure for applying the Graph Model follows two main stages: modeling and analyzing, as shown in Figure 3.1. In the modeling stage, the problem is structured by determining the DMs, the states, the possible state transitions controlled by each DM, and each DM's relative preferences with respect to the states. In the analysis stage, the stability of each state from each DM's viewpoint is determined. The objective is to find some stable states that represent a resolution of the conflict. The essential parts of a graph model in option form are the DMs and the options available to each DM. In general, a DM may exercise any combination of the options he or she controls to create a strategy. When every DM has selected a strategy, a state is defined.

There may be restrictions on the option choices or changes to the options available to a DM. When these are specified, the feasible states, which constitute the actual set of states in the model, are determined. Often there are logical reasons why a particular combination of options does not represent a feasible state. If so, the combination is removed since it is not a feasible state. The following are the most common types of infeasibility (Fraser and Hipel, 1984):

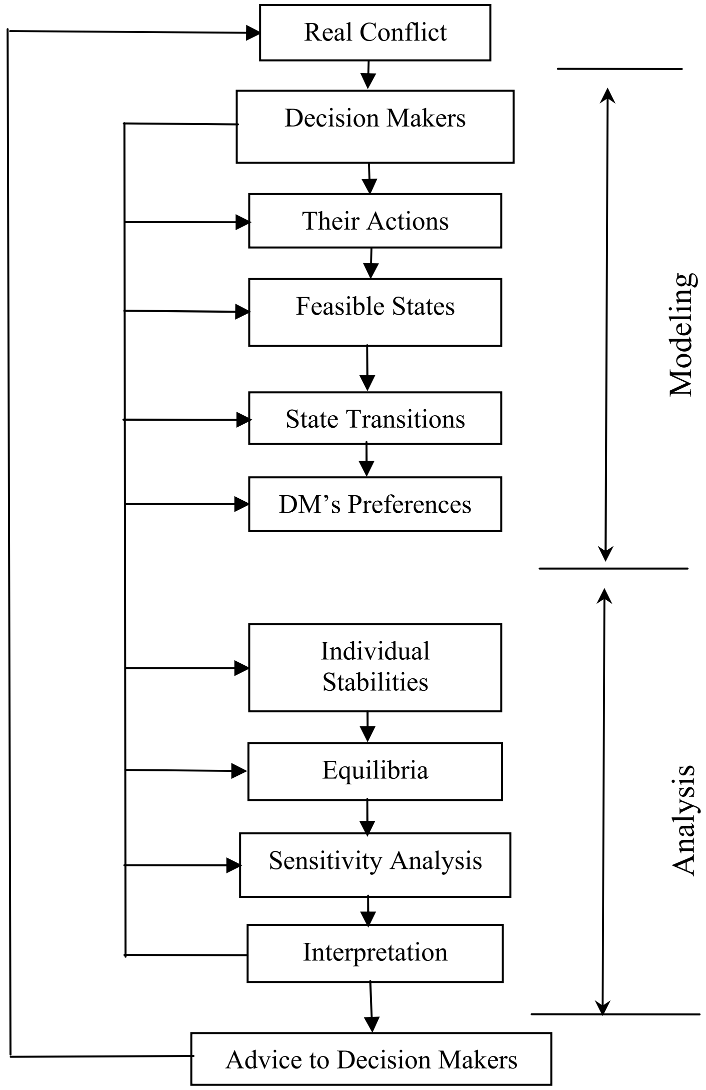


Figure 3.1: Systematic Procedure for Applying GMRC (Hipel et al., 2005)

1. The availability of an option depends on the selection of another option. For example, option “A” can be selected only if option “B” is selected;
2. An option must be taken when another option is taken (i.e., “A” must be taken when “B” is taken, and “A” cannot be taken when “B” is not taken);
3. From a group of options, at least one must be taken; and
4. From a group of options, only one can be taken (mutually exclusive). For instance, option “A” or option “B” or neither can be chosen, but not both.

The state-to-state transitions controlled by a DM are exactly those implied by a unilateral change in the DM’s option selection. These steps produce the usual set of directed graphs, and the graph model is completed by the incorporation of each DM’s relative preferences among the feasible states. Since each DM’s graph has the same set of nodes, it is often useful to show all DMs’ graphs on the same diagram by simply combining them as a single graph and labelling each arc to indicate the DM who controls it. Such a graph is referred to as the integrated graph of the model.

The Graph Model can handle both transitive and intransitive preferences. However, in most real-life conflicts, a DMs’ preferences can be assumed to be transitive and thus expressed as a ranking (ordering) of the states from most to least preferred, in which ties are allowed. Some of the advantages of applying a graph model compared with the classical normal form (Von Neumann and Morgenstern, 1944) include the following: 1) the graph model can handle irreversible moves; 2) it provides a flexible framework for defining, comparing, and characterizing solution concepts; and 3) it can be applied easily in practice.

In GMCR, the set of all states that DM *i* can unilaterally reach from state *s* in one step is the *reachable list (R).* A Unilateral Improvement (UI) from a particular state for a specific DM is a more preferred state (for that DM) to which he or she can unilaterally move in one step. It follows that *R* can be partitioned into three subsets: 1) the set of unilateral improvements from state *s* for DM i, the set of unilateral disimprovements from state *s* for DM i, and the unilateral changes to equally preferred states.

3.3. Stability Analysis

The stability of states for DMs is defined by various solution concepts, or stability definitions as listed in Table 3.1. Nash stability (Nash, 1950, 1951) reflects a DM who thinks only one step ahead. In general metarationality (GMR) (Howard, 1971) and sequential stability (SEQ) (Fraser and Hipel, 1984), a DM considers exactly two steps ahead, whereas in symmetric metarationality (SMR) (Howard, 1971), the DM takes into account three steps by assessing available escapes from any sanctions that may be imposed by the opponents. A disimprovement refers to the tendency of a DM to move to a less preferred state in order to reach a more preferred state eventually, or to block the unilateral improvements of other DMs. In both Nash and sequential stabilities, disimprovements are never permitted, while in general and symmetric metarationality only disimprovements by the opponents for the purpose of sanctioning are allowed. Since different solution concepts may be appropriate for different DMs, states that are stable under many solution concepts are considered to have strong stability. Thus, it is important to consider more than one kind of solution concept for each DM in order to ensure a robust prediction of the conflict resolution.

3.3.1. Definitions of Solution Concepts

A state is considered to be stable for a DM if and only if (iff) that DM is not tempted to move away from it unilaterally. A state is in equilibrium, or is a possible resolution under a particular solution concept, if all DMs find it to be stable under that solution concept. Solution concepts are defined below for the case of two DMs and are summarized in Table 3.1. These definitions can be easily generalized to apply to conflicts involving multiple DMs.

Table 3.1: Solution Concepts Implemented in GMCR (Hipel, 2008a, b)

Stability Type	Description	Characteristics			
		Foresight	Knowledge of Preference	Strategic Risk	Dis-improvement
Nash (R)	Focal DM (decision maker) has no unilateral improvements.	Low	Own	Ignores Risk	Never
General Metarationality (GMR)	Focal DM's unilateral improvements are all sanctioned by subsequent unilateral moves by other DMs.	Medium	Own	Avoids Risk; Conservative	By Opponents
Symmetric Metarationality (SMR)	Focal DM's unilateral improvements are sanctioned, even after responses by the focal DM.	Medium	Own	Avoids Risk; Conservative	By Opponents
Sequential (SEQ)	Focal DM's unilateral improvements are all sanctioned by subsequent unilateral improvements by other Ms.	Medium	All	Takes some Risks; Strategies	Never
Limited-move (L_h)	Focal DM prefers not to move, based on assumption that all DMs act optimally over up to h state transitions.	Variable	All	Accept Risk; Strategies	Strategic
Non-myopic (NM)	Limiting case of limited move stability as the maximum number of state transitions (h) increases to infinity.	High	All	Accept Risk; Strategies	Strategic

1. **Nash stability:** Under the Nash solution concept, a DM will move to a more preferred state whenever possible, regardless of any possible countermoves by the opponent. Hence, a state *s* is Nash stable for DM *i* iff *i* has no unilateral improvements from *s*.
2. **General metarationality (GMR):** A state *s* is general metarational stable for DM *i* iff for every UI *i* can take advantage of, the opponent, DM *j*, can subsequently move to a state that is at most as good for *i* as the original state *s*. In other words, DM *j* can *sanction* each of *i*'s UIs by moving to a state that is less than or equally preferred to state *s* by DM *i*. Therefore, a DM who follows general metarationality selects his or her unilateral moves in light of the opponent's possible reactions, irrespective of the opponent's preferences.
3. **Symmetric metarationality (SMR):** A state *s* is symmetric metarational stable for DM *i* iff not only every UI for *i* from *s* is sanctioned by the opponent, but also no unilateral counter-reply by DM *i* can leave it better off than the original state *s*. It is noted that the above solution concepts are used only for rational or regular stability analysis.
4. **Sequential stability (SEQ):** A state *s* is sequentially stable for DM *i* iff every UI for *i* from *s* is *credibly sanctioned* by the sanctioner DM *j*. A credible sanction is a sanction that directly benefits the sanctioner. In other words, the second possible movement is a UI for the sanctioner. A DM who follows sequential stability takes into consideration not only his or her own possible moves, but also the opponent's unilateral improvements.

When the above solution concepts are used within the paradigm of GMCR it is important to consider the relationship between the proposed solution concepts and the stability of states so that different equilibrium states can be reached. The following theorems are taken into account to determine the stability of a state: *Theorem 1* (Fang et al., 1993)*: For i є N and c є C, if c є* C_i^{Nash} *, then c є* C_i^{SMR} *; if c є* C_i^{SMR} *, then c є* C_i^{GMR} *. Theorem 2* (Fang et al., 1993)*: For i є N and c є C, if c є CNash i , then c є CSEQ i ; if c є CSEQ i , then c є CGMR i .* Then, a state is said to be an equilibrium state for Nash stability, general metarationality, symmetric metarationality and sequential stability, if and only if it is Nash stable, generally metarational, symmetrically metarational, and sequentially stable for all DMs, respectively.

3.4. Sensitivity Analyses

Sensitivity analysis is used to make sure that uncertainty in the DMs' preferences and other model preferences, as well as sudden or unforeseen events cannot affect the robustness of the stability analyses. A sensitivity analysis focuses on the implications of changes in model parameters, by considering, for example, how the preferences of a DM would have to be changed in order to produce more preferable equilibria for another DM. A reasonable range of possible preferences can be analyzed in order to ascertain how equilibria are affected. If the equilibria do not change as preferences are modified, one can have greater confidence in the results of the analysis. Alternatively, when small preference changes produce dramatic equilibria changes, then the analyst must ensure that the model is as accurate and reliable as possible. The following are types of sensitivity analyses:

- Preference changes,
- Option modification or expansion,
- Other decision makers added into the game,
- Consideration of other kinds of human behaviour and attitudes (different solution concepts), and
- Consideration of coalitions.

3.5. Summary

In this chapter, Graph Model for Conflict Resolution was presented and its methodology and involving stages were reviewed. The Graph Model is a promising methodology to model complex conflicts and provide the involved decision makers with potential resolutions at strategic level. Therefore, the Graph Model approach is first improved in Chapter 4 to incorporate the attitudes of decision makers into the Graph Model methodology. Subsequently, the proposed attitude-based Graph Model is utilized to develop an attitude-based negotiation methodology at the strategic level for resolving complex disputes in construction operations. The strategic negotiation methodology proposed in Chapters 4 and 5, will be complemented by a tactical negotiation methodology proposed in Chapters 6 and 7 for two and multiple decision makers, respectively.

CHAPTER 4
Attitude-Based Strategic Negotiation Methodology Involving Two Decision Makers

4.1. Introduction

The primary objective of this chapter is to propose an attitude-based strategic negotiation methodology for resolving complex construction disputes using the Graph Model for Conflict Resolution (GMCR) technique. Because controversies and differences of opinion and attitudes are so pervasive in human decision making, there is a great need for flexible decision technologies to assist in the understanding, modeling, analyzing, and managing of strategic conflicts. The need for such decision methodologies is intensified when human factors, such as attitudes, are added to the consideration of conflict analysis.

This chapter focuses on the strategic level of negotiation, which defines a set of the most beneficial decision options that can be further negotiated at a tactical level discussed in Chapters 6 and 7. This chapter first introduces the proposed negotiation framework for construction disputes. To provide an understanding of construction negotiations, the characteristics of negotiations in construction projects are identified, and the behavior of the parties involved in negotiations is discussed. Attitude-based solution concepts for conflicts in construction projects are then formally defined, and the performance of the proposed attitude-based stability analyses within the paradigm of GMCR is described. The proposed strategic negotiation methodology is systematically developed using a brownfield construction case study in order to clarify the advantages and capabilities of the methodology. Finally, the resulting strategic decision options provided by the methodology are discussed.

4.2. Proposed Negotiation Framework

The proposed negotiation framework consists of three major components which constitute three major stapes (i.e., objectives): 1) understand construction negotiations, 2) develop negotiation methodology, and 3) design a negotiation decision support system. These three components conveniently constitute a systematic negotiation model that consider the strategic as well as the tactical levels of decision making. Each component of the framework also encompasses key subcomponents. A diagram of the proposed negotiation framework is provided in Figure 4.1. This chapter addresses the first component of the proposed framework, as well as the strategic level defined within the second component when only two decision makers (DMs) are involved in the negotiation process.

4.3. Understand Construction Negotiations

Generally, if a negotiation model is to be developed for a specific purpose, it is vital to understand the nature and the characteristics of the problem at hand. To this end, an extensive literature review was carried out in Chapter 2, relevant case study data were obtained, and several meetings were held with construction professionals and participants at Kitchener City Hall. These meetings were useful in a practical sense to identify the key issues involved in construction negotiations, particularly when the municipality is a key DM in a construction conflict. Negotiations in the construction industry are normally studied from three perspectives: the characteristics of construction negotiations (e.g., parties involved, types and number of conflicting issues, and project types), the characteristics of the negotiators (e.g., attitudes, positions, and choices), and the inherent challenges and needs of the decision making. These perspectives are explained in the following subsections.

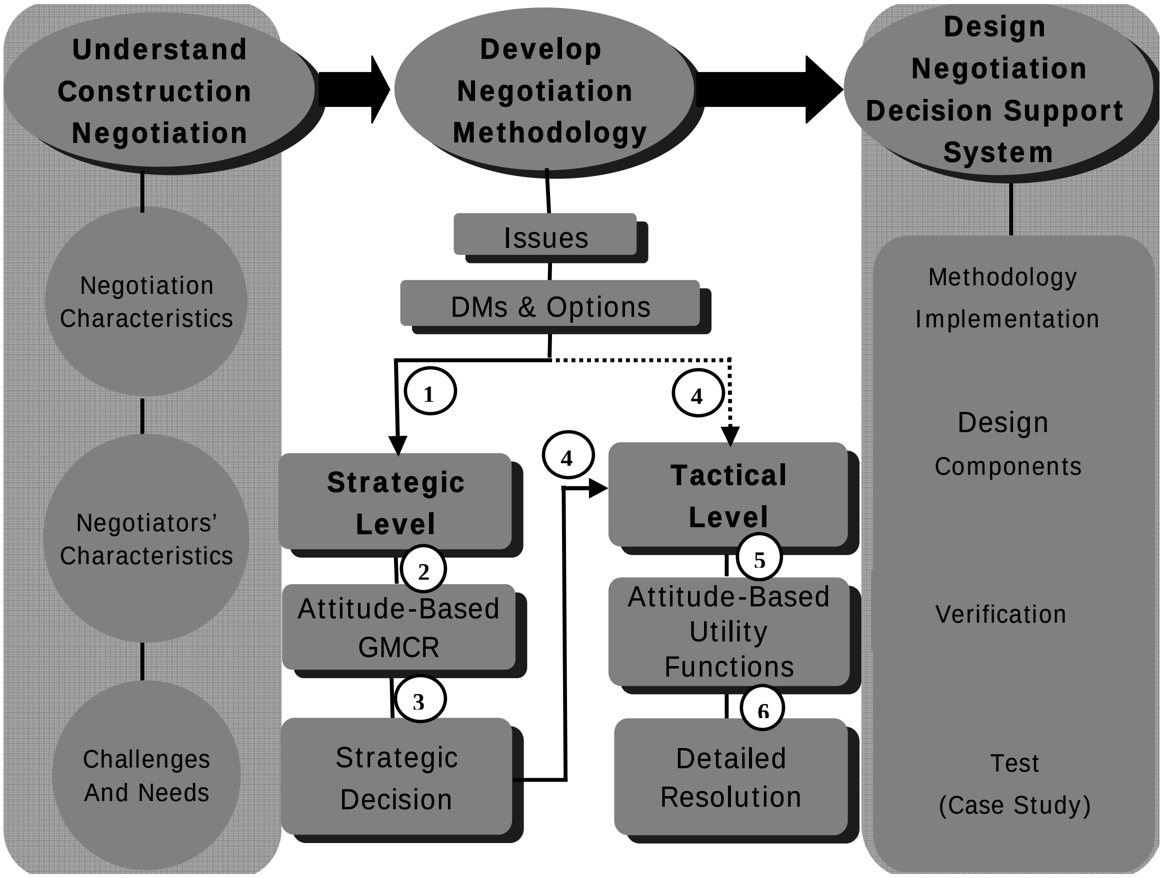


Figure 4.1: Proposed Negotiation Framework

4.3.1. General Negotiation Characteristics

With respect to negotiations for resolving construction disputes, the following characteristics reflect the series of factors construction participants consider when negotiations take place (Pena-Mora and Wang, 1998):

A) *Domain-dependent knowledge*: Participants in construction operations are normally experts in only one domain of knowledge and, as such, often know little about other domains. For example, architects are experts in the aesthetics of structures whereas engineers have experience in the design and analysis of structures. Each group views a project from its own perspective. Therefore, none of the involved participants has an in-depth global view of all knowledge domains (Odeh and Battaineh, 2002). The unfamiliarity with other knowledge domains within projects can cause disagreement when conflicts arise and may hinder the finding of a common meeting ground for the participants.

B) *Competitive-cooperative environment*: In the construction industry, disputes are dealt with according to the objectives of the project and the participants. The participants (rationally) have the common goal of successful project completion because it ensures a profit for all. If the project fails, some or all of them will lose because not only will they not profit from the project but they will also be liable for its failure. Consequently, they are willing to cooperate with each other in order to finish the project on time and within the budget (Hegazy, 2002). At the same time, they will also try to maximize their own profits at the expense of the other parties, thus departing from the cooperative nature of the construction team. This competitive-cooperative environment has an impact on the participants' strategies and, subsequently, on the outcomes of the negotiation.

C) *Strategy-influenced outcome*: Because of the competitive-cooperative nature of construction work, the DMs involved try to maximize their gain without losing cooperation (Fellow et al., 1994). They take a course of action (called a strategy) that influences the outcome of the negotiations. Since a competitive-cooperative condition exists throughout the project's life cycle, these strategies are employed frequently and have a strong influence on the outcome of negotiations. The most common strategy and the one most easily used by participants is domain-dependent knowledge. Participants can influence the outcome of the issues related to their specialty by exaggerating their contributions without being held fully accountable because others are not fully familiar with the issues. This domain-dependent barrier can prevent participants from fully realizing the situation that any other participant faces. Bringing in an expert in a given area to inform teams who are unfamiliar with the issues can prevent the use of this strategy. However, the complexity of the problem increases as more people become involved in the negotiations and their preferences must also be considered. Therefore, given the competitive-cooperative nature and the prevalence of domain-dependent barriers, using a manipulative strategy is common in construction particularly when the involved DMs have aggressive behavior and negative attitudes toward one another (Walton et al., 2000).

4.3.2. Negotiators’ Characteristics

The participation of people in the construction industry, such as the owner, the government, the contractor, and the stakeholders, depends on their position. When conflicts and disputes arise, the DMs involved use different strategies to maximize their benefits during the negotiation process (Essex, 1996). The DMs involved in construction projects will certainly have different attitudes about different projects and will try to prioritize the conflicting issues that are common in projects (Heng, 1996). For example, the two main conflicting issues between the owner and the contractor are usually time extensions and cost overruns, and both DMs know their own advantages and disadvantages with respect to these issues. The contractor knows his costs exactly, can adjust prices for the maximum revenue, and can accept or reject a settlement. The owner, on the other hand, has a strong advantage in that he owns the project and controls the money. The owner is, however, bound by the procurement rules, regulations, and approvals put in place by the government. The contractor has a larger degree of freedom in making his proposal and accepting a settlement and thus, he has the advantage of setting the pace and direction of the negotiation (Levin, 1998).

4.3.3. Challenges and Needs

The construction industry is facing increasing challenges due to the growing complexity of the design, construction, operation, and maintenance stages. Such complexities boost the level and the number of risks and uncertainties involved in construction operations. Moreover, construction projects are often behind schedule or have cost overruns and the DMs involved prefer to blame other DMs for construction delays (Hegazy, 2002; Glasner, 2000). These challenges can increase the possibility of conflict among participants and also influence the decision-making process, particularly with respect to conflict negotiation. Construction negotiations are more challenging because the participants lack negotiation skills and they belong to different knowledge-dependent domains (Mnookin et al., 2000). These challenges can significantly hinder the progress of construction projects, and they must therefore be appropriately addressed in any effective decision-making methodology. Models that address these challenges will better mimic the societal activities of those participating in conflict resolution.

Table 4.1 summarizes discussions in Subsections 4.3.1, 4.3.2, and 4.3.3 with respect to a brownfield reconstruction case study. Table 4.1 points out the characteristics of the parties involved in a brownfield redevelopment project when they intend to negotiate conflicting issues, such as redevelopment costs. These characteristics have been compiled based on previous studies (e.g., Stipanowich, 1997; Fellow et al., 1994; Odeh and Battaineh, 2002) and several meetings with the consultants, researchers, and representatives of the City of Kitchener, located in southern Ontario, Canada, who are concerned with Kitchener’s brownfield sites. It should be noted that the types and number of parties involved in a construction project depend on the type of project. Although contractors are often involved in negotiations in many situations, such as in brownfield projects, initial negotiations normally take place between the current property owner and the government; the contractor may be hired later. In the brownfield case study used in this chapter, it is assumed that the two DMs involved are the current property owner and the government, who are both directly concerned about the costs and duration of the project. In future research, a purchaser may be included later in the process. This case study will be also used to systematically develop the proposed negotiation methodology as explained in the following sections.

Table 4.1: Negotiators' Characteristics in Brownfield Reconstruction

Party	Characteristics
Owner	• Lack of funds or the will to cleanup the contaminated property, • Expects government help in marketing the land, • Wants to share its liabilities for cleanup through negotiation, • Sometimes refuses to cooperate when the owner must clean the land, • Avoids revealing his or her identity, • Tries to understand the concerns of the perspective purchaser, • Very concerned about the costs of redevelopment, and • Not concerned about the future risk of site contamination.
Purchaser	• Prefers to have environmental testing and certificate, • Wants to receive incentives from other parties, • Takes into account the preferences and interests of the owner, • Considers other options for investments, • Very concerned about the risks of buying the property, • Usually one purchaser is considered in buying the contaminated property, and • Considers time and cost of redevelopment and responsibilities of future contamination not caused by purchaser.
Government	• Provides available resources of municipalities to make a deal among parties, • Has fair working relationship with both the owner and the purchaser, • Plays key role to initiate negotiation process in various phases, • Provides inducements for both the owner and the purchaser, • Wants to have contaminated property cleaned and redeveloped, • Considers private-owned brownfield sites as being different from public-owned brownfield sites, • Uses reactive approach to deal with brownfield problems, • Has concerns about the justification of the resources used for brownfield redevelopment, • Tends to be more risk averse, and • Non-remedied contamination is his key future concern.

4.4. Attitude-Based GMCR

Based on the previously discussed characteristics of construction negotiations, the development of the proposed negotiation methodology involving only two DMs at the strategic level is described in the remainder of this chapter, while the development of the proposed methodology involving two DMs at the tactical level, which complements that at the strategic level, is explained in Chapter 6.

At the strategic level, the proposed methodology uses the Graph Model for Conflict Resolution, (GMCR) with its powerful modeling and stability analysis stages. GMCR (Fang et al., 1993) is a comprehensive systems engineering technique that provides strategic advice to a negotiator through a prescription for actions that will achieve his or her preferred outcome. It also suggests to a mediator which possible resolutions of the conflict would be stable and reveals to a policymaker how the strategic structure of the situation shapes the outcome. This strategic advice reflects the capacity of GMCR to identify individually stable states and equilibria. It should be noted that GMCR is intended to be used prescriptively to advise a negotiator in a negotiation round rather than descriptively or normatively to predict which choices will be made or to determine which choices “should” be made (Kilgour, 2007).

4.4.1. GMCR Formal Definition

Formal definition of Graph Model for Conflict Resolution (GMCR): A graph model of a conflict is a 4-tuple $(N, C, (S_i)_{i \in N}, (\geq_i)_{i \in N})$. N is the set of all (DMs). C is the set of all states of the focal decision making situation, where $|C| \geq 2$. For $i \epsilon N$, S_i is a function from C to the power set P(C) of C such that $c \notin Si(c) \epsilon P(C)$ for all $c \epsilon C$. S_i is called the irreflexive reachable list function of DM $i \epsilon N$ and $S_i(c)$ is called the irreflexive reachable list of DM $i \epsilon N$ from $c \epsilon C$. $\geq_i$ is the preference of DM $i \epsilon N$ on C. Defining E_i as the set $\{(c, c') \epsilon C \times C \mid c' \epsilon S_i(c)\}$, there is the graph (C, E_i) of DM $i \epsilon N$, denoted by G_i, where C is the set of all vertices of the graph and E_i is the set of all arcs of the graph (Fang et al., 1993).

For $i \epsilon N$ and $c, c' \epsilon C$, $c \geq_i c'$ means that c is more or equally preferred to c' by DM i. $c \sim_i c$ means that $c \geq_i c'$ and $c' \geq_i c$, that is, c is equally preferred to c' by DM i. $c >_i c'$ means that $c \geq_i c'$ and “not $(c' \geq_i c)$” that is, c is strictly more preferred to c' by DM i. DM i’s preferences $\geq_i$ is said to be transitive, if and only if for all c, c' , c'' ϵC, if $c \geq_i c'$ and $c' \geq_i c''$ then $c \geq_i c''$.$\geq_i$ is said to be anti-symmetric, if and only if for all $c, c' \epsilon C$, if $c \geq_i c'$ and $c' \geq_i c$ then $c = c'$. $\geq_i$ is said to be complete, if and only if for all $c, c' \epsilon C$, $c \geq_i c'$ or $c' \geq_i c$ (Fang et al., 1993).

4.4.2. Attitude Representation

In construction conflicts and disputes, the attitudes of construction participants can affect the outcome of their negotiations. Therefore, analyzing the conflict as well as the accompanying attitudes of the DMs is useful for a better understanding of the negotiation process. It is also beneficial to model DMs’ attitudes and incorporate them into construction negotiation methodology so that the influence of DMs’ attitudes can be examined.

In this research, three types of attitudes are proposed, that is, positive, negative, and neutral attitudes in which a DM's attitudes toward her/himself as well as toward others are considered. Moreover, it is assumed in this research that positive, negative, and neutral attitudes of a DM toward others derive "altruistic", "sadistic", and "apathetic" behaviors, respectively, and those toward her/himself derive "selfish", "masochistic", and "selfless" behaviors, respectively (Inohara et al., 2008). Table 4.2 shows these assumptions on the relationships between attitudes and DMs' behavior. These assumptions imply that a DM modeled in this research is not "rational" in the classical game-theoretic sense, but is consistent with those of DMs' emotions in the 'soft' game theory (Howard 1990; Howard 1998), drama theory (Bennett and Howard 1996; Howard 1994 - Parts 1 and 2), and confrontation analysis (Bennett 1998).

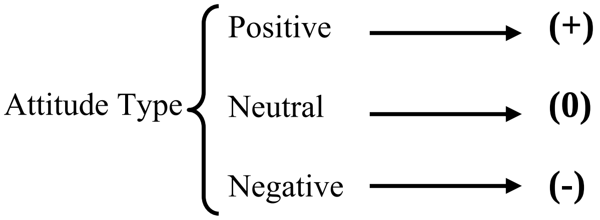
Table 4.2: Assumptions on Relationships between Attitudes and Behaviors (Inohara et al., 2008)

Attitudes		
Types	**Toward Others**	**Toward her/himself**
Positive	Altruistic	Selfish
Negative	Sadistic	Masochistic
Neutral	Apathetic	Selfless

This research proposes a negotiation methodology that incorporates the attitudes of the DMs into the methodology at both the strategic and tactical levels. It represents a major contribution and expansion of GMCR: combining attitudes within the paradigm of GMCR furnishes a flexible analytical tool which reflects how the DMs' attitudes may change the strategic outcomes of the negotiation. The range of definitions for attitudes in this section follows those defined by Inohara et al. (2007).

4.4.3. Formal Definition of Attitude

In this research, three basic types of attitude are defined and used to develop the negotiation methodology. A DM's attitude is defined toward him/helself as well as toward other DMs involved in negotiation.



In order to formally define attitude, at least two decision makers "DM i" and "DM j" should be considered. For DMs i, j ϵ N, let $E_i = \{+, 0, –\}^N$ represent the set of attitudes of DM i. An element $e_i \epsilon E_i$ is called the attitudes of DM i for which $e_i = (e_{ij})$ is the list of attitudes of DM i toward DM j for each j ϵ N where $e_{ij} \epsilon \{+, 0, –\}$. The e_{ij} is referred to as the attitude of DM i to DM j where the values $e_{ij} = +$, $e_{ij} = 0$ or $e_{ij} = –$ indicates that DM i has a positive, neutral, or negative attitude toward DM j, respectively.

According to the above definition, the attitudes of the DMs can be represented in a matrix format, as shown in Table 4.3 in which each cell entry can take on a value of ‘+’, ‘0’ or ‘–‘. For example, for a rational game between two DMs (DM ‘o’: owner; DM ‘g’: government) in which it is assumed that each DM decides rationally, the attitude matrix is represented as displayed in Table 4.4. As can be seen, the owner and the government are positive toward themselves since e_{oo} = + and e_{gg} = + and neutral toward each other (e_{og} = 0 and e_{go} = 0). Such type of attitude matrix represents regular or rational attitudes of two DMs.

Table 4.3: Tabular Representation of Attitudes (Inohara et al., 2007)

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

Table 4.4: Attitudes of DMs ‘o’ and ‘g’ in a Regular Analysis

DM	o	g
O	$e_{oo} = +$	$e_{og} = 0$
G	$e_{go} = 0$	$e_{gg} = +$

4.4.4. Attitude-Based Solution Concepts

The solution concepts presented in Chapter 3 (Subsection 3.3.1) are referred to as “rational” or regular solution concepts since the DMs do not consider the various attitudes of other DMs. These solution concepts are now refined and expanded to explicitly account for the DMs’ attitudes and, hence, are appropriately called attitude-based or “relational” solution concepts. Prior to providing these stability definitions, a range of preference structures and special types of movements among states are defined (Inohara et al., 2008). According to the attitude tables shown in Table 4.3, corresponding moves among the decision states can be one of the following possibilities:

Devoting Preference (Positive Attitude): The devoting preference (DP) of DM i ϵ N with respect to DM j ϵ N is $\geq_j$, denoted by DP_{ij}, such that for s, t ϵ S, "s DP_{ij} t" if and only if s $\geq_j$ t. In other words, the devoting preference means that if DM i has a devoting preference for state s with respect to state t for DM j, then DM j must prefer state s to state t. For example, if an owner has devoting preference or positive attitudes toward a contractor in a construction negotiation, and the contractor prefers state 2 to state 5, then the owner also prefers state 2 to state 5. A similar definition can be written for aggressive preference.

Aggressive Preference (Negative Attitude): The aggressive preference (AP) of DM i ϵ N with respect to DM j ϵ N is NE($>_j$), denoted by AP_{ij}, where NE($>_j$) is defined as follows: for s, t ϵ S, s NE($>_j$) t if and only if "s $>_j$ t" is not true. That is, for s, t ϵ S, s AP_{ij} t if and only if s NE ($>_j$) t (if and only if t $\geq_j$ s under completeness of $\geq_j$). In contrast to the devoting preference, the aggressive preference means that if DM i has an aggressive preference for state s with respect to state t for DM j, then DM j must prefer state t to state s. Using these concepts, as well as an indifference preference represented by I, the relational preference can then be determined. For example, if an owner has aggressive preference or negative attitudes toward a contractor in a construction negotiation, and the contractor prefers state 2 to state 5, then the owner must prefer state 5 to state 2.

Using these attitude-based possible moves, the following attitude-related terms are defined and used in the stability analysis within the structure of GMCR:

Relational Preference (RP): The relational preference $RP(e)_{ij}$ of DM i є N with respect to DM j є N at e is defined as follows:

$$RP(e)ij = \begin{cases} DP_{ij} & \text{if} \quad e_{ij} = + \\ AP_{ij} & \text{if} \quad e_{ij} = - \\ I_{ij} & \text{if} \quad e_{ij} = 0 \end{cases}$$

In the above equation, I_{ij} indicates that DM i is indifferent with respect to j's preference, and hence, s I_{ij} x means that DM i's preferences between state s and x is not influenced by DM j's preference. Here, the types of preferences are matched with the three different attitudes. What this means is that if DM i has a positive attitude toward DM j, DM i will have a devoting preference with respect to DM j. If DM i has a negative attitude toward DM j, DM i will have an aggressive preference with respect to DM j. Thus, a DM behaves according to his or her attitudes.

Total Relational Preference (TRP): The total relational preference of DM i є N at e is defined as the ordering of $TRP(e)_i$ such that for s, t є S, s $TRP(e)_i$ t if and only if s $RP(e)_{ij}$ t for all j є 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 toward all of the DMs in the conflict. Thus, if state s is a total relational preference of DM i relative 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.

Total Relational Reply (TRR): The total relational reply list of DM i є N at e for state s є S is defined as the set {t є R_i(s) U {s} | t TRP$(e)_i$ s} ⊂ R_i(s) U {s}, denoted by TRR$(e)_i$(s).

Relational less preferred or equally preferred states: RΦ$(e)_i$ (s) is the set of all states which are "relationally less or equally preferred" to s by DM i (under attitude e). It should be noted that NE(x TRP$(e)_i$ s) means that "x TRP$(e)_i$ s" is not true. The same concept is defined for rational $Φ_i$ (s).

It should be mentioned that the above attitude-based definitions are used in this research for the first time to develop an attitude-based negotiation methodology for resolving complex disputes among participants involved in the construction industry. Employing the above proposed definitions, attitude-based solution concepts can be defined as an extension of rational solution concepts when attitudes are taken into account. Table 4.5 displays rational and attitude-based solution concepts within the structure of GMCR. In Table 4.5, "N" is the set of DMs, $R_{i(s)}$ is the DM i's reachable list, and $R^{+}_{i(s)}$ is the DM i's unilateral improvement list. Attitude-based general metarationality (RGMR) is best described as a situation in which a DM makes a unilateral move and opposing DMs sanction that move with moves of their own. In RGMR, these sanctioning moves do not have to be total attitude-based replies by the other DMs; they only have to be possible moves by the sanctioning DMs. As in the case of RGMR, the sanctioning moves need be only possible moves by the other DMs and do not have to be either credible or relational. Sequential stability also occurs when one DM makes a move according to his or her total attitude-based reply list, and opposing DMs can sanction the move by moving to a state in their total attitude-based reply lists.

Table 4.5: Rational and Attitude-Based (Relational) Solution Concepts in GMCR

Solution Concept	No Attitude (Rational)	Attitude-Based (Relational)
Nash Stability	Nash: For i ϵ N, state s ϵ S is Nash stable for DM i, denoted by $s \epsilon S_i^{Nash}$, if and only if $R_i^+(s) = \Phi$	RNash: For i ϵ N, state s ϵ S is attitude-based Nash stable at e for DM i, denoted by $s \epsilon S_i^{RNash(e)}$, if and only if $TRR(e)_i (s) = \{s\}$.
Description	Decision maker cannot move to a more preferred state.	
Sequential Stability	SEQ: For i ϵ N, state s ϵ S is sequential stable for DM i, denoted by $s \epsilon S_i^{SEQ}$, if and only if for all $x \epsilon R_i^+(s)$, $R^+_{N\backslash\{i\}}(x) \cap \Phi_i(s) \neq \Phi$	RSEQ: For i ϵ N, state s ϵ S is attitude-based sequential stable at e for DM i, denoted by $s \epsilon S_i^{RSEQ(e)}$, if and only if for all x ϵ TRR(e)i(s) \ {s}, $TRR(e)_{N\backslash\{i\}}(x) \cap R\Phi(e)_i(s) \neq \Phi$
Description	All decision makers' improvements are sanctioned by subsequent moves by others	
Symmetric Metarationality	SMR: For i ϵ N, state s ϵ S is symmetric metarational for DM i, denoted by $s \epsilon S_i^{SMR}$, if and only if for all $x \epsilon R_i^+(s)$, there exists $y \epsilon R_{N\backslash\{i\}}(x) \cap \Phi_i(s)$ such that $z \epsilon \Phi_i(s)$ for all $z \epsilon R_i(y)$.	RSMR: For i ϵ N, state s ϵ S is attitude-based symmetric metarational at e for DM i, denoted by $s \epsilon S_i^{RSMR(e)}$, if and only if for all $x \epsilon TRR(e)_i(s) \backslash \{s\}$, there exists $y \epsilon R_{N\backslash\{i\}}(x) \cap R\Phi(e)_i(s)$ such that $z \epsilon R\Phi(e)_i(s)$ for all $z \epsilon R_i(y)$.
Description	All decision makers' improvements are still sanctioned even after a possible response by the original decision maker to sanctioning.	
General Metarationality	GMR: For i ϵ N, state s ϵ S is general metarational for DM i, denoted by $s \epsilon S_i^{GMR}$, if and only if for all $x \epsilon R_i^+(s)$, $R_{N\backslash\{i\}} \cap \Phi_i (s) \neq \Phi$	RGMR: For i ϵ N, state s ϵ S is attitude-based general metarational at e for DM i, denoted by $s \epsilon S_i^{RGMR(e)}$, if and only if for all $x \epsilon TRR(e)_i(s) \backslash \{s\}$, $R_{N\backslash\{i\}}(x) \cap R\Phi(e)_i (s) \neq \Phi$
Description	All decision makers' improvements are sanctioned by subsequent unilateral moves by others.	

With respect to attitude-based stability analysis, DMs may have different attitudes toward each other. According to Table 4.2, DM i may have a positive, negative, or neutral attitude toward herself or her opponent, DM j. That is, each cell in

Table 4.2 can take one of the three possibilities (+, –, 0). Because there are only two DMs, four cases represent the DMs' attitudes toward themselves and each other. Accordingly, the number of attitude cases or scenarios representing the DMs' attitudes is calculated as follows.

Attitude Scenarios = (number of possible attitudes)$^{\wedge(\text{number of DMs' positions})}$ =$(3)^4$=81.

Since one scenario has been already considered for rational analysis (Table 4.3), the remaining attitude scenarios for attitude-based analysis equal 81-1 = 80 attitude scenarios. For example, if 3 DMs are involved, then the number of scenarios becomes $(3^{\wedge 9})$ = 19,683 attitude scenarios of the DMs' attitudes toward themselves and one another. These scenarios constitute an attitude-based stability analysis that can be implemented in a graph model technique to arrive at strategic decisions for conflict analysis when the DMs' attitudes are considered. Figure 4.2 depicts the systematic graph model procedure using rational and attitude-based approaches.

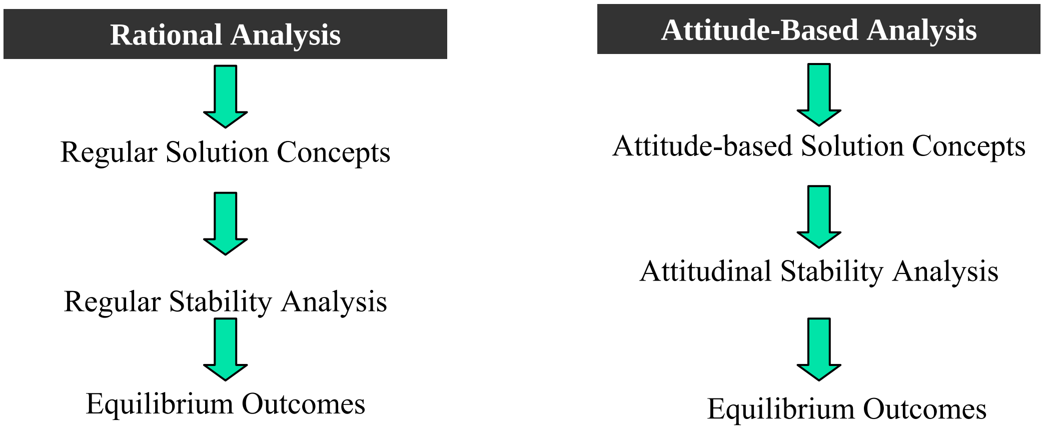


Figure 4.2: GMCR Procedures Using Rational and Attitude-Based Analyses

4.4.5. Propositions on Relationships among Attitude-based Stability Types

One of the contributions of this research is to investigate how incorporating the DMs' attitudes into the stability concepts can change the relationship among the stability concepts. In other words, when the attitudes of DMs change then the different relationships are considered for the attitude-based stability concepts. Three propositions on the relationships among attitude-based stability concepts within the paradigm of the GMCR are proposed in the following. The proofs of these propositions are presented by Inohara et al. (2008).

Proposition 1: Consider a graph model (N, C, $(S_i)_{i \epsilon N}$, $(\geq_i)_{i \epsilon N}$) of a conflict and a list e = $(e_i)_{i \epsilon N}$ of attitudes e_i of DM i for i є N. For i є N; Where N is the set of all decision makers (DMs). C is the set of all states of the focal decision making situation, where |C| ≥ 2. For i є N, S_i is a function from C to the power set P(C) of C such that c є S_i(c) є P(C) for all c є C. S_i is called the irreflexive reachable list function of DM i є N and S_i(c) is called the irreflexive reachable list of DM i є N from c є C. $\geq_i$ is the preference of DM i є N on C. Accordingly, $C_i^{RNash(e)} \subset C_i^{RSMR(e)} \subset C_i^{RGMR(e)}$ and $C_i^{RNash(e)} \subset C_i^{RSEQ(e)} \subset C_i^{RGMR(e)}$. In other words, if states 1 and 2, for example, are attitude-based Nash stable for DM i, they have also attitude-based Symmetric Metarationality stability and further, they have attitude-based General Metarationality stability. Moreover, if states 1 and 2, for example, are attitude-based Nash stable for DM i, they have also attitude-based Sequential stability and further, they have attitude-based General Metarationality stability. It should be noted that these relationships among the relational stability concepts are logically true from their definitions shown in Table 3.4

Proposition 2: Consider a graph model (N, C, $(S_i)_{i \in N}$, $(\geq_i)_{i \in N}$) of a conflict and a list e = $(e_i)_{i \in N}$ of attitudes e_i of DM i for i є N. Assume that N = {1, 2} and the DMs' attitudes e = $(e_i)_{i \in N}$ are positive toward both themselves and other DMs. Also, assume that DMs' preferences $\geq_1$ and $\geq_2$ are transitive and antisymmetric. Then, for i є N and c є C, c є $C_i^{RNash(e)}$ if and only if c є $C_i^{RSEQ(e)}$.

Proposition 3: Consider a graph model (N, C, $(S_i)_{i \in N}$, $(\geq_i)_{i \in N}$) of a conflict and a list e = $(e_i)_{i \in N}$ of attitudes e_i of DM i for i є N. Assume that N = {1, 2} and the DMs' attitudes e = $(e_i)_{i \in N}$ are negative toward both themselves and other DM. Moreover, assume that DMs' preferences $\geq_1$ and $\geq_2$ are transitive, antisymmetric, and complete. Then, for i є N and c є C, c є $C_i^{RNash(e)}$ if and only if c є $C_i^{RSEQ(e)}$.

The interpretation of Propositions 2 and 3 indicates that when DMs have totally positive (or totally negative) attitudes toward themselves and one another, then attitude-based Nash Stability (RNash) and attitude-based sequential stability (RSEQ) are equivalent to each other, respectively.

4.5 Strategic Negotiation Methodology: A Brownfield Case Study

The attitude-based solution concepts, defined in the foregoing section, are incorporated into GMCR technique to propose a negotiation methodology for construction conflicts. To clarify the development of the methodology, the procedure is demonstrated using a brownfield construction case study. More information about brownfield negotiations have been provided in Subsection 2.2.3. In the proposed case study, the land of a privately owned property is contaminated, and according to the municipality’s laws, the property is considered a brownfield site which needs to be redeveloped in two steps: remediation, which means that the contaminated soil must be replaced, and redevelopment, which means that a new structure is to be constructed. Due to the enormous costs, responsibilities, risks, and uncertainties involved with brownfield construction, conflicts have often arisen between the current property owner and Kitchener municipality. To illustrate these conflicts, a hypothetical case study is considered in which the DMs are the owner and the government (Yousefi et al., 2009). In the real world, the owner is very often a company, and the government represents a body of people. However, since this research deals with personal attitudes, it is more convenient to refer to the DMs as individuals. Therefore, for the purpose of the analysis, the owner will be referred to as “she”, “her”, “herself”, etc. The government will be referred to as “he”, “him”, “himself”, etc.

With respect to the modeling stage of GMCR, first, the DMs involved in the brownfield conflict and their available options are to be determined. It can be assumed that both DMs in this case study have reviewed the different choices available to them and selected the following options:

Owner's Options
- 1) Accept Liability
- 2) Sell Property

Government's Options
- 1) Share Costs
- 2) Lawsuit

Each option can be either accepted or rejected by each DM and since there are four choices in total, the number of states is $2^{\wedge 4}$ = 16. Four of the 16 states are infeasible, so the total number of feasible states is 12. Infeasible states and the process of deleting them are explained by Fraser and Hipel (1984). The two DMs, whose goals differ, would prefer first to have strategic-level advice which can help them decide which conflicting issues they may further negotiate at the tactical level. GMCR is an appropriate technology for analyzing this case-study conflict. As Kilgour (2007) pointed out, GMCR provides an understanding of and insight into strategic decisions, and therefore DMs can benefit from the strategic advice provided by GMCR. At the strategic level, GMCR will also allow the two DMs to define the most beneficial decisions among the 12 states. In Chapter 6, a complementary negotiation methodology is introduced that will support the tactical level of negotiations such as negotiating the exact amount of brownfield redevelopment cost each DM should pay in order to reach a sustaible mutual agreement.

4.5.1. Feasible States and Preferences

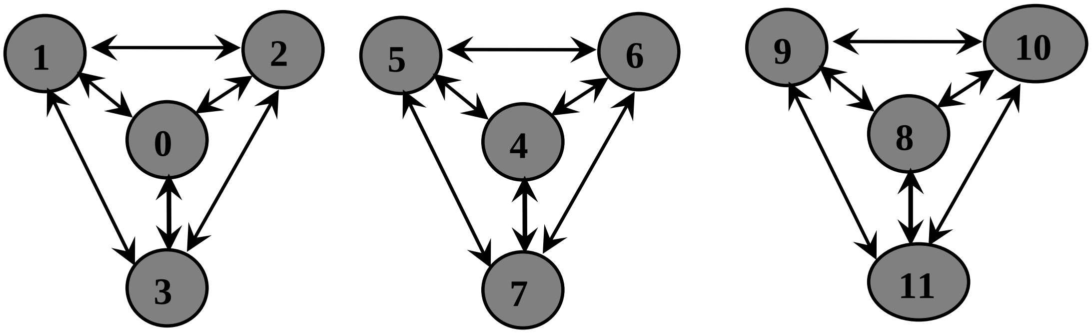
Table 4.6 shows the 12 feasible states for the case study. Each state is assigned a number label for referencing purposes. In a given column, a "Y" means "yes", the option is selected by the DM controlling it, whereas an "N" indicates "no", it is not taken. For example, state 2 in Table 4.6 represents a scenario in which

Owner does not accept liability (N), sells the property (Y), Government does not share the costs (N), and does not file the case in court (N).

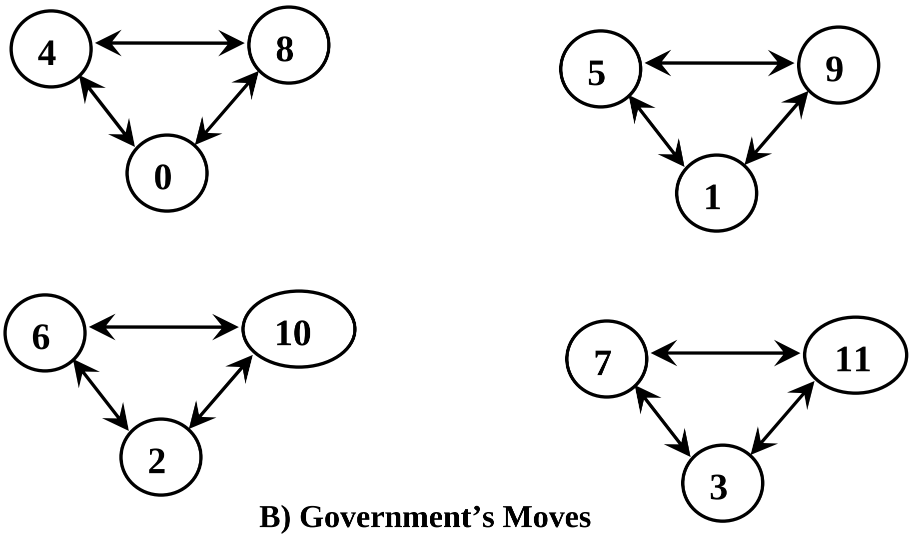
Table 4.6: Feasible States for the Case Study

DMs	Options	12 Feasible States											
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Owner	1)Accept Liability	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
	2) Sell Property	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
Government	3) Share Costs	N	N	N	N	Y	Y	Y	Y	N	N	N	N
	4) Lawsuit	N	N	N	N	N	N	N	N	Y	Y	Y	Y

Figure 4.3 is the integrated graph model representation for the case study and the ranking of the states for each DM from the most preferred to the least preferred state. The government's graph model, for example, consists of four groups of graphs in which each node represents a feasible state and an arc with arrowheads depicts the movement that the DM unilaterally controls between the two states. Part C of Figure 4.3 displays the ordinal ranking of the states for both DMs, sorted from the most preferred states on the left to the least preferred states on the right. Accordingly, the owner most prefers that the government shares the costs of redevelopment with the owner (state 4) and least prefers to accept liability and have the case filed in court (state 9). The most preferred state for the government is state 1, in which the current owner accepts liability and no other actions are taken (i.e., Government does not take the case to court), and the least preferred state is state 4, in which the government shares the costs of the brownfield redevelopment.



A) Owner's Moves



B) Government's Moves

DMs	Ordering of States from Most to Least Preferred											
	Most Preferred				-------------→				Least Preferred			
Owner	4	5	6	7	2	0	3	1	10	8	11	9
Government	1	5	7	11	3	2	6	9	10	8	0	4

C) DMs' Ordinal State Preferences

Figure 4.3: Integrated Graph Model and State Preference for DMs

4.5.2. Reachable List

The reachable list is a record of all the states that a given DM can reach from a specified starting state in one step. The reachable list is mathematically defined as follows (Hamouda et al., 2004): for i є N and s є S, DM i's reachable list from state s is the set {t є S ∣ (s, t) є A_i}, denoted by $R_{i(s)} \subset S$. For the case study, the reachable lists for both DMs are displayed in Table 4.7. The reachable lists of the DMs will be used to determine unilateral improvement states for each DM when their attitudes are incorporated into their decision to either move to another state or remain in the current state.

4.5.3. Stability Analysis

A stability analysis is the systematic study of potential moves and countermoves by the DMs as they jostle for more preferred positions during the evolution of the conflict and determine whether they can reach the most likely resolution (Hipel, 2007). The solution concepts, defined in Table 4.5, are used to test the feasible states in order to determine whether each of the DMs' movements is stable or unstable.

Table 4.7: Reachable Lists for the Case Study

State	$R_{(owner)}$ - State	$R_{(government)}$ - State
0	1,2,3	4,8
1	0,2,3	5,9
2	0,1,3	6,10
3	0,1,2	7,11
4	5,6,7	0,8
5	4,6,7	1,9
6	4,5,7	2,10
7	4,5,6	3,11
8	9,10,11	0,4
9	8,10,11	1,5
10	8,9,11	2,6
11	8,9,10	3,7

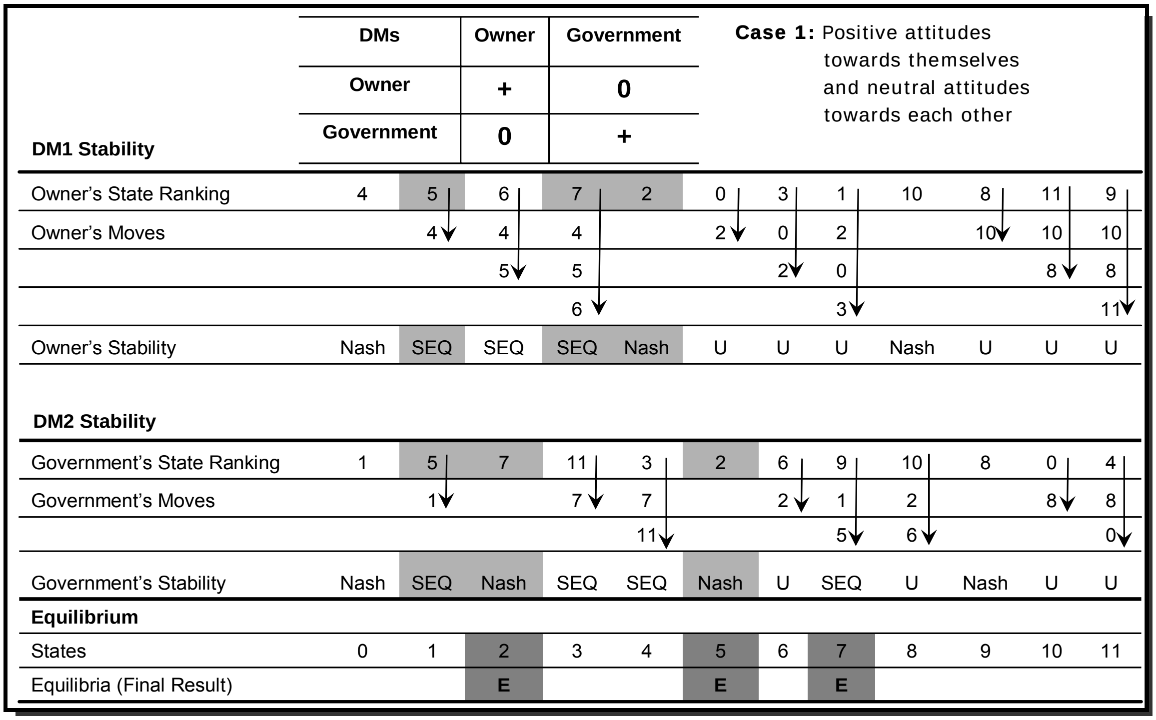
The mathematical forms for the solution concepts, shown in the centre column of Table 4.5, are interpreted for the two DMs in this case as follows (Fraser and Hipel, 1984):

1. *Nash*: In this situation, a DM has no Unilateral Improvement (UI) to make from the state. In other words, the already selected strategy is the best that can be chosen given the strategy selection of the other DM. A UI is a state to which a particular DM can unilaterally move by a change in strategy, assuming that the other DM's strategy remains the same. The Nash (rational) state is a stable outcome and is denoted by "Nash."
2. *Unstable*: In this situation, the DM has at least one UI from which the other DM can take no credible action that results in a less preferred state for the given DM. An unstable outcome is denoted by "U."
3. *Sequentially sanctioned*: In this case, for all UIs available to one DM, credible actions can be taken by the other DM in which a less preferred state than the one from which the DM is improving will be resulted. A credible action is one that results in a more preferred state for the DM taking the action. The possibility that a worse state could result from a DM changing strategy deters the DM from unilaterally attempting a position improvement and induces a stability type labeled as "SEQ."

4.5.4. Analysis of the DMs' Neutral Attitudes towards Each Other

The attitudes of the DMs can be integrated into the stability analysis using a stability analysis tableau which consists of each DM's state ranking (i.e., preference vector), moves, stability types, and equilibrium results in an organized format. A tableau helps in the systematic modeling and analysis of the moves and countermoves by the DMs to reach possible resolution for a conflict. More details about stability analysis tableau are provided by Fraser and Hipel (1984).

For the brownfield case study, a stability analysis tableau has been developed for the two DMs who initially have rational attitudes (Table 4.3). Rational DMs have positive attitudes with respect to themselves and have neutral or zero attitudes toward each other as shown in Figure 4.4.



DMs	Owner	Government
Owner	+	0
Government	0	+

Case 1: Positive attitudes towards themselves and neutral attitudes towards each other

DM1 Stability

Owner's State Ranking	4	5	6	7	2	0	3	1	10	8	11	9
Owner's Moves		4	4	4		2	0	2		10	10	10
			5	5			2	0			8	8
				6				3				11
Owner's Stability	Nash	SEQ	SEQ	SEQ	Nash	U	U	U	Nash	U	U	U

DM2 Stability

Government's State Ranking	1	5	7	11	3	2	6	9	10	8	0	4
Government's Moves		1		7	7		2	1	2		8	8
					11			5	6			0
Government's Stability	Nash	SEQ	Nash	SEQ	SEQ	Nash	U	SEQ	U	Nash	U	U

Equilibrium

States	0	1	2	3	4	5	6	7	8	9	10	11
Equilibria (Final Result)			E			E		E				

Figure 4.4: Stability Analysis Tableau for Two DMs with Rational Attitudes

4.5.4.1. Assessment of the stability

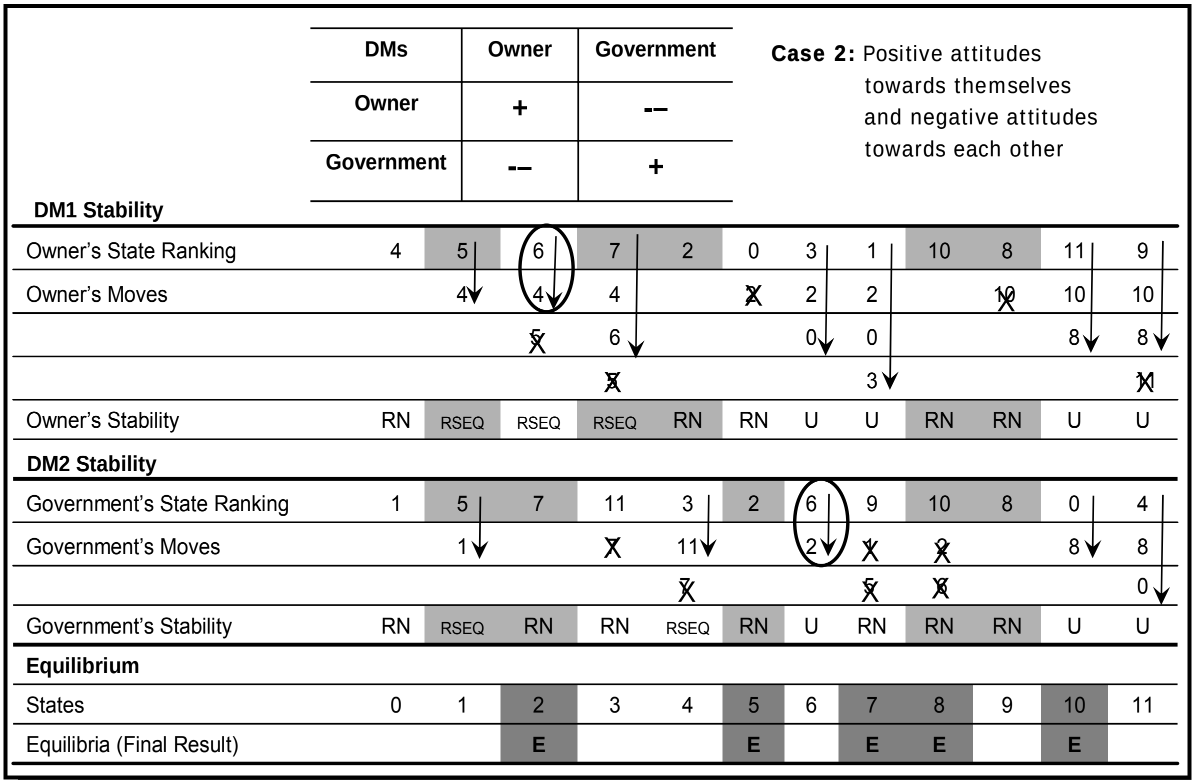
As displayed in Figure 4.4, the moves from a state that are preferred by a DM are listed blow the state and also appear to the left of that state in the state ranking.

The procedure for determining the types of stability are quite straightforward and is extensively explained by Fraser and Hipel (1984). In order to check the Nash stability, for example, Figure 4.4 is examined for states in the DMs' state rankings that do not have any moves listed under them. Since the DMs can not move from these states, they are Nash stable and can be immediately marked with "Nash". In Figure 4.4, states 2, 4, and 10 are Nash stable for the owner, whereas states 1, 7, 2, and 8 are Nash stable for the government. Each of the remaining states in the two state rankings can be assessed for their stability, which is normally done for each DM sequentially. The owner can unilaterally move to state 4 from state 5. However, the examination of the government's vector reveals that the government has an improvement from 4 to 8 and then to zero. As shown in the owner's state ranking (i.e., preference vector), both 8 and zero are less preferred than 5, and the owner is therefore deterred from improving from 5 because of the possibility that 8 or zero could result. Because the government would improve its position by unilaterally moving from 4 to 8 or to zero, the sanction is credible. Consequently, sate 5 is sequentially stable and a "SEQ" is written below state 5 in the owner's state ranking. In the actual conflict, state 5 means that the owner keeps sharing liability for the costs with the government who shares the costs of brownfield redevelopment as well. Otherwise, if the owner does not share the liability costs, then the government may either reject sharing the costs with the owner or take the case to court. The same procedure applies for the government regarding state 5. If the government unilaterally moves to state1, then the owner has an improvement from 1 to 2 which is less preferred by the government and more preferred by the owner. Thus, state 1 is sequentially sanctioned by the owner and hence, outcome 5 is “SEQ” for the government. The same stability analysis process is used to test the remaining states, as summarized in Table 4.8.

If a state possesses some types of stability for all DMs, it is called an equilibrium state which constitutes a possible resolution to the conflict (Fraser and Hipel, 1984). All other outcomes are unstable for at least one of the DMs, and therefore are not normally considered possible resolution. Equilibria are indicated by “E” placed below the corresponding state (i.e., states 2, 5, and 7) on the last row in the stability analysis tableau (Figure 4.4). An outcome that is unstable for at least one DM is not marked by “E” In a stability tableau.

4.5.5. Analysis of the DMs’ Negative Attitudes towards Each Other

In the previous case, it was assumed that the DMs have rational attitudes toward each other, and therefore, the DMs attitudes were not investigated. In this case however, a situation is examined in which the DMs do not behave rationally and the DMs’ various attitudes affect the outcome of their negotiation. To examine the influence of DMs’ attitudes toward each other in this case, a situation is considered in which the DMs change their attitudes from rational to relational attitudes and possess negative attitudes toward each other and positive attitudes toward themselves. In other words, the owner has a positive attitude toward herself and negative attitude toward the government, whereas the government has a positive attitude toward himself and negative attitude toward the owner. The results of the change in DMs' attitudes are displayed in Figure 4.5 and discussed below. The interactive decision-making analysis, defined within the structure of GMCR, is performed and the attitude-based solution concepts defined in Table 4.5 are applied. The results of the attitude-based stability analysis indicate that outcomes 5, 7, 2, 10, and 8 (Figure 4.5) were resulted since they are Relational Nash (RN) and Relational Sequentially Sanctioned (RSEQ) stables for both DMs. In the previous scenario explained in Subsection 4.5.4, different equilibria (2, 5, and 7) were obtained. Thus, the changes in the attitudes cause the changes in the resulting equilibria.



DMs	Owner	Government
Owner	+	-–
Government	-–	+

Case 2: Positive attitudes towards themselves and negative attitudes towards each other

DM1 Stability												
Owner's State Ranking	4	5	6	7	2	0	3	1	10	8	11	9
Owner's Moves		4	4	4		~~2~~	2	2		~~10~~	10	10
			~~5~~	6			0	0			8	8
				~~5~~				3				~~11~~
Owner's Stability	RN	RSEQ	RSEQ	RSEQ	RN	RN	U	U	RN	RN	U	U
DM2 Stability												
Government's State Ranking	1	5	7	11	3	2	6	9	10	8	0	4
Government's Moves		1		~~7~~	11		2	~~1~~	~~2~~		8	8
					~~7~~			~~5~~	~~6~~			0
Government's Stability	RN	RSEQ	RN	RN	RSEQ	RN	U	RN	RN	RN	U	U
Equilibrium												
States	0	1	2	3	4	5	6	7	8	9	10	11
Equilibria (Final Result)			E			E		E	E		E	

Figure 4.5: Attitude-Based Stability Analysis for Two DMs with Negative Attitudes

4.5.5.1. Assessment of the stability

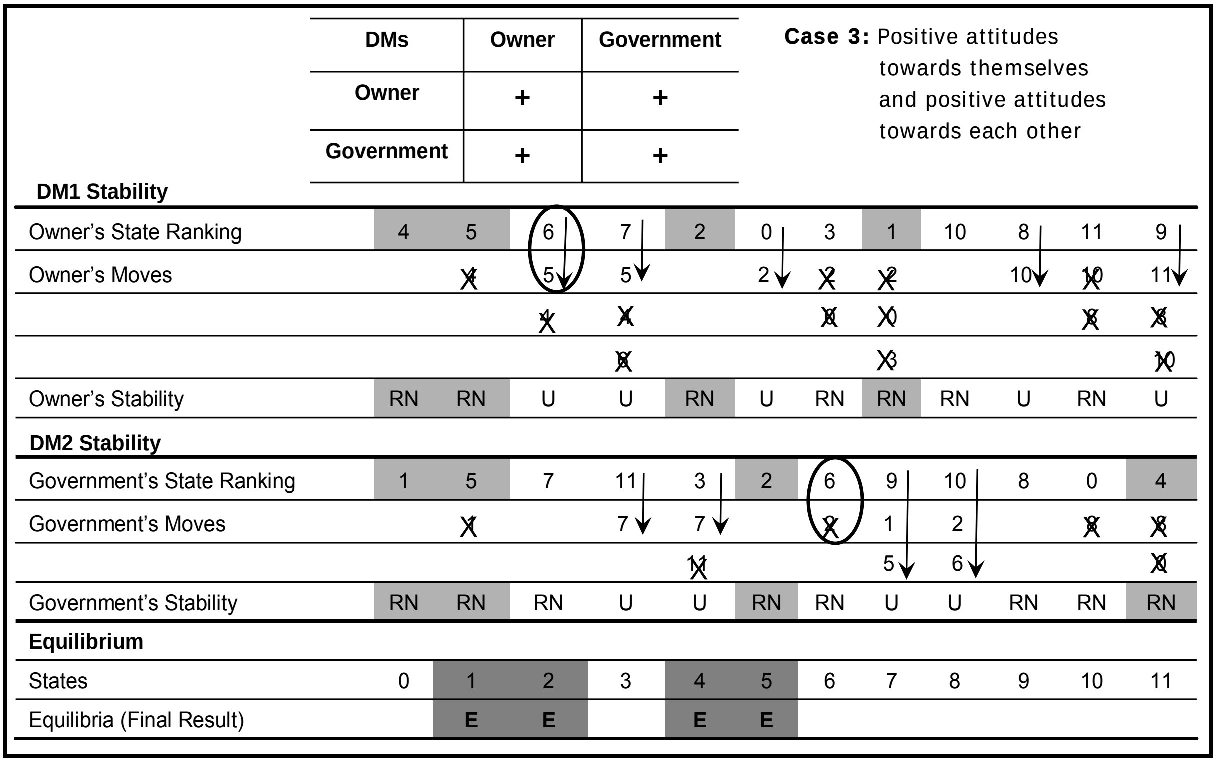
As shown in Figure 4.5, below a given state in the state ranking for each DM are the DM's possible moves or the Total Relational Reply (TRR) lists determined according to the attitudes shown above the tableau in Figure 4.5. The stability of each sate in the sate ranking has been evaluated and shown below the DMs' state ranking. State 6, circled in Figure 4.5, is assessed, for example, for the owner. According to the reachable list of the owner in Table 4.7, R_{owner} (6) = {4, 5, 7}. As the owner has a positive attitude with respect to herself, the owner has a devoting preference (defined in Subsection 4.4.2) toward herself. From the ranking of the states in Figure 4.5, it can be seen that states 4 and 5 are more preferred and 7 is less preferred to state 6 for the owner within the reachable list for state 6, therefore, 4, 5 RP ($e_{owner,\ owner}$= +) 6. Since the owner has a negative attitude toward the government, the owner wants to ensure that her improving move from 6 to 4 or 5 will not benefit her opponent. From the ordering of the states for the government in Figure 4.5, it can be seen that 5 is more preferred and 4 is less preferred to 6 and thus, 4 RP ($e_{owner,\ government}$= -) 6. It can be concluded that 4 TRP (e_{owner}) 6 and thus TRR $(6)_{owner}$ ={4}, which is circled in Figure 4.5. The same procedure is carried out for other states to determine TRR for each DM. Once TRR (6) for the owner is obtained, the stability of state 6 is examined. If the owner moves from 6 to 4, then the government can move from 4 to 8. Although 8 is less preferred to 6 for the government, state 8 is also less preferred to 6 for the owner and because the owner has a positive attitude toward herself she is deterred to move from 6 to 4. Thus, state 6 becomes RSEQ for the owner and an “RSEQ” is written below state 6 for the owner’s state ranking.

The stability of state 6 is now assessed for the government. According to his reachable list in Table 4.7, $R_{government}$ (6) = {2, 10}. As the government has a positive attitude with respect to himself (Figure 4.5), he has a devoting preference toward himself. It can be seen from his state ranking that state 2 is more preferred and 10 is less preferred to state 6 within the reachable list for state 6. As such, 2 RP ($e_{gov.,gov.}$= +) 6. Since the government has a negative attitude toward the owner, he wants to ensure that his improving move from 6 to 2 will not benefit his opponent (the owner). It can be noticed from the ordering of the states for the owner that 2 is less preferred to 6, and thus, the government can escalate the conflict by unilaterally moving to state 2. It should be noted that the government is not deterred to move to 2 from 6 because state 2 is “RN” for the owner. State 6 then becomes unstable for the government and an “U” is written below state 6 for the government’s state ranking. It can be concluded that 2 TRP ($e_{gov.}$) 6, so TRR $(6)_{gov.}$ ={2}. The same stability analysis is performed for the other states, and the results are summarized in Table 4.8.

4.5.6. Analysis of the DMs’ Positive Attitudes towards Each Other

A situation is now considered in which both DMs have positive attitudes with respect to themselves and toward each other. Such situation is in contrast to the preceding situation in which the DMs had negative attitudes toward each other.

The objective is to examine how the possible strategic negotiation outcome changes when the DMs' attitudes change. The interactive decision-making analysis, defined within the structure of GMCR, is performed and the attitude-based solution concepts defined in Table 4.4 are applied. Accordingly, states 1, 2, 4, and 5, shown in Figure 4.6, were resulted as equilibria since they are Relational Nash (RN) stable for the DMs. It should be remembered that in the previous scenarios, different equilibria were obtained. It can again be seen that the changes in the DMs' attitudes cause corresponding changes in the resulting equilibria. In this scenario, states 1, 2, 4, and 5 constitute equilibrium states, indicating that the positive attitudes of the DMs have provided both DMs with better equilibrium states; thus, the DMs may reach a better strategic resolution to their conflict.



DMs	Owner	Government
Owner	+	+
Government	+	+

Case 3: Positive attitudes towards themselves and positive attitudes towards each other

DM1 Stability												
Owner's State Ranking	4	5	6	7	2	0	3	1	10	8	11	9
Owner's Moves		~~4~~	5	5		2	~~2~~	~~2~~		10	~~10~~	11
			~~4~~	~~4~~			~~0~~	~~0~~			~~8~~	~~8~~
				~~6~~				~~3~~				~~10~~
Owner's Stability	RN	RN	U	U	RN	U	RN	RN	RN	U	RN	U
DM2 Stability												
Government's State Ranking	1	5	7	11	3	2	6	9	10	8	0	4
Government's Moves		~~1~~		7	7		~~2~~	1	2		~~8~~	~~8~~
					~~11~~			5	6			~~0~~
Government's Stability	RN	RN	RN	U	U	RN	RN	U	U	RN	RN	RN
Equilibrium												
States	0	1	2	3	4	5	6	7	8	9	10	11
Equilibria (Final Result)		**E**	**E**		**E**	**E**						

Figure 4.6: Attitude-Based Stability Analysis for Two DMs with Positive Attitudes

4.5.6.1. Assessment of the stability

For this situation, the stability of state 6, circled in Figure 4.6, is evaluated for both DMs. It should be noted that state 6 was already examined for previous situation in Subsection 4.5.5. According to the reachable list of the owner in Table 4.7, R_{owner} (6) = {4, 5, 7}. Because the owner has a positive attitude with respect to herself, she has a devoting preference (defined in Subsection 4.4.2) toward herself. From the ranking of the states in Figure 4.6, it can be seen that states 4 and 5 are more preferred and 7 is less preferred to state 6 for the owner within the reachable list for state 6, so 4, 5 RP ($e_{owner,\ owner}$= +) 6. Since the owner has also a positive attitude toward the government, the owner wants to ensure that her move from 6 to 4 or 5 will not lower her opponent's position. Thus, from the ordering of the states for the government in Figure 4.6, it can be seen that 5 is more preferred and 4 is less preferred to 6 and thus, 5 RP ($e_{owner,\ government}$= +) 6. It means that the owner's move from 6 to 5 benefits the DMs and, thus, the owner has a possible move from 6 to 5. It is concluded that, 5 TRP (e_{owner}) 6, so TRR $(6)_{owner}$ ={5}, circled in Figure 4.6.

The stability of state 6 is now assessed for the government. According to his reachable list in Table 4.6, $R_{government}$ (6) = {2, 10}. Because the government has a positive attitude with respect to himself (Figure 4.6), he has a devoting preference toward himself. It can be seen from his ranking states that state 2 is more preferred and 10 is less preferred to state 6 within the reachable list for state 6, so 2 RP ($e_{gov.,gov.}$= +) 6. Since the government has a positive attitude toward the owner, he wants to ensure that his unilateral move from 6 to 2 will not lower his opponent's position. Thus, it can be seen from the ordering of the states for the owner that 2 is less preferred to 6, and thus the government is deterred from escalating the conflict by moving to state 2. Accordingly, the government has no possible move from state 6 according to his attitude.

Once the TRR lists for the DMs are determined, the stability of state 6 is examined. If the owner moves from 6 to 5, the government has no move from 5 and, therefore, the owner can move from 6 to 5 and, thus, state 6 becomes unstable for the owner. Because the government has no move from 6, state 6 becomes RNASH stable for the government as shown in Figure 4.6. It can be concluded that Φ TRP ($e_{gov.}$) 6, so TRR $(6)_{gov.}$ ={ Φ }. The same stability analysis has been performed for the other states, and the results are summarized in Table 4.8. Separate stability analyses for the owner and the government are also shown in Tables 4.9 and 4.10, respectively. The resulting outcomes of the three situations in the case study are discussed as follows.

4.6. Discussion of the Resulting Strategic Decisions

In the previous section, a brownfield case study was studied considering three attitude cases: 1) the DMs had neutral (zero) attitudes toward each other; 2) they had negative attitudes toward each other; and 3) they had positive attitudes toward each other. The objective is to examine how changes in the DMs' attitudes can influence the negotiation outcome.

Table 4.8: Summary of the Stability Analysis for the Case Study

Note 1: "O" stands for owner and "G" stands for government.

Note 2: The grayed states are equilibria for each situation.

Note 3: States with gray cells stand for equilibria or possible solutions

State	DMs	DMs' Attitudes toward each other		
		Neutral (zero)	Negative	Positive
0	O	**Unstable:** O is not deterred to move to 2, because 2 is Nash stable state for G.	**Stable:** O is deterred to move to her only UI state 2, because 2 is more preferred to 0 for G and O does not want to improve G's position.	**Unstable:** to improve her position and G' position, O moves to her only state 2 which is more preferred state to 0 for O and G.
	G	**Unstable:** if G moves to 8, O can countermove from 8 to 10 which is more preferred state than 8 for G.	**Unstable:** to lower O's position , G moves to his only state 8 which is less preferred to 0 for O.	**Stable:** G is deterred to move to her only UI state 8, because 8 is less preferred to 0 for O and G does not want to lower O's position.
1	O	**Unstable:** O is not deterred to move to 2, because 2 is Nash stable state for G.	**Unstable:** to lower G's position, O moves to 2,0, and 3 which are less preferred to 1 for G.	**Stable:** O is deterred to move to UIs 2, 0, or 3 because they are less preferred to 1 for G, and O does not want to lower G's position.
	G	**Nash Stable:** no unilateral moves	**Nash Stable:** no improvement moves within G' reachable list	**Nash Stable:** no improvement moves within G' reachable list
2	O	**Nash Stable:** no unilateral moves	**Nash Stable:** no improvement moves within O' reachable list	**Nash Stable:** no improvement moves within O' reachable list
	G	**Nash Stable:** no unilateral moves	**Nash Stable:** no improvement moves within G' reachable list	**Nash Stable:** no improvement moves within G' reachable list
3	O	**Unstable:** O is not deterred to move to 2, because 2 is Nash stable state for G.	**Unstable:** to lower G's position, O moves to 0 and 2 which are less preferred states to 3 for G.	**Stable:** O is deterred to move to UIs 2 or 0, because they are less preferred to 3 for G, and O does not want to lower G's position.
	G	**Stable:** if G moves to UIs 7 or 11, then O countermoves to states 4 and 10 respectively which are less preferred to 3 for G.	**Stable:** G is deterred to move to 11 since O has a credible sanction from 11 to 10 which is less preferred to 3 for G.	**Unstable:** to improve his position and O' position, G moves to UI state 7 which is more preferred state to 3 for G and O; also, G is deterred to lower O's position by moving to his UI state 11.
4	O	**Nash Stable:** no unilateral moves	**Nash Stable:** no improvement moves within O' reachable list	**Nash Stable:** no improvement moves within O' reachable list
	G	**Unstable:** if G moves to 8, O can countermove from 8 to 10 which is more preferred state than 4 for G.	**Unstable:** to lower O's position , G moves to 8 and 0 which are less preferred to 4 for O.	**Stable:** G is deterred to move to UIs 8 or 0, because they are less preferred to 4 for O, and G does not want to lower O's position.
5	O	**Stable:** if O moves to UI 4, then G countermoves from 4 to 8 or 0 which are less preferred to 5 for O.	**Stable:** O is deterred to move to 4 since G has a credible sanction from 4 to 8 which is less preferred to 5 for O.	**Stable:** O is deterred to move to her only UI state 4, because 4 is less preferred to 5 for G, and O does not want to lower G's position.
	G	**Stable:** if G moves to UI 1, then O countermoves from 1 to 2, 0, or 3 which are less preferred to 5 for G.	**Stable:** G is deterred to move to 1 since O has a credible sanction from 1 to 2 which is less preferred to 5 for G.	**Nash Stable:** no improvement moves within G' reachable list
6	O	**Stable:** if O moves to UI 4 or 5, then G can countermove from 4 or 5 to 8, 0, or 1 which are less preferred to 6 for O.	**Stable:** O is deterred to move to 4 since G has a credible sanction from 4 to 8 which is less preferred to 6 for O.	**Unstable:** O moves to 5 to improve her own and her opponent' positions.
	G	**Unstable:** G is not deterred to move to 2, because 2 is Nash stable state for O.	**Unstable:** to lower O's position, G moves to his only state 2 which is less preferred state to 6 for O.	**Stable:** G is deterred to move to his only UI state 2, because 2 is less preferred to 6 for O, and G is deterred to lower O's position.
7	O	**Stable:** if O moves to UIs 4, 5, or 6 then G can countermove from 4, 5, and 6 to 8, 0, 1, and 2 respectively which are less preferred states to 7 for O.	**Stable:** O is deterred to move to 4 or 6 since G has credible sanction from 4 and 6 to 8 and 2 respectively. 8 and 2 are less preferred to 7 for O.	**Unstable:** to improve her position and G' position, O moves to UI state 5 which is more preferred state to 7 for G and O; also, O is deterred to lower G's position by moving to her UIs 4 or 6 which are less preferred to 7 for G.

Table 4.8 (Cont.)

State	DMs	DMs' Attitudes toward each other		
		Neutral (zero)	Negative	Positive
	G	**Nash Stable:** no unilateral moves	**Nash Stable:** no improvement moves within G' reachable list	**Nash Stable:** no improvement moves within G' reachable list
8	O	**Unstable:** if O moves to 10, then G can countermove from 10 to 2 and 6 which are more preferred state than 8 for O.	**Nash Stable:** no improvement moves within O' reachable list	**Unstable:** to improve her position and G' position, O moves to her only UI state 10 which is more preferred state to 8 for O and G.
	G	**Nash Stable:** no unilateral moves	**Nash Stable:** no improvement moves within G' reachable list	**Nash Stable:** no improvement moves within G' reachable list
9	O	**Unstable:** if O moves to 8, 10, or 11, then G can not deter O because 9 is the least preferred state for O.	**Unstable:** to lower G's position, O moves to 8 or 10 which are less preferred states to 9 for G who has no credible sanction from 8 or 10.	**Unstable:** to improve her position and G' position, O moves to UI state 11 which is more preferred state to 9 for G and O; also, O is deterred to lower G's position by moving to her UIs 8 or 10 which are less preferred to 9 for G.
	G	**Stable:** if G moves to 1 or 5, O can countermove from 1 to 0 and from 5 to 4. 0 and 4 are less preferred than 9 for G.	**Stable:** G is deterred to move to 1 or 5, because 1 and 5 are more preferred to 9 for O and G is deterred to improve O's position.	**Unstable:** to improve his position and O' position, G can move to his both UIs 1 and 5 which are more preferred states to 9 for G and O.
10	O	**Nash Stable:** no unilateral moves	**Nash Stable:** no improvement moves within O' reachable list	**Nash Stable:** no improvement moves within O' reachable list
	G	**Unstable:** G is not deterred to move to 2, because 2 is Nash stable state for O.	**Nash Stable:** no improvement moves within G' reachable list	**Unstable:** to improve his position and O' position, G can move to his both UIs 2 and 6 which are more preferred states to 10 for G and O.
11	O	**Unstable:** O is not deterred to move to 8, because 8 is Nash stable state for G.	**Unstable:** to lower G's position, O moves to 8 or 10 which are less preferred to 11 for G who has no credible sanction from 8 or 10.	**Stable:** O is deterred to move to her UIs 8 or 10, because they are less preferred to 11 for G, and O is deterred to lower G's position.
	G	**Stable:** if G moves to 7, then O can countermove from 7 to 4 or 6 which are less preferred states than 11 for G.	**Nash Stable:** no improvement moves within G' reachable list	**Unstable:** to improve his position and O' position, G moves to his only UI state 7 which is more preferred state to 11 for G and O.

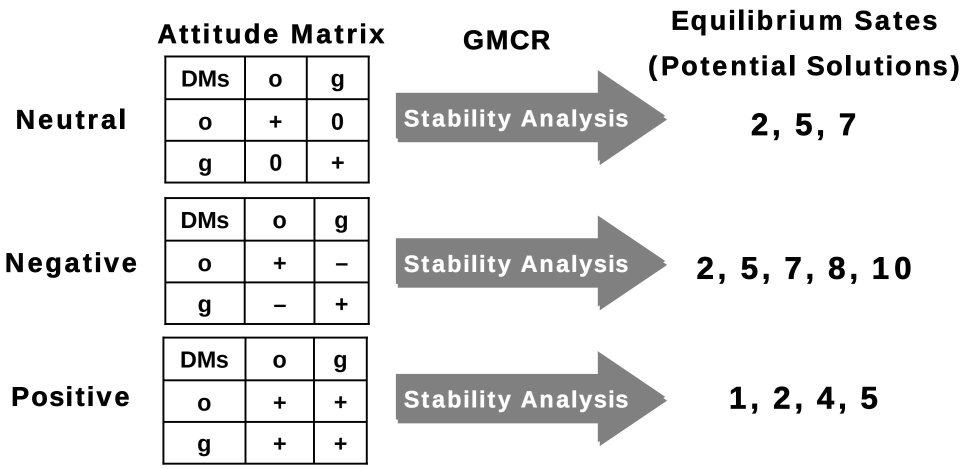
Table 4.9: Results for the Owner

State	Attitude		
	0	–	+
0	U	S	U
1	U	U	S
2	S	S	S
3	U	U	S
4	S	S	S
5	S	S	S
6	S	S	U
7	S	S	U
8	U	S	U
9	U	U	U
10	S	S	S
11	U	U	S

Table 4.10: Results for the Government

State	Attitude		
	0	–	+
0	U	U	S
1	S	S	S
2	S	S	S
3	S	U	U
4	U	U	S
5	S	S	S
6	U	U	S
7	S	S	S
8	S	S	S
9	S	S	U
10	U	S	U
11	S	S	U

To achieve this objective, the attitude-based stability analysis was performed. Due to the changes in the DMs' attitudes regarding the three attitude cases, three different sets of outcomes, were obtained. The resulting equilibrium states are reviewed and one agreed-upon equilibrium state as the most beneficial strategic decision of the brownfield negotiation is determined. The results of the stability analysis for each attitude case are shown in Figure 4.7, and a brief discussion is provided in the following subsections.



DMs	o	g
o	+	0
g	0	+

DMs	o	g
o	+	–
g	–	+

DMs	o	g
o	+	+
g	+	+

Note: Decision 2 is considered a beneficial strategic decision

Figure 4.7: Three Sets of Equilibria for Three Attitude Cases

4.6.1. Attitude Case 1

In this attitude case, the DMs have neutral (zero) attitudes toward each other. Using the proposed attitude-based stability analysis, three possible strategic solutions (i.e., states 2, 5, and 7) were obtained for this case as shown in Figure 4.7. The DMs evaluate the three resulting decision options and try to find the most beneficial strategic outcome for the conflict. One key outcome of the stability analysis for this case study is outcome 2, which means that the owner does not accept liability and sells the property, and that the government does not share the costs of the brownfield redevelopment and does not take the case to court. Another possible solution to the conflict is outcome 5, which corresponds to saying that the owner accepts her liability regarding the property remediation and does not sell her property, and the government shares the costs of remediation and does not file a court case. The third possible solution to the conflict is outcome 7, which means that the owner accepts liability and the government shares the costs. Once the land is remediated, the owner sells the property to the government and the government does not take the case to court.

4.6.2. Attitude Case 2

In this attitude case, the DMs have negative attitudes toward each other. The results of the proposed attitude-based stability analysis show that the set of equilibria changed toward more hostile possible solutions when the DMs changed their attitudes from neutral to negative toward each other. In this case, the equilibrium set includes 5, 7, 2, 8, and 10. It is observed that outcomes 2 and 5 (possible solutions in Case 1) are also resulted and thereby, are still considered in this case as possible solution options although the DMs have changed their attitudes. It can also be noticed that outcomes 8 and 10 are less preferred solutions for both DMs in comparison to outcomes 2, 5, and 7. Equilibrium state 8 for the conflict corresponds to saying that the owner neither accepts liability nor sells her property and that the government does not share any cost and takes the case to court. In other words, both DMs escalate the conflict because they have negative attitudes toward each other. Since they have positive attitudes only with respect to themselves, they strive to improve their own position and lower their opponents' position in the conflict. Equilibrium state 10 also corresponds to saying that the owner does not accept liability and sells the property and that the government rejects any cost sharing and tries to lower the owner's position by taking the case to court. Hence, the owner rejects liability since she considers liability acceptance as a positive point for the government, and this positive move is in contrast with her negative attitude toward the government. As can be seen, if DMs with negative attitudes interact, the strategic solutions that result are more hostile.

4.6.3. Attitude Case 3

With respect to this attitude case, the DMs have positive attitudes toward themselves and each other. In this scenario, outcomes 1, 2, 4, and 5 are considered as possible solution options for the conflict. Equilibrium state 1 means that the owner accepts liability and does not sell her property and that the government does not share the costs and does not take the case to court. Equilibrium state 4 means that the owner neither accepts liability nor sells her property, and that the government does accept all the costs and does not take the case to court. It can be observed that better possible solution options were obtained in this attitude case due to the positive attitudes of the DMs toward each other. It is noted that outcomes 2 and 5 (possible solutions in Cases 1 and 2) are also resulted in this case and thereby, are still considered as possible solution options although the DMs have changed their attitudes. Considering the results of the three attitude cases, the following observations are considered:

1. The increase in the number of solution options (equilibria) in a conflict may help the involved DMs choose a better possible solution from the resulting equilibrium states;
2. Outcomes 2, 4, and 5 are more preferred for both DMs than the outcomes 8 and 10 obtained from Case 2. In other words, the positive attitudes of the DMs toward themselves and each other not only mitigate the degree of hostility involved in outcomes 8 and 10 but also shift the range of solution options in the DMs' state ranking (i.e., preference vector) from right (less preferred states) to the left (more preferred states). Considering the DMs' state rankings in Figure 4.3 c, it can be seen that the positive attitudes of the DMs help shift the set of equilibria in the state rankings from the subset of 5, 7, 2, 8, and 10 on the right to the better subset of 1, 2, 4, and 5 on the left for both DMs;
3. One important observation is that the resulting equilibria for the three scenarios share equilibria 2 and 5, as shown in Figure 4.7. Solution options 2 and 5 are the only common equilibria obtained from the stability analysis based on three different DM attitudes because no matter what type of attitudes (neutral, negative, or positive) the DMs have toward each other, these outcomes provide equilibrium solutions. Thus, the DMs

involved may (or may not) consider each of the equilibrium states a reasonable decision and a strategic outcome of their conflict and may cooperatively continue their interactive negotiation to develop a tactical level of tradeoffs for the conflicting issue involved in solutions 2 and 5. It should be noted that the only conflicting issue in equilibrium state 2 is that the owner sells the property as indicated by “Y” in Table 4.6. The issues indicated by “N” for that equilibrium are not considered to be conflicting issues. Equilibrium state 5 consists of two conflicting issues indicated by two “Y” in this outcome: the amount of liability that the owner accepts and the amount of cost that the government shares. From the two possible solutions 2 and 5, the owner and the government can strategically agree on outcome 2, which has only one conflicting issue, and continue to negotiate in order to find a concession price for the owner’s property. Such negotiations have to be carried out at the tactical level rather than at the strategic decision-making level. The tactical level of negotiation methodology involving two DMs is proposed in Chapter 6.

4.7. Summary

The primary objective of this chapter was to present meaningfully and constructively the strategic level of the proposed negotiation methodology involving two decision makers. The proposed methodology systematically employs GMCR and incorporates the decision makers’ attitudes into the methodology. In this chapter, the proposed negotiation framework was initially introduced. As shown in Figure 4.1, three major components constitute the proposed negotiation framework: understanding the construction negotiation, developing an attitude-based construction negotiation methodology, and designing a negotiation decision support system. The requirements for understanding construction negotiations were explained, and the characteristics of construction negotiations as well as construction participants were highlighted. An attitude-based negotiation methodology at the strategic level was then developed. To demonstrate the advantages of the proposed methodology, a case study of a brownfield construction conflict involving two decision makers was used in order to develop the negotiation methodology. The brownfield case study has been also used in Chapter 6 to develop a negotiation methodology at the tactical level when.

The proposed negotiation methodology at the strategic level has been developed when only two decision makers are involved in the negotiation process to arrive at a mutual strategic agreement. The proposed strategic negotiation methodology in this chapter has been adapted and further developed, as discussed in Chapter 5 in order to include multiple decision makers involved in strategic negotiations.

CHAPTER 5
Attitude-Based Strategic Negotiation Involving Multiple Decision Makers

5.1. Introduction

In this chapter, the negotiation methodology, presented in Chapter 4 for two Decision Makers (DMs), is developed further, and an attitude-based negotiation methodology for multiple DMs and multiple conflicting issues is proposed. A real life brownfield negotiation involving multiple DMs is used to clearly demonstrate the advantages of the proposed methodology. The historical background of the case study is therefore summarized, and the DMs involved, along with their options and the conflicting issues are also presented. The proposed negotiation methodology has been developed using an attitude-based Graph Model for Conflict Resolution which has been expanded to include both qualitative and quantitative analyses.

5.2. Real-Life Brownfield Case Study

Downtown Kitchener, located in southern Ontario has a number of aging buildings, older industrial plants, brownfield lands, and underutilized sites that were once productive contributors to the economy of the community. These lands and buildings need to be brought back into production.

The case study used for this research is a brownfield land at the corner of King Street and Victoria Street in Kitchener. For approximately 75 years, B.F. Goodrich manufactured plastic and rubber components for the automotive industry in a five-story, 5,000 m^2 factory and several adjacent outbuildings on an 8-hectare site near the intersection of King and Victoria Street, as shown in Figure 5.1. Large quantities of fuels and chemicals were used and stored at the site, including solvents. Because of the lack of proper maintenance and the absence of environmental regulations in 1919 when B.F. Goodrich began operation, the land became contaminated, in large part from 75 years of leaks and spills from underground storage tanks, most of which contained naphtha, and some of which held chlorinated solvents and heavy metals. During the remediation process, elevated concentrations of beryllium and zinc, and to a lesser extent, copper were detected in the upper 1.0 m of soil, primarily on the south side of the site.

Figure 5.1: Satellite Image of the Former Brownfield Site

In 1983, B.F. Goodrich sold the site (factory) to Epton. As part of the transaction, Goodrich Canada indemnified Epton for specific claims that could arise from environmental contamination that may have occurred prior to 1983. In 1993, Goodrich (USA) spun off its Geon Vinyl Division as an independent publicly traded U.S. corporation: the Geon Company. Geon Canada thus became the successor to the interests of Goodrich Canada with respect to the brownfield site. The Geon Company later became PolyOne Corporation, and Geon Canada was renamed PolyOne Company.

In March of 1994, Epton demanded that PolyOne accept responsibility for the environmental contamination at the site, based on the indemnifications from Goodrich to Epton in the 1983 sale of the facility. Epton was experiencing financial difficulties at the time and was operating pursuant to a proposal made in 1993 under the Bankruptcy and Insolvency Act. Although PolyOne had no obligation to respond affirmatively to Epton's demand, Epton and PolyOne decided to undertake a joint environmental investigation in order to clean up the land since both parties already knew that the site was contaminated. They agreed that costs were to be split 50-50 and then reallocated later when and if liability was established. It should be mentioned that no legal remediation requirements had been enacted by any governmental organization at that time, but future Ministry of Environment (MOE) involvement was probated, in which case, parties involved, such as PolyOne and Epton, could be asked to complete the brownfield remediation process.

5.2.1. The Causes of the Conflict

Despite its initial agreements with PolyOne and its primary responsibility for the cleanup, Epton filed for bankruptcy in 1995 and disputes therefore arose as to the allocation of the environmental liabilities of the parties involved, including PolyOne, the creditors, the banks, the Trustee in bankruptcy, and the interim operator. In other words, when Epton, the party primarily responsible, filed for bankruptcy, the potential liability for the environmental conditions at the site fell upon numerous other parties, including prior property owners (including Goodrich/Geon), the Trustee itself, secured creditors, specific interim operators, and others that had been involved with plant operations over the years. In addition, the property itself became an albatross. Anyone taking possession, control, or ownership of any of the Epton site automatically became potentially responsible for the existing contamination at the site. Therefore, all the parties involved denied responsibility for brownfield liabilities. Moreover, Epton's creditors and mortgagees, and the The City of Kitchener possessed liens for several million dollars against the real property and other assets. The existence of the liens, claims, and counterclaims, as well as the issue of allocating environmental liability, virtually guaranteed disputes among the parties involved. For example, the The City of Kitchener (The City) had liens of over $1 million on the property, including the debt of accruing property taxes and unpaid hydro charges. In November 1995, the Trustee in bankruptcy wrote to The City officials, informing them that the Epton buildings would be stripped, the utilities and fire protection would be terminated, and the site would be abandoned.

5.3. Identifying DMs and Their Options

The brownfield negotiations between the The City and PolyOne concerning the status of the property were started during 1995. It is therefore important to note that this real-life negotiation is modeled and analyzed based on the information available at that time. The The City had become increasingly concerned about the abandoned buildings and the contaminated land, which presented an extreme fire and safety hazard. On the other hand, PolyOne showed its willingness to take responsibility for remediating the land on its own under specific conditions: 1) full control of the land during the remediation so that it would be fast and inexpensive, they would then transfer the site to the The City by donating it for public use; 2) other incentives from the The City to facilitate the remediation process.

Although PolyOne had the option of litigation, they concluded that even if they assumed the entire burden of the site remediation, it would probably cost less than even a small share of the enormous transactional costs of a traditional lengthy litigation-driven remedy.

Because the The City feared that PolyOne would be discouraged from taking possession if they had to pay the back taxes, the The City offered a write-off of the taxes. In order to facilitate the remediation process, the land was also transferred from the Trustee to PolyOne for only one dollar.

Due to these cooperative negotiations, the site was transferred to PolyOne in October 1996, and the main remediation process was begun. Before the completion of the remediation and the transfer of the land back to the The City, another set of negotiations started regarding the redevelopment plan for the land. The City reviewed the proposed plans and eventually selected a plan to construct an educational center on the remediated site. The City accordingly, asked the University of Waterloo (UW) to provide a proposal for such educational center. In 1997, UW thus became involved in the brownfield negotiation in order to assess whether it could construct a school of pharmacy on the remediated site. At this point, UW wanted work on the school of pharmacy to proceed quickly, but PolyOne had no incentive to speed up the remediation process. Multiple negotiations were therefore begun among three main DMs: 1) PolyOne, 2) the The City of Kitchener, and 3) the University of Waterloo. The DMs and their options are listed in Table 5.1.

Table 5.1: The DMs and Their Options in the UW School of Pharmacy Negotiations

DM	Options
PolyOne	1. Slow remediation of the site (*Slow*) 2. Fast remediation of the site (*Fast*)
The City of Kitchener	3. Provide incentives for PolyOne and UW (*Incentives*), 4. Take legal action against PolyOne (*Legal Actions*).
University of Waterloo	5. Construct the School of Pharmacy at this site (*Construction*).

Each DM can either accept (Y) or reject (N) any of its options and since there are five options in total, the number of decision states is $2^{\wedge 5}$ = 32. However, some states are infeasible and can be deleted, as explained in Subsection 3.2. The sets of infeasible states for this case study are displayed in Table 5.2 and are explained in the following section.

Table 5.2: Infeasible States for the Case Study

DMs	Options	Infeasible States				
		a	b	c	d	e
PolyOne	1) Slow	Y	N	N	Y	-
	2) Fast	Y	N	N	Y	Y
The City	3) Incentives	Y	N	N	-	-
	4) Legal Actions	Y	N	N	-	Y
UW	5) Construction	Y	N	Y	-	-

5.4. Infeasible States

- State a (Y, Y, Y, Y, Y, Y): It is impossible that all DMs simultaneously accept all their options.
- State b (N, N, N, N, N): It is impossible that all DMs simultaneously reject all their options.
- State c (N, N, N, N, Y): When PolyOne and the City choose “No” for all their options, it is impossible that UW accepts the option to construct the project.
- State d (Y, Y, -, -, -): It is impossible that PolyOne simultaneously accepts its two options no matter which options are accepted or rejected by the other DMs.
- State e (-, Y, -, Y, -): It is impossible that PolyOne remediates the land by on its own and donates the site for public use and that the City simultaneously

takes legal action no matter which options are accepted or rejected by the other DMs.

According to the above reasoning, the number of infeasible states is 14 and they have been removed from the total number of states ($2^{\wedge 5}$ = 32). The remaining 18 feasible states are labeled and listed from 0 to 17 and are shown in Table 5.3 in which each column represents a state for which Y means “Yes” and N indicates “No.”

Table 5.3: Resulting Feasible States for the Case Study

DMs	Options	18 Feasible States																	
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PolyOne	1) Slow	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N
	2) Fast	N	N	N	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N
The City	3) Incentives	Y	N	Y	Y	N	N	Y	N	Y	N	Y	N	Y	Y	Y	N	N	Y
	4) Legal Action	Y	N	N	N	Y	N	Y	Y	N	N	N	N	Y	Y	N	Y	Y	N
UW	5) Construction	Y	N	Y	N	Y	Y	N	N	Y	Y	N	N	Y	N	N	N	Y	Y

N: No (reject) ; Y: Yes (accept)

5.5. DMs’ State Rankings

Once the feasible states are obtained, the ranking of the states is determined for each DM from the most preferred state on the left to the least preferred state on the right as shown in Table 5.4. For example, PolyOne most prefers state 2, according to which PolyOne accepts only partial liability after a long-term conflict, completes remediation with delays and with incentives from the City, and finally sells the site to UW to construct a school of pharmacy when the remediation process is complete. PolyOne least prefers state 15, according to which PolyOne cleans up the site neither in the long term (with delays) nor in the short term, the City refuses to provide incentives and takes legal action against PolyOne, and UW rejects the construction of a school of pharmacy.

Table 5.4: DMs' State Rankings for the School of Pharmacy Negotiations

DMs	States Ranking																	
	Most Preferred --→ Least Preferred																	
PolyOne	2	3	5	1	8	10	9	11	17	14	0	6	4	7	12	13	16	15
The City	9	8	11	10	17	14	12	13	16	15	5	2	0	4	7	1	6	3
UW	8	17	10	9	11	12	14	16	15	13	2	0	4	5	7	6	1	3

The City most prefers state 9 in which the City takes no action, and PolyOne does not postpone the remediation process, cleans the site over the short term, and donates the site to UW in order for UW to construct a school of pharmacy. The City least prefers state 3, according to which PolyOne cleans the site with delays and sells the site, the City provides incentives, and UW does not construct a school of pharmacy. Finally, UW most prefers state 8, in which PolyOne completes the remediation process and donates the site, the City provides incentives for both UW and PolyOne, and UW constructs a school of pharmacy. UW least prefers state 4 which means that PolyOne completes the remediation process of the contaminated site after a long period of time, the City takes legal action against PolyOne, and UW constructs a school of pharmacy when the site was decontaminated after a long time.

5.6. Stability Analysis

When a strategic negotiation is modeled using GMCR, one point in time should be specified for the start of negotiation. In the Graph Model, the initial state of the conflict is referred to as the status quo. In this case study, the status quo occurred in 1997 and is represented by state 1, in which PolyOne completes the remediation process over the long term and with delays, the City neither provides incentives nor takes legal action, and UW does not construct a school of pharmacy.

5.6.1. Reachable List

The set of states in the reachable list for each DM are the states in which the particular DM can change his or her strategy while the strategies of all the other DMs remain fixed (Fraser and Hipel, 1984). The reachable lists for UW School of Pharmacy negotiation are displayed in Table 5.5.

It should be noticed that irreversible moves for DMs are considered when the reachable lists are constructed. An irreversible move is a move in which a DM can move from state a to state b but can not move back from state b to state a (Fang et. al 1993). If DMs choose irreversible moves, they can influence the attitude-based stability analysis that is dependent on the DMs' moves and countermoves. As shown in the first row of Table 5.5, PolyOne, for example, can not move from state 0 to state 12, but can move from state 12 to state 0, as shown in row 12. This means that once PolyOne accepts its first option (i.e., accept partial liability and eventually remediate and sell the site), it cannot logically or practically move to its second option (i.e., clean up the land on its own in the short term and donate the site for public use).

Table 5.5: Reachable Lists for the School of Pharmacy Negotiation

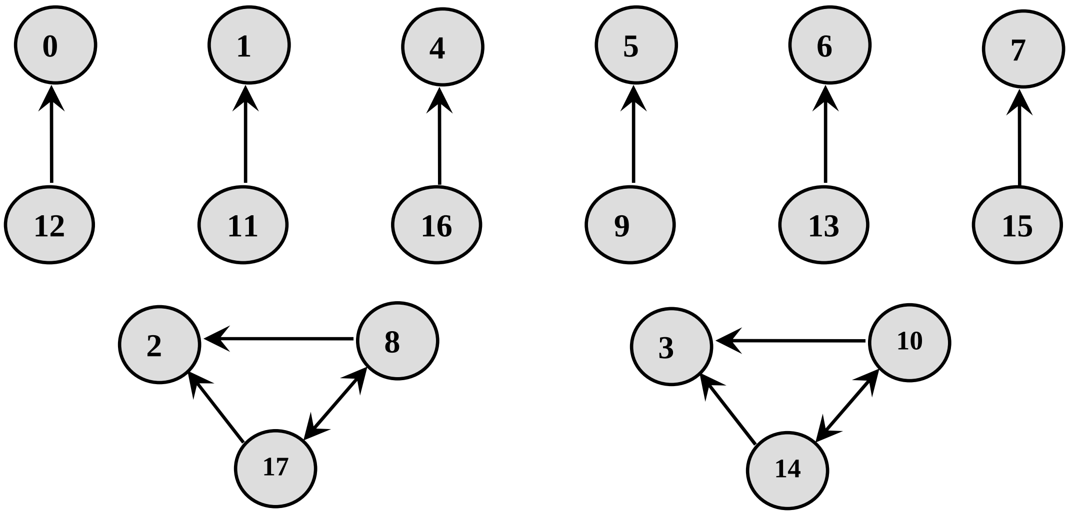
From State	PolyOne	The City	UW
	To Sate	To Sate	To Sate
0	--	2, 4, 5	--
1	--	3, 6, 7	5
2	--	0, 4, 5	--
3	--	1, 6, 7	2
4	--	0, 2, 5	--
5	--	0, 2, 4	--
6	--	1, 3, 7	0
7	--	1, 3, 6	4
8	2, 17	9	--
9	5	8	--
10	3, 14	11	8
11	1	10	9
12	0	16, 17	--
13	6	14, 15	12
14	10, 3	13, 15	17
15	7	13, 14	16
16	4	12, 17	--
17	2, 8	12, 16	--

Once the reachable list is constructed for each DM, the Graph Model representation can be developed as shown in Figure 5.2, in which the arrows represent the moves of the DMs and the circles represent the states. The Graph

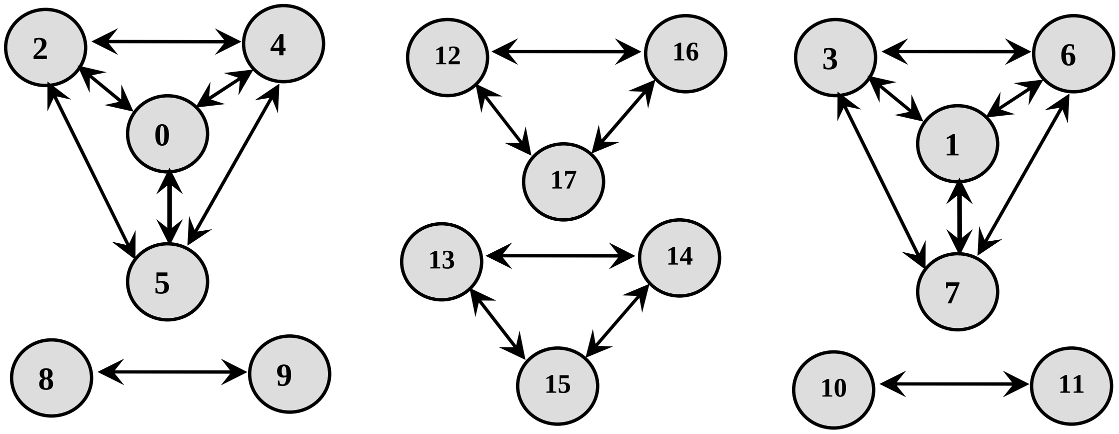
Model approach permits an efficient representation of irreversible moves, for example, PolyOne's irreversible move between states 0 and 12. The direction of the arrow shows that once PolyOne moves from state 12 to state 0, it can not move back from state 0 to state 12. However, when PolyOne moves from state 10 to state 14, it can also move back to state 10, and vice versa. Based on the historical background of the case study and as shown in Figure 5.2 b, the City has no irreversible moves.

5.6.2. Attitude-Based Stability Analysis for Three DMs

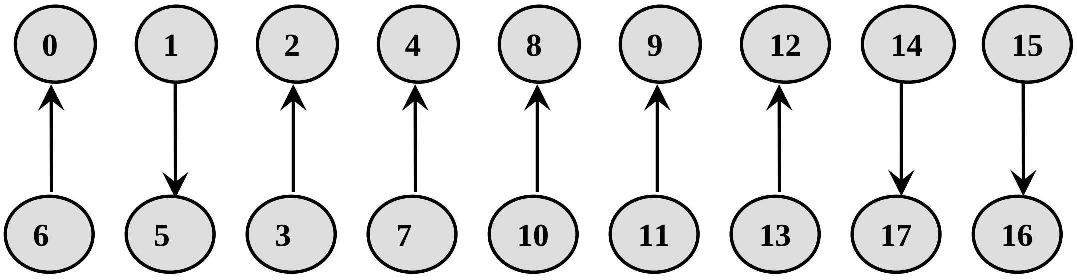
Once the reachable lists and the Graph Model representation of the states for the DMs were developed, the interactive decision-making analysis, defined within the structure of GMCR, can be performed and the attitude-based solution concepts defined in Table 4.4 applied. Attitude-based stability analysis was carried out for the school of pharmacy negotiation which included three DMs, with each DM having three possible types of attitudes toward itself and the others: positive, negative, and neutral. Three DMs constitute a 3 × 3 matrix in which each cell of the matrix can be +, ─, or 0, representing the positive, negative, or neutral attitudes of the DMs, respectively. Therefore, the total number of the attitudes of the DMs toward themselves and one another becomes 3^9, in which 3 represents the three types of attitude and 9 represents the number of cells in a 3 × 3 matrix. The total number of attitude scenarios thus equals 19,683. However, many of these scenarios are infeasible and can be removed. The process of removing infeasible attitude cases is explained in the following subsection.



A) PolyOne's Moves



B) The City's Moves



C) UW's Moves

Figure 5.2: Graph Model for the DMs Involved in the School of Pharmacy Negotiations

5.6.3. Proposed Algorithms for Removing Infeasible Attitude Cases

During negotiation, DMs may have a variety of attitudes toward themselves and one another. Each attitude case corresponds to a situation in which the DMs involved in the negotiations have one specific type of attitude (e.g., negative or positive) toward themselves and one specific type of attitude (e.g., negative or positive) toward other DMs. Among the total set of attitude cases, there are always many attitude cases that cannot be taken into account and they are referred to as infeasible attitude cases. Removing infeasible attitude cases depends primarily on the real negotiation process. A negotiator in a negotiation process may exhibit a variety of behaviors toward other negotiators. Inohara et al. (2008) assumed that positive, negative, and neutral attitudes of a DM toward others derive from "altruistic," "sadistic," and "apathetic" behaviors, respectively, and those toward her/himself derive from "selfish," "masochistic," and "selfless" behaviors, respectively, as shown in Table 4.2. Darling and Mumpower (1990) identified eight strategic behavioral orientations for negotiators: 1) individualistic, 2) cooperative, 3) altruistic, 4) sacrificing, 5) self-destructive, 6) nihilistic, 7) punitive, and 8) competitive, as shown in Figure 5.3. While such orientations are uncommon and may sometimes be pathological, under specific circumstances they may be useful concepts for achieving the broader purposes of negotiators.

The essence of the proposed algorithm for removing infeasible attitude cases is based on the logic that DMs involved in construction negotiations cannot have negative attitudes toward themselves. Therefore, all attitude cases in which a DM or all DMs have negative attitudes toward themselves, either individually or simultaneously should be removed from the total number of attitude cases.

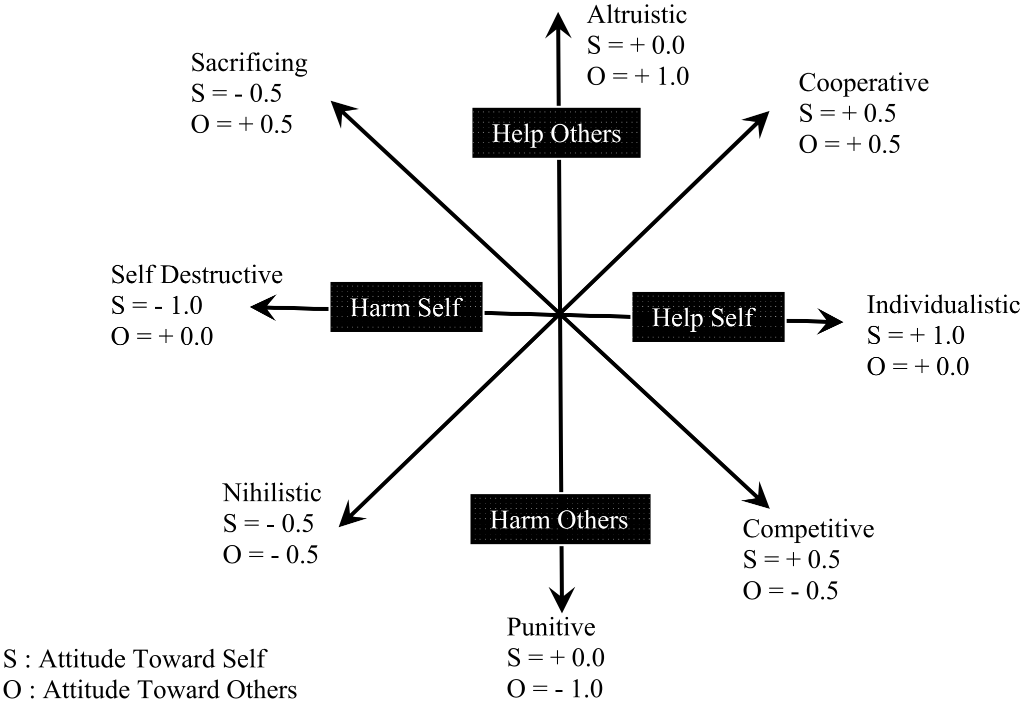


Figure 5.3: Eight Strategic Orientations of DMs' Negotiations (Darling and Mumpower 1990)

With respect to Figure 5.3, this study cannot include a situation in which a DM has an attitude of “harm self” and therefore follows the orientations of nihilistic, self destructive, and sacrificing. Therefore, cases in which a DM has a negative attitude toward itself are removed from the total number of strategic orientations. The proposed algorithm for negotiations that involve two DMs and three DMs are summarized in Table 5.6 and Table 5.7, respectively. The proposed algorithm has also been generalized for negotiations involving n DMs, as shown in Table

5.8. The computer programming codes for these algorithms are provided in Appendix A.

Table 5.6: Algorithm for Removing Infeasible Attitude Cases in Negotiations with Two DMs

Step	Infeasible Matrix	Description	Infeasible Cases
1	$\begin{array}{c\|c\|c} & \text{DM1} & \text{DM2} \\ \hline \text{DM1} & - & \\ \hline \text{DM2} & & +\text{ or }0 \end{array}$	Remove all cases in which DM1 has negative attitudes toward itself and DM2 has only neutral and positive attitudes toward itself, no matter what attitudes the DMs have toward each other.	1×3×3×2=18
2	$\begin{array}{c\|c\|c} & \text{DM1} & \text{DM2} \\ \hline \text{DM1} & +\text{ or }0 & \\ \hline \text{DM2} & & - \end{array}$	Remove all cases in which DM2 has negative attitudes toward itself and DM1 has only neutral and positive attitudes toward itself, no matter what attitudes the DMs have toward each other.	2×3×3×1=18
3	$\begin{array}{c\|c\|c} & \text{DM1} & \text{DM2} \\ \hline \text{DM1} & - & \\ \hline \text{DM2} & & - \end{array}$	Remove all cases in which DM1 has negative attitudes toward itself and DM2 has negative attitudes toward itself, no matter what attitudes the DMs have toward each other.	1×3×3×1=9
4	Total Number of Infeasible Attitude Cases		18+18+9 = 45
5	Total Number of Attitude Cases		3$^{\wedge 4}$ = 81
6	Total Number of Feasible Attitude Cases		81 – 45 = 36

Table 5.7: Algorithm for Removing Infeasible Attitude Cases in Negotiations with Three DMs

Step	Infeasible Matrix	Description	Number of Infeasible Cases
1	$\begin{array}{c\|c\|c\|c} & \text{DM1} & \text{DM2} & \text{DM3} \\ \hline \text{DM1} & - & & \\ \hline \text{DM2} & & +\text{ or }0 & \\ \hline \text{DM3} & & & +\text{ or }0 \end{array}$	Remove all cases in which DM1 has negative attitudes toward itself and DM2 and DM3 have only neutral and positive attitudes toward themselves, no matter what attitudes the DMs have toward each other.	1×3×3×3×2×3×3×3×2=2916
2	$\begin{array}{c\|c\|c\|c} & \text{DM1} & \text{DM2} & \text{DM3} \\ \hline \text{DM1} & +\text{ or }0 & & \\ \hline \text{DM2} & & - & \\ \hline \text{DM3} & & & +\text{ or }0 \end{array}$	Remove all cases in which DM2 has negative attitudes toward itself and DM1 and DM3 have only neutral and positive attitudes toward themselves, no matter what attitudes the DMs have toward each other.	2×3×3×3×1×3×3×3×2=2916

Table 5.7: Cont.

3	$\begin{array}{cccc} & \text{DM1} & \text{DM2} & \text{DM3} \\ \text{DM1} & + \text{ or } 0 & & \\ \text{DM2} & & + \text{ or } 0 & \\ \text{DM3} & & & - \end{array}$	Remove all cases in which DM3 has negative attitudes toward itself and DM1 and DM2 have only neutral and positive attitudes toward themselves, no matter what attitudes the DMs have toward each other.	2×3×3×3×2×3×3×3×1=2916
4	$\begin{array}{cccc} & \text{DM1} & \text{DM2} & \text{DM3} \\ \text{DM1} & - & & \\ \text{DM2} & & - & \\ \text{DM3} & & & + \text{ or } 0 \end{array}$	Remove all cases in which DM1 and DM2 have negative attitudes toward themselves and DM3 has only neutral and positive attitudes toward itself, no matter what attitudes the DMs have toward each other.	1×3×3×3×1×3×3×3×2=1458
5	$\begin{array}{cccc} & \text{DM1} & \text{DM2} & \text{DM3} \\ \text{DM1} & - & & \\ \text{DM2} & & + \text{ or } 0 & \\ \text{DM3} & & & - \end{array}$	Remove all cases in which DM1 and DM3 have negative attitudes toward themselves and DM2 has only neutral and positive attitudes toward itself, no matter what attitudes the DMs have toward each other.	1×3×3×3×2×3×3×3×1=1458
6	$\begin{array}{cccc} & \text{DM1} & \text{DM2} & \text{DM3} \\ \text{DM1} & + \text{ or } 0 & & \\ \text{DM2} & & - & \\ \text{DM3} & & & - \end{array}$	Remove all cases in which DM2 and DM3 have negative attitudes toward themselves and DM1 has only neutral and positive attitudes toward itself, no matter what attitudes the DMs have toward each other.	2×3×3×3×1×3×3×3×1=1458
7	$\begin{array}{cccc} & \text{DM1} & \text{DM2} & \text{DM3} \\ \text{DM1} & - & & \\ \text{DM2} & & - & \\ \text{DM3} & & & - \end{array}$	Remove all cases in which DM1, DM2, and DM3 have negative attitudes toward themselves, no matter what attitudes the DMs have toward each other.	1×3×3×3×1×3×3×3×1=729
4	Total Number of Infeasible Attitude Cases		13851
5	Total Number of Attitude Cases		$3^{\wedge 9}$ = 19683
6	Total Number of Feasible Attitude Cases		19683 – 13851 = 5832

5.6.4. Determining the Most Relevant Feasible Attitude Cases

The proposed algorithms summarized in Tables 5.6 and 5.7 help a conflict analyst remove a considerable number of infeasible attitude cases so that only feasible attitude cases are considered. However, the remaining number of feasible attitude cases is still too large to be evaluated using stability analysis. Moreover, when the number of DMs increases, the resulting number of feasible attitude cases increases exponentially, as shown in Tables 5.6 and 5.7.

Table 5.8: Algorithm for Removing Infeasible Attitude Cases in Negotiations with *n* DMs

Step	Infeasible Matrix	Description	Number of Infeasible Cases
1	$\begin{array}{c\|c\|c\|c\|c\|} & \text{DM1} & \text{DM2} & \cdots & \text{DMn} \\ \hline \text{DM1} & - & & & \\ \hline \text{DM2} & & \text{+ or 0} & & \\ \hline \vdots & & & \cdots & \\ \hline \text{DMn} & & & & \text{+ or 0} \\ \hline \end{array}$	Remove all cases in which only one DM has negative attitudes toward itself and other DMs have only neutral and positive attitudes toward themselves, no matter what attitudes all DMs have toward each other.	$n\left[1\times 2^{(n-1)}\times 3^{n(n-1)}\right]$
2	$\begin{array}{c\|c\|c\|c\|c\|c\|} & \text{DM1} & \text{DM2} & \text{DM3} & \cdots & \text{DMn} \\ \hline \text{DM1} & - & & & & \\ \hline \text{DM2} & & - & & & \\ \hline \text{DM3} & & & \text{+ or 0} & & \\ \hline \vdots & & & & \cdots & \\ \hline \text{DMn} & & & & & \text{+ or 0} \\ \hline \end{array}$	Remove all cases in which two DMs simultaneously have negative attitudes toward themselves and other DMs have only neutral and positive attitudes toward themselves, no matter what attitudes all DMs have toward each other.	$\frac{n(n-1)}{2}\left[1\times 2^{(n-2)}\times 3^{n(n-1)}\right]$
3	$\begin{array}{c\|c\|c\|c\|c\|c\|c\|} & \text{DM1} & \text{DM2} & \text{DM3} & \text{DM4} & \cdots & \text{DMn} \\ \hline \text{DM1} & - & & & & & \\ \hline \text{DM2} & & - & & & & \\ \hline \text{DM3} & & & - & & & \\ \hline \text{DM4} & & & & \text{+ or 0} & & \\ \hline \vdots & & & & & \cdots & \\ \hline \text{DMn} & & & & & & \text{+ or 0} \\ \hline \end{array}$	Remove all cases in which three DMs simultaneously have negative attitudes toward themselves and other DMs have only neutral and positive attitudes toward themselves, no matter what attitudes all DMs have toward each other.	$\frac{n(n-1)(n-2)}{6}\left[1\times 2^{(n-3)}\times 3^{n(n-1)}\right]$
4	Total Number of Infeasible Attitude Cases		[1] + [2] + [3]
5	Total Number of Attitude Cases		$3^{\wedge n}$
6	Total Number of Feasible Attitude Cases		$3^{\wedge n}$ – {[1] + [2] + [3]}

Because carrying out stability analysis manually for the whole set of feasible attitude cases is impossible, a reasonable strategy is needed in order to reduce the number of feasible attitude cases. One such strategy is to select only the feasible attitude cases that are most relevant to the negotiation situation under investigation. In other words, determining the most relevant attitude cases depends on each specific negotiation situation and how the DMs involved are expected to behave before and during the negotiation. This strategy helps the analyst focus on a small number of attitude cases with the highest degree of relevance so that going through the whole set of feasible cases is unnecessary.

With respect to the brownfield negotiation case study, the historical background was reviewed and the attitudes of the three DMs toward one another were studied. A list of the six most relevant attitude cases was then determined, and these six cases were examined using attitude-based stability analysis. The six attitude cases and a brief description of each are listed in Table 5.9.

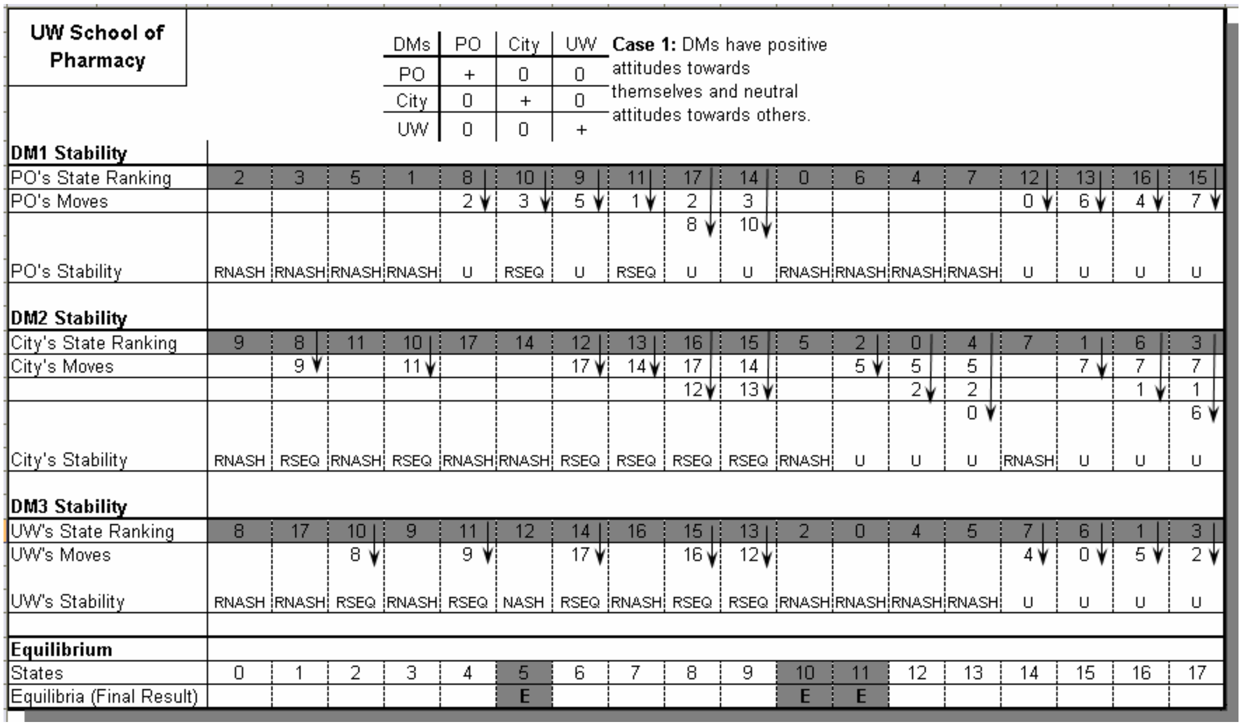
5.6.5. Analysis of the Most Relevant Attitude Cases

Once the six most relevant attitude cases were selected, the stability analysis within the paradigm of GMCR was carried out in order to obtain equilibrium states or possible solutions for the conflict. A separate attitude-based stability analysis was carried out for each of the six attitude cases selected, as shown in the stability tableaus displayed in Figures 5.4, 5.5, 5.6, 5.7, 5.8, and 5.9. It is noted that the tableaus used in the conventional GMCR were expanded in order to include the attitude based stability analysis.

Table 5.9: The Most Relevant Attitude Cases for the School of Pharmacy Negotiations

Case	Attitude Matrix	Description
1	$\begin{array}{cccc} & \text{PO} & \text{City} & \text{UW} \\ \text{PO} & + & 0 & 0 \\ \text{City} & 0 & + & 0 \\ \text{UW} & 0 & 0 & + \end{array}$	DMs have positive attitudes toward themselves and neutral attitudes toward others.
2	$\begin{array}{cccc} & \text{PO} & \text{City} & \text{UW} \\ \text{PO} & + & - & 0 \\ \text{City} & - & + & 0 \\ \text{UW} & 0 & 0 & + \end{array}$	DMs have positive attitudes toward themselves and neutral attitudes toward others except PO and The City that have negative attitudes toward each other.
3	$\begin{array}{cccc} & \text{PO} & \text{City} & \text{UW} \\ \text{PO} & + & - & + \\ \text{City} & 0 & + & 0 \\ \text{UW} & - & - & + \end{array}$	PO has negative toward The City, positive attitudes toward itself and UW; The City has positive attitudes toward itself, neutral attitudes toward others; and UW has positive attitudes toward itself, negative attitudes toward others.
4	$\begin{array}{cccc} & \text{PO} & \text{City} & \text{UW} \\ \text{PO} & + & - & - \\ \text{City} & - & + & - \\ \text{UW} & - & - & + \end{array}$	DMs have positive attitudes toward themselves and negative attitudes toward others.
5	$\begin{array}{cccc} & \text{PO} & \text{City} & \text{UW} \\ \text{PO} & + & + & + \\ \text{City} & + & + & + \\ \text{UW} & + & + & + \end{array}$	DMs have positive attitudes toward themselves and positive attitudes toward others.
6	$\begin{array}{cccc} & \text{PO} & \text{City} & \text{UW} \\ \text{PO} & + & - & - \\ \text{City} & + & + & 0 \\ \text{UW} & + & + & + \end{array}$	PO has positive attitudes toward itself, negative attitudes toward others; The City has neutral attitudes toward UW, positive attitudes toward others; and UW has positive attitudes toward itself and others.

PO: PolyOne City: The City of Kitchener UW: University of Waterloo



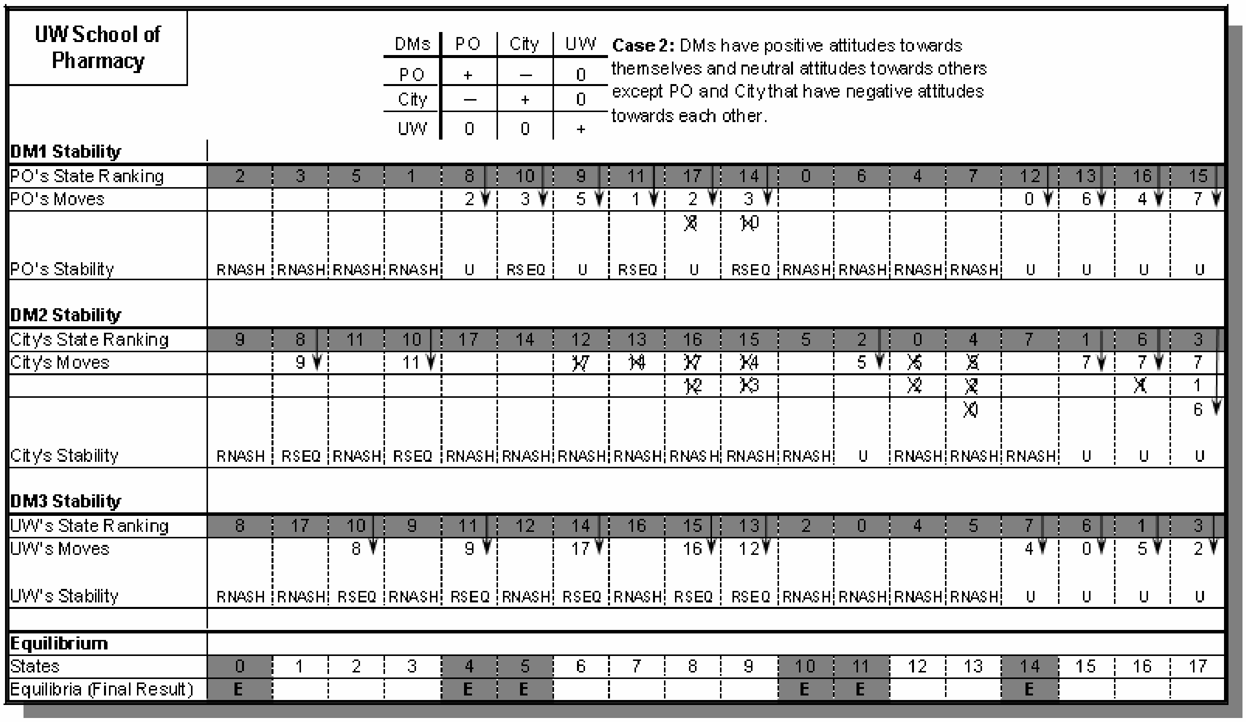
UW School of Pharmacy

DMs	PO	City	UW
PO	+	0	0
City	0	+	0
UW	0	0	+

Case 1: DMs have positive attitudes towards themselves and neutral attitudes towards others.

DM1 Stability																		
PO's State Ranking	2	3	5	1	8	10	9	11	17	14	0	6	4	7	12	13	16	15
PO's Moves					2↓	3↓	5↓	1↓	2	3					0↓	6↓	4↓	7↓
									8↓	10↓								
PO's Stability	RNASH	RNASH	RNASH	RNASH	U	RSEQ	U	RSEQ	U	U	RNASH	RNASH	RNASH	RNASH	U	U	U	U
DM2 Stability																		
City's State Ranking	9	8	11	10	17	14	12	13	16	15	5	2	0	4	7	1	6	3
City's Moves		9↓		11↓			17↓	14↓	17	14		5↓	5	5		7↓	7	7
									12↓	13↓			2↓	2			1↓	1
														0↓				6↓
City's Stability	RNASH	RSEQ	RNASH	RSEQ	RNASH	RNASH	RSEQ	RSEQ	RSEQ	RSEQ	RNASH	U	U	U	RNASH	U	U	U
DM3 Stability																		
UW's State Ranking	8	17	10	9	11	12	14	16	15	13	2	0	4	5	7	6	1	3
UW's Moves			8↓		9↓		17↓		16↓	12↓					4↓	0↓	5↓	2↓
UW's Stability	RNASH	RNASH	RSEQ	RNASH	RSEQ	NASH	RSEQ	RNASH	RSEQ	RSEQ	RNASH	RNASH	RNASH	RNASH	U	U	U	U
Equilibrium																		
States	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Equilibria (Final Result)						E					E	E						

Figure 5.4: Stability Tableau for Case 1



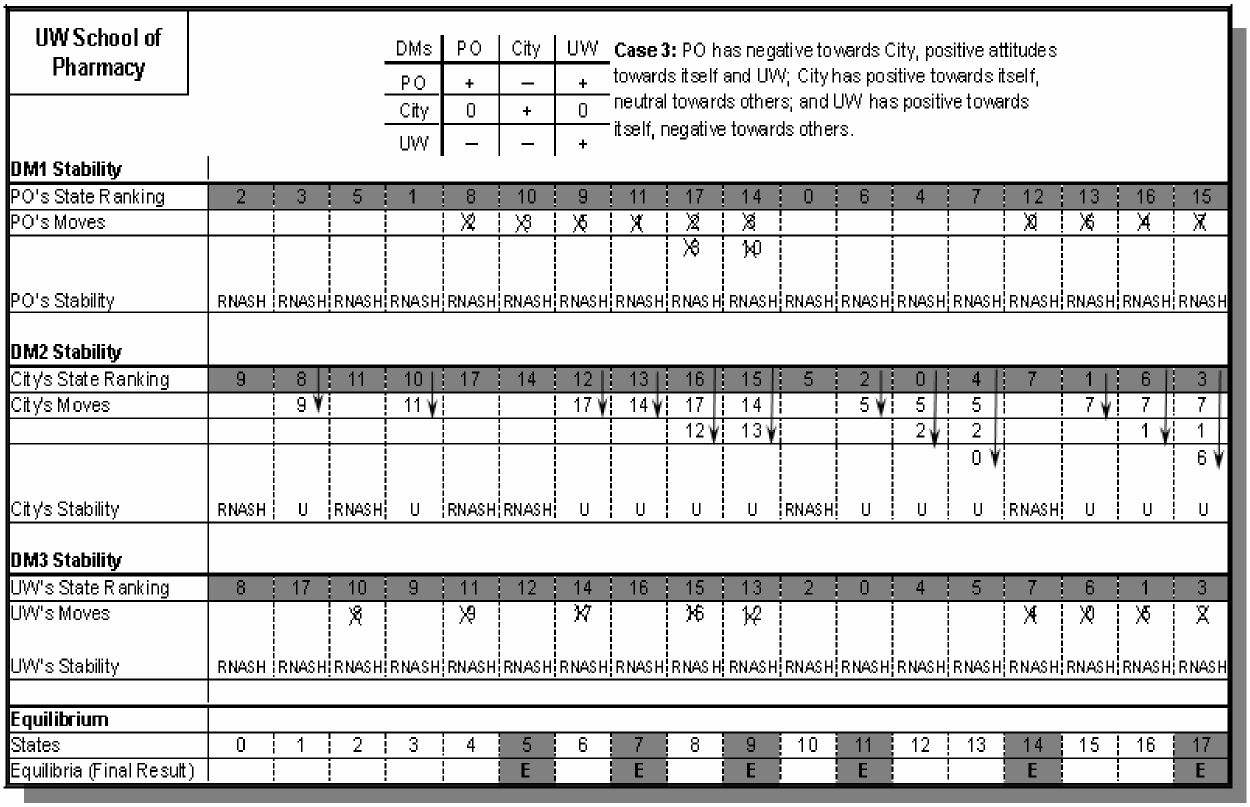
UW School of Pharmacy

DMs	PO	City	UW
PO	+	–	0
City	–	+	0
UW	0	0	+

Case 2: DMs have positive attitudes towards themselves and neutral attitudes towards others except PO and City that have negative attitudes towards each other.

DM1 Stability																		
PO's State Ranking	2	3	5	1	8	10	9	11	17	14	0	6	4	7	12	13	16	15
PO's Moves					2↓	3↓	5↓	1↓	2↓	3↓					0↓	6↓	4↓	7↓
									~~8~~	~~10~~								
PO's Stability	RNASH	RNASH	RNASH	RNASH	U	RSEQ	U	RSEQ	U	RSEQ	RNASH	RNASH	RNASH	RNASH	U	U	U	U
DM2 Stability																		
City's State Ranking	9	8	11	10	17	14	12	13	16	15	5	2	0	4	7	1	6	3
City's Moves		9↓		11↓			~~17~~	~~14~~	~~17~~	~~14~~		5↓	~~5~~	~~5~~		7↓	7↓	7
									~~12~~	~~13~~			~~2~~	~~2~~			~~1~~	1
														~~0~~				6↓
City's Stability	RNASH	RSEQ	RNASH	RSEQ	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	U	RNASH	RNASH	RNASH	U	U	U
DM3 Stability																		
UW's State Ranking	8	17	10	9	11	12	14	16	15	13	2	0	4	5	7	6	1	3
UW's Moves			8↓		9↓		17↓		16↓	12↓					4↓	0↓	5↓	2↓
UW's Stability	RNASH	RNASH	RSEQ	RNASH	RSEQ	RNASH	RSEQ	RNASH	RSEQ	RSEQ	RNASH	RNASH	RNASH	RNASH	U	U	U	U
Equilibrium																		
States	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Equilibria (Final Result)	E				E	E					E	E			E			

Figure 5.5: Stability Tableau for Case 2



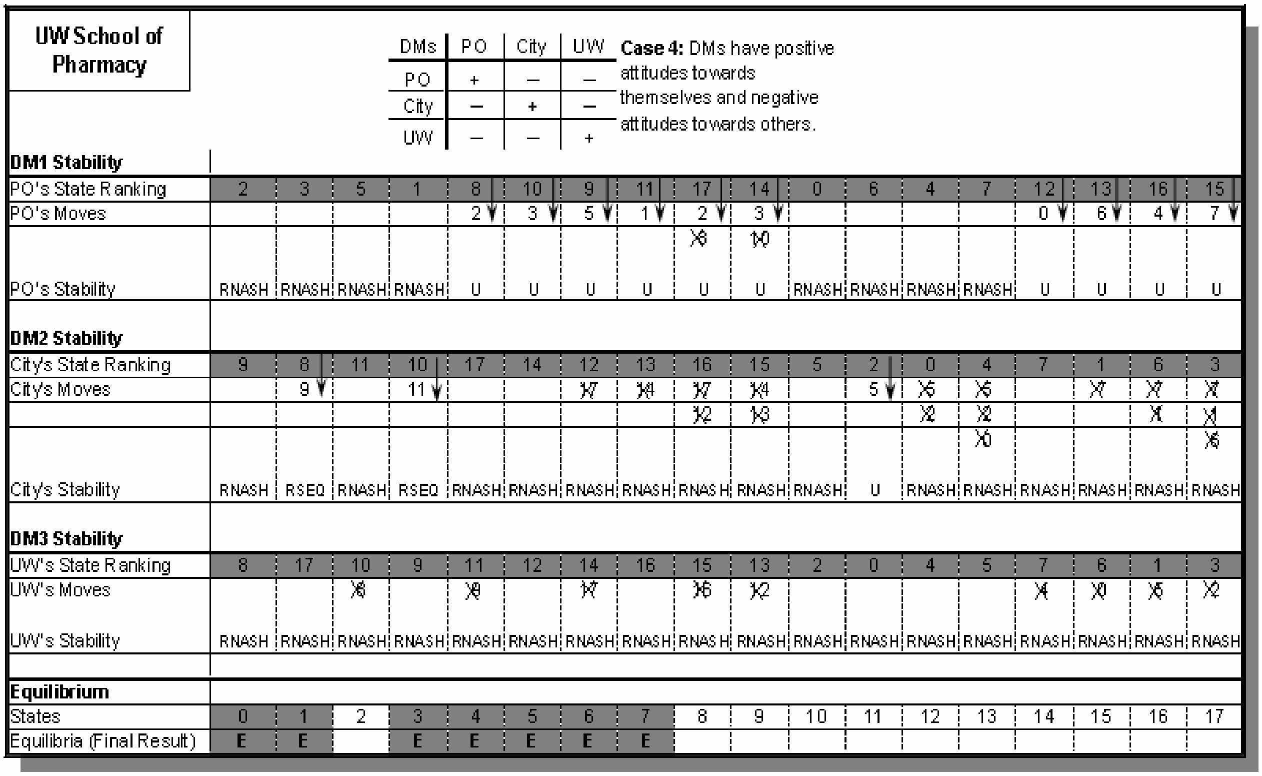
UW School of Pharmacy

DMs	PO	City	UW
PO	+	–	+
City	0	+	0
UW	–	–	+

Case 3: PO has negative towards City, positive attitudes towards itself and UW; City has positive towards itself, neutral towards others; and UW has positive towards itself, negative towards others.

DM1 Stability																		
PO's State Ranking	2	3	5	1	8	10	9	11	17	14	0	6	4	7	12	13	16	15
PO's Moves					~~2~~	~~3~~	~~5~~	~~1~~	~~2~~	~~3~~					~~0~~	~~6~~	~~4~~	~~7~~
									~~8~~	~~10~~								
PO's Stability	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH
DM2 Stability																		
City's State Ranking	9	8	11	10	17	14	12	13	16	15	5	2	0	4	7	1	6	3
City's Moves		9 ↓		11 ↓			17 ↓	14 ↓	17	14		5 ↓	5	5		7 ↓	7	7
									12 ↓	13 ↓			2 ↓	2			1 ↓	1
														0 ↓				6 ↓
City's Stability	RNASH	U	RNASH	U	RNASH	RNASH	U	U	U	U	RNASH	U	U	U	RNASH	U	U	U
DM3 Stability																		
UW's State Ranking	8	17	10	9	11	12	14	16	15	13	2	0	4	5	7	6	1	3
UW's Moves			~~8~~		~~9~~		~~17~~		~~16~~	~~12~~					~~4~~	~~0~~	~~5~~	~~2~~
UW's Stability	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH
Equilibrium																		
States	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Equilibria (Final Result)						E		E		E		E			E			E

Figure 5.6: Stability Tableau for Case 3



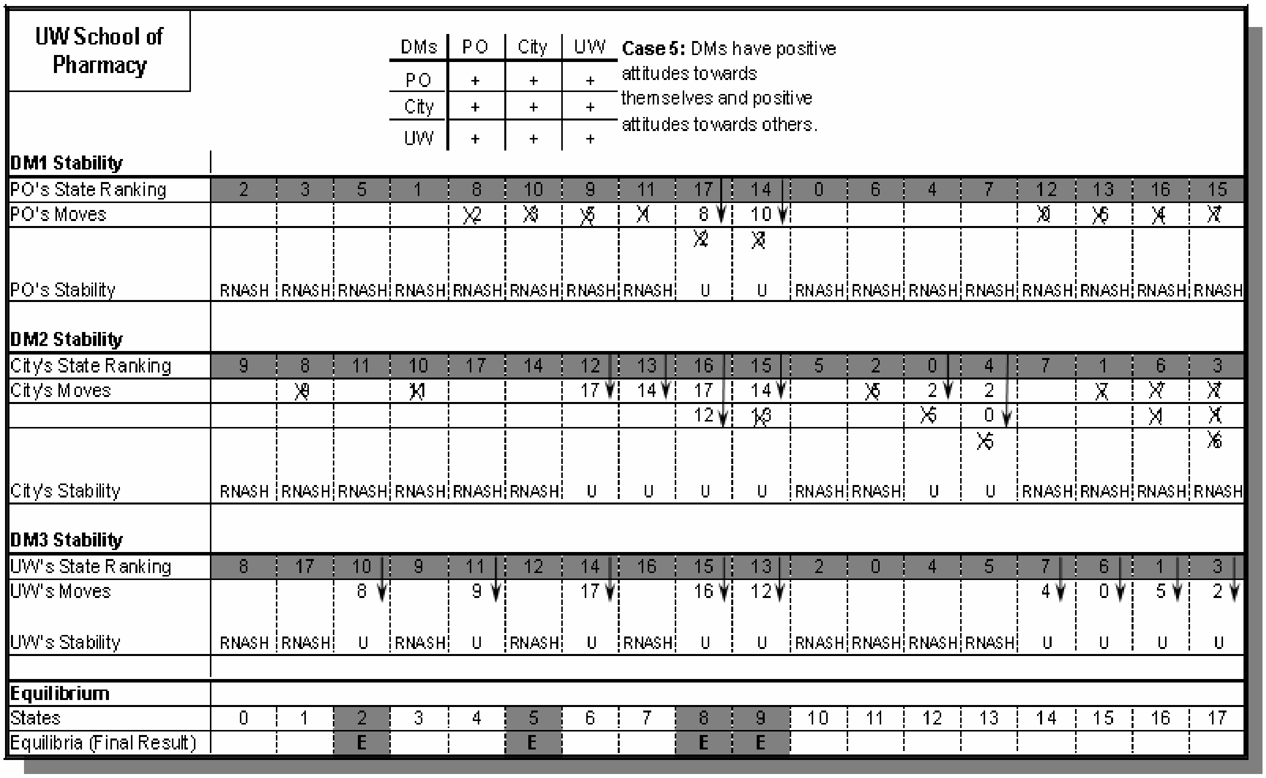
UW School of Pharmacy

DMs	PO	City	UW
PO	+	–	–
City	–	+	–
UW	–	–	+

Case 4: DMs have positive attitudes towards themselves and negative attitudes towards others.

DM1 Stability																		
PO's State Ranking	2	3	5	1	8	10	9	11	17	14	0	6	4	7	12	13	16	15
PO's Moves					2 ↓	3 ↓	5 ↓	1 ↓	2 ↓	3 ↓					0 ↓	6 ↓	4 ↓	7 ↓
									~~8~~	~~10~~								
PO's Stability	RNASH	RNASH	RNASH	RNASH	U	U	U	U	U	U	RNASH	RNASH	RNASH	RNASH	U	U	U	U
DM2 Stability																		
City's State Ranking	9	8	11	10	17	14	12	13	16	15	5	2	0	4	7	1	6	3
City's Moves		9 ↓		11 ↓			~~17~~	~~14~~	~~17~~	~~14~~		5 ↓	~~5~~	~~5~~		~~7~~	~~7~~	~~7~~
									~~12~~	~~13~~			~~2~~	~~2~~			~~1~~	~~1~~
														~~0~~				~~6~~
City's Stability	RNASH	RSEQ	RNASH	RSEQ	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	U	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH
DM3 Stability																		
UW's State Ranking	8	17	10	9	11	12	14	16	15	13	2	0	4	5	7	6	1	3
UW's Moves			~~8~~		~~9~~		~~17~~		~~16~~	~~12~~					~~4~~	~~0~~	~~5~~	~~2~~
UW's Stability	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH
Equilibrium																		
States	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Equilibria (Final Result)	E	E		E	E	E	E	E										

Figure 5.7: Stability Tableau for Case 4



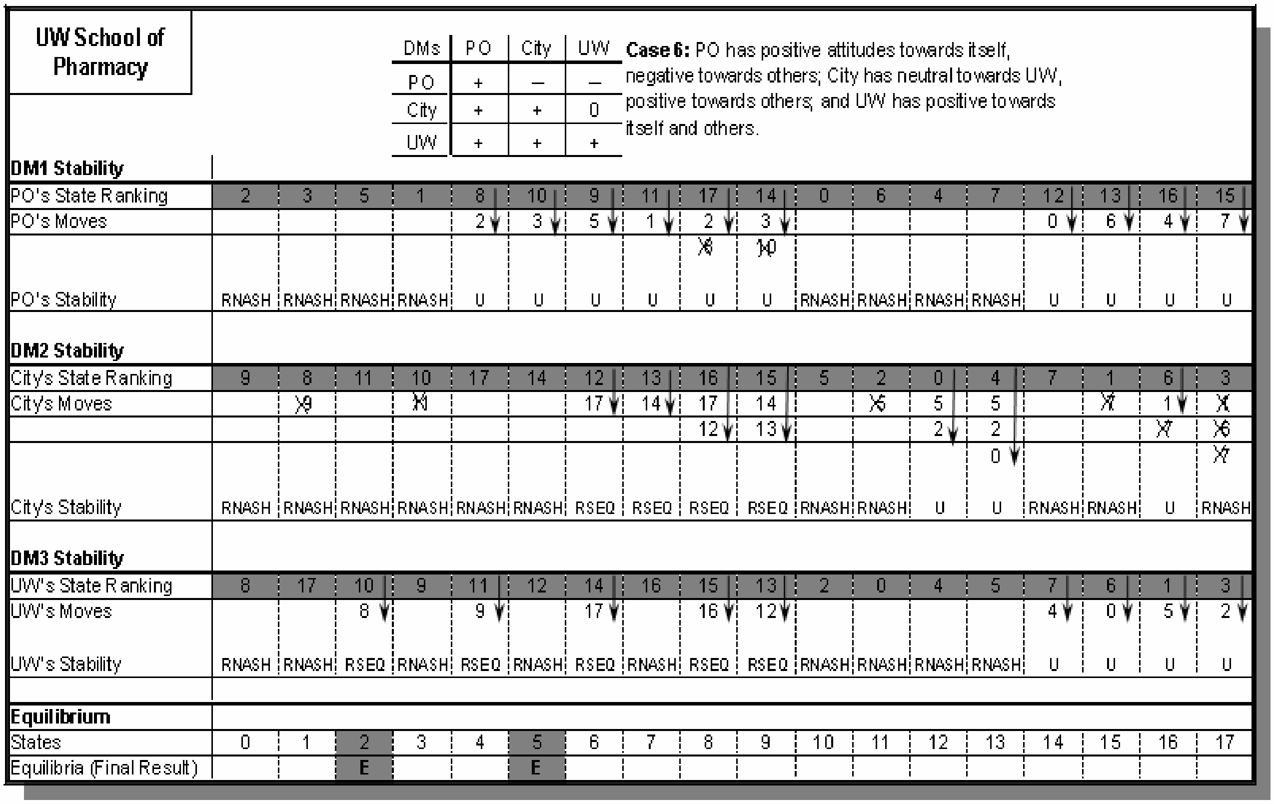
UW School of Pharmacy

DMs	PO	City	UW
PO	+	+	+
City	+	+	+
UW	+	+	+

Case 5: DMs have positive attitudes towards themselves and positive attitudes towards others.

DM1 Stability																		
PO's State Ranking	2	3	5	1	8	10	9	11	17	14	0	6	4	7	12	13	16	15
PO's Moves					~~2~~	~~3~~	~~5~~	~~1~~	8 ↓	10 ↓					~~0~~	~~6~~	~~4~~	~~7~~
									~~2~~	~~3~~								
PO's Stability	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	U	U	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH
DM2 Stability																		
City's State Ranking	9	8	11	10	17	14	12	13	16	15	5	2	0	4	7	1	6	3
City's Moves		~~9~~		~~11~~			17 ↓	14 ↓	17	14 ↓		~~5~~	2 ↓	2		~~7~~	~~7~~	~~7~~
									12 ↓	~~13~~			~~5~~	0 ↓			~~1~~	~~1~~
														~~5~~				~~6~~
City's Stability	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	U	U	U	U	RNASH	RNASH	U	U	RNASH	RNASH	RNASH	RNASH
DM3 Stability																		
UW's State Ranking	8	17	10	9	11	12	14	16	15	13	2	0	4	5	7	6	1	3
UW's Moves			8 ↓		9 ↓		17 ↓		16 ↓	12 ↓					4 ↓	0 ↓	5 ↓	2 ↓
UW's Stability	RNASH	RNASH	U	RNASH	U	RNASH	U	RNASH	U	U	RNASH	RNASH	RNASH	RNASH	U	U	U	U
Equilibrium																		
States	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Equilibria (Final Result)			E			E			E	E								

Figure 5.8: Stability Tableau for Case 5



UW School of Pharmacy

DMs	PO	City	UW
PO	+	–	–
City	+	+	0
UW	+	+	+

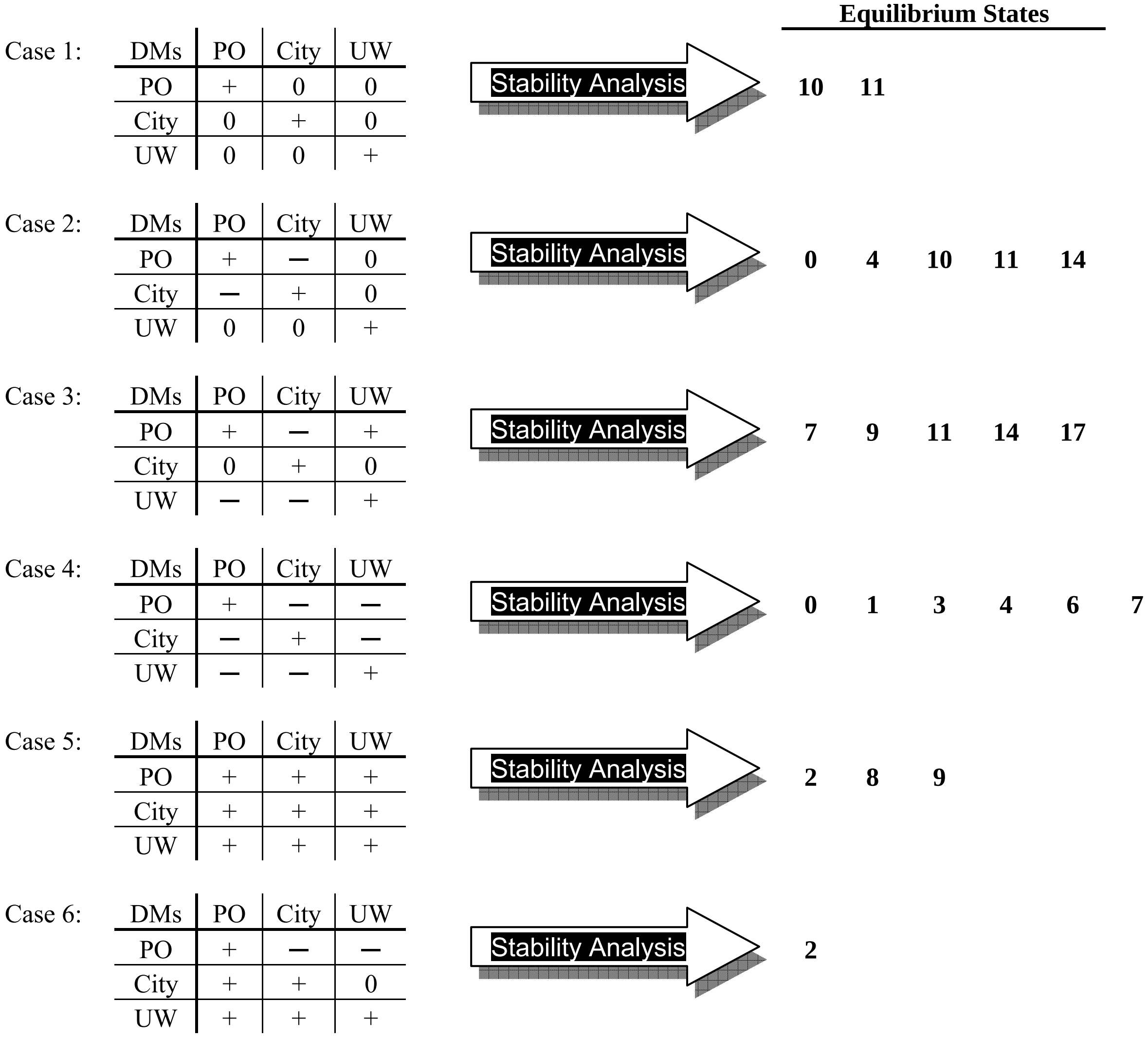
Case 6: PO has positive attitudes towards itself, negative towards others; City has neutral towards UW, positive towards others; and UW has positive towards itself and others.

DM1 Stability																		
PO's State Ranking	2	3	5	1	8	10	9	11	17	14	0	6	4	7	12	13	16	15
PO's Moves					2 ↓	3 ↓	5 ↓	1 ↓	2 ↓	3 ↓					0 ↓	6 ↓	4 ↓	7 ↓
									~~8~~	~~10~~								
PO's Stability	RNASH	RNASH	RNASH	RNASH	U	U	U	U	U	U	RNASH	RNASH	RNASH	RNASH	U	U	U	U
DM2 Stability																		
City's State Ranking	9	8	11	10	17	14	12	13	16	15	5	2	0	4	7	1	6	3
City's Moves		~~9~~		~~11~~			17 ↓	14 ↓	17	14		~~5~~	5	5		~~7~~	1 ↓	~~1~~
									12 ↓	13 ↓			2 ↓	2			~~7~~	~~6~~
														0 ↓				~~7~~
City's Stability	RNASH	RNASH	RNASH	RNASH	RNASH	RNASH	RSEQ	RSEQ	RSEQ	RSEQ	RNASH	RNASH	U	U	RNASH	RNASH	U	RNASH
DM3 Stability																		
UW's State Ranking	8	17	10	9	11	12	14	16	15	13	2	0	4	5	7	6	1	3
UW's Moves			8 ↓		9 ↓		17 ↓		16 ↓	12 ↓					4 ↓	0 ↓	5 ↓	2 ↓
UW's Stability	RNASH	RNASH	RSEQ	RNASH	RSEQ	RNASH	RSEQ	RNASH	RSEQ	RSEQ	RNASH	RNASH	RNASH	RNASH	U	U	U	U
Equilibrium																		
States	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Equilibria (Final Result)			E			E												

Figure 5.9: Stability Tableau for Case 6

5.7. Discussion of the Results of the Stability Analyses

As shown in Figures 5.4 – 5.9, because of the changes in the attitudes of the DMs, six different sets of equilibrium states were obtained, corresponding to the six different attitude cases. The equilibrium states involved in each attitude case represent possible strategic solutions for the multi-DM negotiations. These six sets of resulting decision options were then evaluated in order to determine the best strategic decision. The resulting equilibrium states are shown in Figure 5.10, and a brief discussion of each case follows.



Case 1:

DMs	PO	City	UW
PO	+	0	0
City	0	+	0
UW	0	0	+

10 11

Case 2:

DMs	PO	City	UW
PO	+	–	0
City	–	+	0
UW	0	0	+

0 4 10 11 14

Case 3:

DMs	PO	City	UW
PO	+	–	+
City	0	+	0
UW	–	–	+

7 9 11 14 17

Case 4:

DMs	PO	City	UW
PO	+	–	–
City	–	+	–
UW	–	–	+

0 1 3 4 6 7

Case 5:

DMs	PO	City	UW
PO	+	+	+
City	+	+	+
UW	+	+	+

2 8 9

Case 6:

DMs	PO	City	UW
PO	+	–	–
City	+	+	0
UW	+	+	+

2

Figure 5.10: The Results of the Stability Analysis for the Six Attitude Cases

It should be mentioned that of the 14 resulting equilibrium states, equilibrium state 5 is a false equilibrium and is not listed in Figure 5.10 because state 5 is the only state that remained RNASH stable for all DMs and in all attitude cases (Fraser and Hipel, 1984). In other words, state 5 is the only state in which the involved DMs can not find one move from that state to other states in the six attitude cases investigated above. Moreover, status quo analysis shows that state 5 can not be an equilibrium state (Li et al., 2004). Status quo analysis addresses concerns about the reachability of any specified state from the status quo. Since the Graph Model introduces the notion of irreversible moves (DMs can cause the conflict to move in one direction but not the other) to reflect no-return decisions, the reachability of a state from a status quo is not automatically guaranteed. If some of the moves are specified as irreversible at the modeling stage, it is possible that some of the predicted resolutions cannot be attained from the status quo state, and an analyst may safely eliminate such states (e.g., equilibrium state 5) from the potential resolution list and concentrate on a refined list (Li et al., 2004).

5.7.1. Qualitative Analysis of the Findings

Case 1: Figure 5.4 displays a scenario in which the DMs have positive attitudes toward themselves and neutral attitudes toward other DMs. The stability analysis was carried out, and outcomes (i.e., equilibrium states) 10 and 11 resulted for this case. Outcome 10 is more preferred to outcome 11 for PolyOne and UW. Also, outcome 11 is more preferred to outcome 10 for the city. Outcome 10 means that PolyOne (PO) cleans up the property in the short term (fast), UW refuses to construct a school of pharmacy in the remediated site, and the City does not take legal action against PO and provides incentives for both PO and UW. Outcome 11 means that PO cleans up the land quickly, the City neither takes legal action nor provides incentives, and UW does not construct a school of pharmacy on the site. It should be mentioned that an attitude case (i.e., case 0) was considered in which the DMs have neutral attitudes towards themselves and towards other DMs. When such attitude case was considered, the same individual stability and equilibrium results, as for case 1, were obtained.

<u>Case 2</u>: Figure 5.5 shows another attitude case in which the DMs have positive attitudes toward themselves and neutral attitudes toward others except for PO and the City who have negative attitudes toward each other. In this attitude case, the resulting set of possible solutions includes outcomes 0, 4, 10, 11, and 14. A comparison of the sets of outcomes for Case 1 and Case 2 (Figure 5.10) indicates that Case 2 is identical to Case 1, except that the set of solutions also includes outcomes 0 and 4. Considering the DMs' state rankings, it can be seen that of the set of outcomes in Case 2, outcomes 0 and 4 are the least preferred for all DMs. Outcome 4, for example, means that PO cleans up the land over the long term (slow), the City does not provide incentives and takes legal action against PO, and UW constructs a school of pharmacy without any incentives. It can be concluded that because two DMs (i.e., PO and the City) have negative attitudes toward each other, the set of possible solutions in Case 2 has been

shifted to the right side of the DMs' state rankings which represent states that are less preferred by the DMs.

Case 3: Figure 5.6 shows the attitude scenario that occurs when PO has a negative attitude toward the City, a positive attitude toward itself and UW; the City has a positive attitude toward itself, a neutral attitude toward the others; and UW has a positive attitude toward itself, and a negative attitude toward the others. This attitude scenario examines a situation in which the attitudes of the DMs toward one another are not consistent. In other words, while DM 1 has a negative attitude toward DM 2, it is possible that DM 2 has a positive attitude toward DM 1. For example, PO has a negative attitude toward the City; whereas the City has a neutral attitude toward PO, as shown in Figure 5.6. In addition, when UW has a negative attitude toward the others, PO and the City have positive and neutral attitudes toward UW, respectively. The resulting set of possible solutions for Case 3 includes outcomes 7, 9, 11, 14, and 17. According to the DMs' state rankings, some of the outcomes are less preferred and some are more preferred so that no single outcome is the most beneficial for all DMs. A comparison of the sets of outcomes in Cases 2 and 3 shows that outcome 7 appears in Case 3, in which the DMs have more hostile attitudes toward one another than in Case 2 (i.e., Case 2 has two negative symbols (─) in its attitude matrix, whereas Case 3 has three negative symbols (─) in its attitude matrix, as shown in Figures 5.5 and 5.6, respectively). Outcome 7 is also the only outcome that is the least beneficial outcome for all DMs. Outcome 7 means that PO cleans up the land, the City does not provide incentives and takes legal action against

PO, and UW does not construct a school of pharmacy. The reason that this outcome is the least preferred can be explained by the legal action taken by the City. In other words, the DMs least prefer the costly and lengthy litigation involved in taking a conflict case to court. It can be concluded from this attitude scenario that because of the inconsistency in the attitudes of the DMs toward one another, a less coherent set of outcomes is obtained, and as a result, some outcomes are shifted to the left side (more preferred) and some outcomes are shifted to the right side (less preferred) of the DMs' state rankings. In this case, it is very hard for an analyst to provide a single beneficial solution for the DMs involved in the strategic negotiations.

Case 4: Figure 5.7 shows an attitude scenario in which the DMs have a positive attitude toward themselves and a negative attitude toward the other DMs. This case represents the most hostile attitude scenario in which all the DMs involved have negative attitudes toward one another. The resulting set of outcomes for this attitude scenario consists of outcomes 0, 1, 3, 4, 6, and 7. A comparison of the six sets of outcomes, which correspond to the six attitude cases, indicates that the set of outcomes in Case 4 is the worst set of outcomes resulting from the attitude-based stability analysis. In other words, considering the DMs' state rankings, the resulting outcomes have been shifted substantially to the left side of the state ranking for each DM. For example, outcome 3 is the least preferred state in the state rankings of the City and UW (Table 5.10). Moreover, outcomes 0, 4, 6, and 7 include a situation in which the City takes legal action, which is the least preferred action for all the DMs. It can be concluded that when the DMs involved in the strategic negotiations possess a negative attitude toward one another, the resulting outcomes represent the least beneficial decisions for the DMs involved.

Case 5: Figure 5.8 shows an attitude scenario in which the DMs have a positive attitude toward themselves and a positive attitude toward one another: the opposite of the previous case (Case 4) in which the DMs have a negative attitude toward one another. The stability analysis for case 5 results in a set of outcomes 2, 8, and 9. This set is shifted to the far left side of the DMs' state rankings and are therefore more preferred by the DMs. With such an attitude scenario, outcome 8, for example, is the most preferred outcome for UW, the second most preferred outcome for the city, and the fifth most preferred outcome for PO. Outcome 8 means that PO cleans up the land fast, the city does not take legal action against PO and provides incentives for PO and UW, and UW constructs a school of pharmacy on the decontaminated site. It can be concluded that, in multi-DMs brownfield negotiations, when the DMs possess positive attitudes toward one another, more beneficial outcomes result and the DMs have a better opportunity to agree on one outcome at the strategic level and then continue with detailed negotiations at the tactical level. It should be mentioned that if the level of information indicates that the DMs indeed have positive attitudes toward one another, outcome 8 can be considered as potential final solution to the negotiations at the strategic level. Further discussion has been provided in Subsection 5.7.2.

Case 6: Figure 5.9 shows an attitude scenario in which PO has a positive attitude toward itself and a negative attitude toward the others, the city has a neutral attitude toward UW and a positive attitude toward itself and PO, and UW has a positive attitude toward itself and the others. This attitude scenario examines how the outcome of the negotiation changes when a DM (e.g., PO) that has a negative attitude negotiates with the other DMs (e.g., the City and UW) that have a positive attitude. The resulting set of outcomes is limited to outcome 2. Considering the DMs' state rankings, it can be observed that outcome 2 is more preferred by PO and less preferred by the City and UW and that, it is very difficult the DMs involved to reach mutual agreement with this attitude case. It can be concluded that when DM 1 has a negative attitude toward DM 2 and DM 3, but DM 2 and DM 3 have a positive attitude toward DM 1, only a few outcomes can be resulted from negotiations, and the outcomes mostly benefit DM 1. There is also a low likelihood that the DMs will agree on one outcome as a possible solution.

The qualitative analysis of the above six attitude cases indicates that the resulting outcomes in case 4 are more hostile for all DMs and may therefore be less preferred. On the other hand, the resulting outcomes in case 5 are more beneficial for all DMs and may therefore be more preferred if the level of negotiation information is sufficient to indicate that all DMs involved indeed have had positive attitudes toward one another. As well, of the 14 resulting equilibrium outcomes, some are repeated in some of the attitude cases. For example, outcome 11 resulted in cases 1, 2, and 3. As mentioned in Chapter 4, the frequency with which a state becomes a possible solution in different attitude cases may indicate that the state is a stable state and that no matter how the attitudes of the DMs change, the stable state can still result as an equilibrium state (outcome). As a result, the likelihood of such stable states becoming the best strategic outcome of the negotiations is increased. It should be noted, however, that the attitudes of the DMs can significantly influence the final outcome of the strategic negotiations. Therefore, to assess the impact of the DMs' attitudes on the choice of the final strategic solution, a quantitative analysis was conducted, as explained in the following subsection.

5.7.2. Quantitative Analysis of the Findings

Qualitative analysis of the resulting equilibrium states is a common procedure in the conventional GMCR. However, when the number of resulting equilibrium states is increased, it is cumbersome to qualitatively recommend one possible solution to the conflict. Therefore, to support the qualitative analysis of the stability results discussed in the previous subsection, quantitative analysis was also conducted for the brownfield case study negotiations as an ad hoc analysis. The objective was to provide quantitative measures 1) to show how different types of DMs' attitudes can influence their level of satisfaction with the multilateral negotiations conducted in the case study and 2) to provide a complementary tool for the qualitative approach in order to determine the most beneficial strategic decision resulting from the negotiation. To achieve these objectives, attitude case 6 (Figure 5.10), for example, was considered and the quantitative analysis was carried out using the proposed framework shown in Figure 5.11. The following steps were involved in developing the quantitative approach.

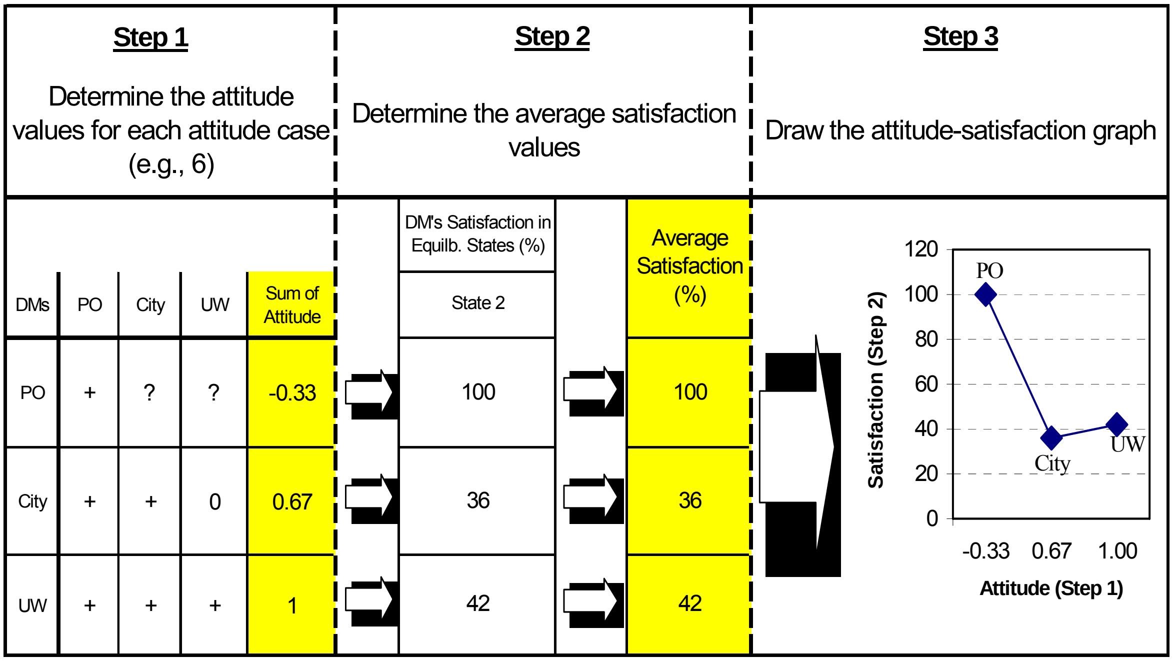


Figure 5.11: The Proposed Framework for the Quantitative Analysis

5.7.2.1. Step 1: Determine the attitude values

In each attitude case, the DMs possess positive, neutral, or negative attitudes toward themselves and one another. In the proposed approach, the qualitative attitudes (i.e., positive, neutral, and negative) are transferred to quantitative values so that a value of +0.33 is assigned to a positive attitude (+), a value of 0.00 is assigned to a neutral attitude (0), and a value of -0.33 is assigned to a negative attitude (-). With respect to attitude case 6, for example, the attitude value for each DM would be algebraically calculated as follows, and the results of which are shown in the Attitude column in Table 5.10 as well as in Step 1 in Figure 5.11.

PO Value = (+0.33) + (-0.33) + (-0.33) = -0.33

The City Value = (+0.33) + (+0.33) + (0.00) = +0.67

UW Value = (+0.33) + (+0.33) + (+0.33) = +1.00

Table 5.10: Attitude Values for Attitude Case 6

DMs	PO	City	UW	Attitude
PO	+	–	–	-0.33
City	+	+	0	0.67
UW	+	+	+	1.00
			Sum:	**1.33**

5.7.2.2. Step 2: Determine the average satisfaction values

The value of DM’s satisfaction represents the degree of the DM’s preference for a state. The more preferred a state for a DM, the higher the satisfaction value for the state. Values of 100 and 1 represent the highest and lowest percentage of a DM’s satisfaction level, respectively. Table 5.4 is used in order to assign a satisfaction value to a DMs’ state ranking. First, a satisfaction value between 1 and 100 is assigned to each state of each DM’s state ranking. Accordingly, the highest satisfaction value (100) is assigned to the most preferred state and the lowest satisfaction value (1) is assigned to the least preferred state, with other values at a decreasing rate of 100/17 being assigned to the rest of states from left to right for each DM, as shown in Table 5.11. It is assumed in this situation that there is a fixed rate of satisfaction between the two adjacent states with respect to all of the DMs. As an alternative approach, it would be possible to assign different satisfaction values to the states with a variable rate. Because of the connection between a DM's satisfaction and preference in this research, the satisfaction value is sometimes referred to as the preference value when the influence of the DMs' attitudes is not considered.

Table 5.11: Satisfaction Values for States in the DMs' State Rankings

DMs		Satisfaction and State Rankings																	
		Most Preferred --→ Least Preferred																	
Poly One	Satisfaction	100	94	88	83	77	71	65	59	53	48	42	36	30	24	18	12	7	1
	State	2	3	5	1	8	10	9	11	17	14	0	6	4	7	12	13	16	15
City	Satisfaction	100	94	88	83	77	71	65	59	53	48	42	36	30	24	18	12	7	1
	State	9	8	11	10	17	14	12	13	16	15	5	2	0	4	7	1	6	3
UW	Satisfaction	100	94	88	83	77	71	65	59	53	48	42	36	30	24	18	12	7	1
	State	8	17	10	9	11	12	14	16	15	13	2	0	4	5	7	6	1	3

One of the benefits of Table 5.11 is that the average satisfaction value of the equilibrium states (Figure 5.10) can be calculated for all DMs. Such a satisfaction value is designated the combined average satisfaction value since the combined satisfaction relates to all DMs. It should be remembered that the equilibrium states constitute a subset of a DM's state ranking. The average satisfaction value for equilibrium states 6 and 8, for example, are calculated as shown in Table 5.12. It is assumed that the DMs have similar valuation for their satisfaction.

The same procedure is carried out in order to calculate the average satisfaction value for the remaining equilibrium states, the results of which are shown in Figure 5.12. It should be mentioned that the average satisfaction value is also referred to as the combined satisfaction value since the value represents the satisfaction level of all DMs.

Table 5.12: The Average Satisfaction Values for Equilibrium States 6 and 8

	PO		**The City**		**UW**	
Equilibrium	8	6	8	6	8	6
Satisfaction	77	36	94	7	100	13
Average Satisfaction for State 8	$\frac{77+94+100}{3}=90$					
Average Satisfaction for State 6	$\frac{36+7+13}{3}=18$					

To facilitate a better understanding of the importance of this approach, the equilibrium states are sorted based on their calculated average satisfaction value. Accordingly, the values and states in Figure 5.12 are replaced and sorted as shown in Figure 5.13. It should be noted that the results shown in Figures 5.12 and 5.13 do not reflect the influence of the attitudes of the DMs and that these figures represent only a regular quantitative preference for the resulting equilibrium states when the DMs equally prefer the states.

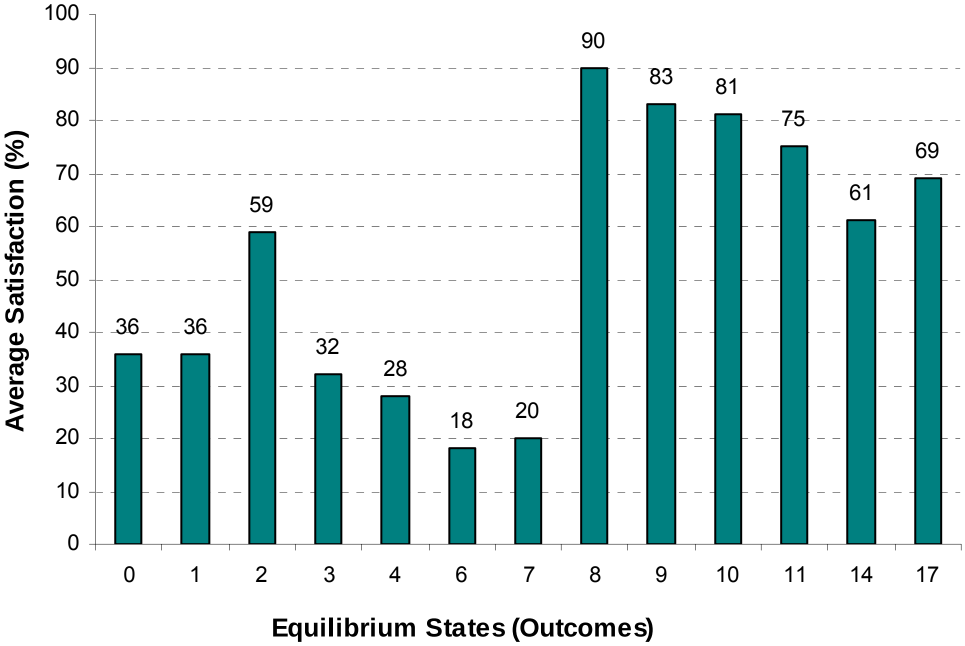


Figure 5.12: Combined Satisfaction Level of the Equilibrium States Disregarding the Influence of the DMs' Attitudes

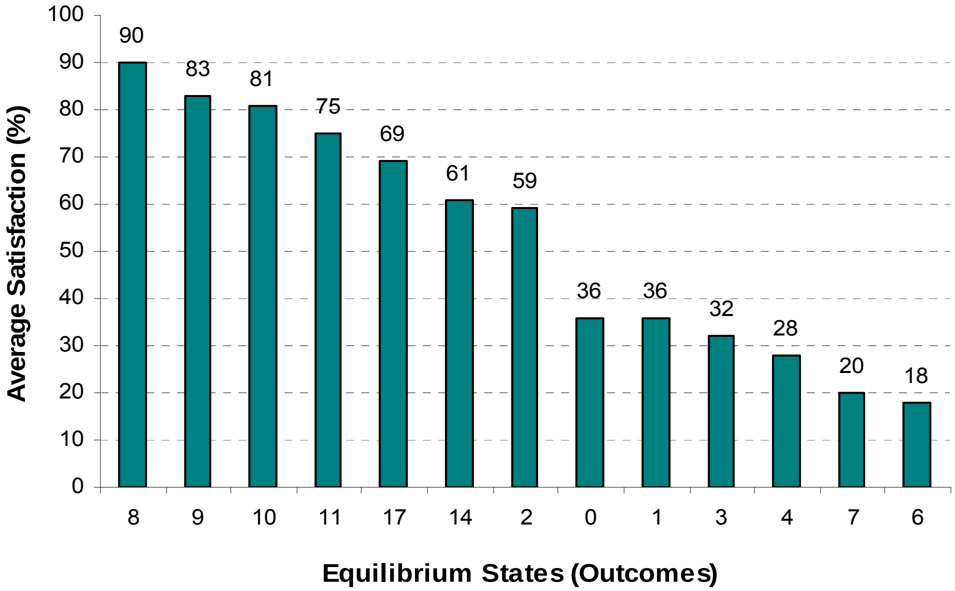


Figure 5.13: Sorted Satisfaction Level of the Equilibrium States Disregarding the Influence of the DMs' Attitudes

Once a satisfaction value is assigned to every state, as shown in Table 5.11, the equilibrium states for each attitude case are considered, and their satisfaction values are calculated. In attitude case 6, for example, the resulting equilibrium state is outcome 2. With respect to equilibrium state 2, satisfaction values of 100, 36, and 42 are determined for Polyone, the City, and UW, respectively. These values are shown in Figure 5.11 (Step 2).

Once the satisfaction level for each equilibrium state has been determined, the average satisfaction value for each DM in each attitude case can be calculated. With respect to attitude case 6, for example, because there is only one equilibrium state, the average satisfaction value for each DM is calculated to be the same as its original value in the attitude case, as shown in Step 2 in Figure 5.11.

5.7.2.3. Step 3: Draw the attitude-satisfaction graph

Once the average satisfaction value is obtained for every DM, the attitude values obtained in Step 1 and the average satisfaction values determined in Step 2 are used to draw an attitude-satisfaction graph. This graph indicates how a DM's attitudes change his or her level of satisfaction and also helps the analyst investigate the position of DMs with respect to every attitude case. In other words, for an attitude-based negotiation involving multiple DMs, the graph shows how much each DM gains when a particular attitude case (which represents the DMs attitudes toward themselves and others) is considered. The attitude-satisfaction graph for attitude case 6, for example, is displayed in Figure 5.14.

The graph shows that when PO possesses an overall negative attitude value of -0.33, PO gains the highest level of satisfaction (100 %). On the other hand, when UW has a very positive attitude (+1), its level of satisfaction reaches the lowest value of 42 %. These results may indicate why attitude case 6 is very encouraging for PO and very discouraging for UW. With respect to the City, although the City's overall attitude value is positive (+0.67), its level of satisfaction is not so high (36 %) and the City may thus not prefer attitude case 6.

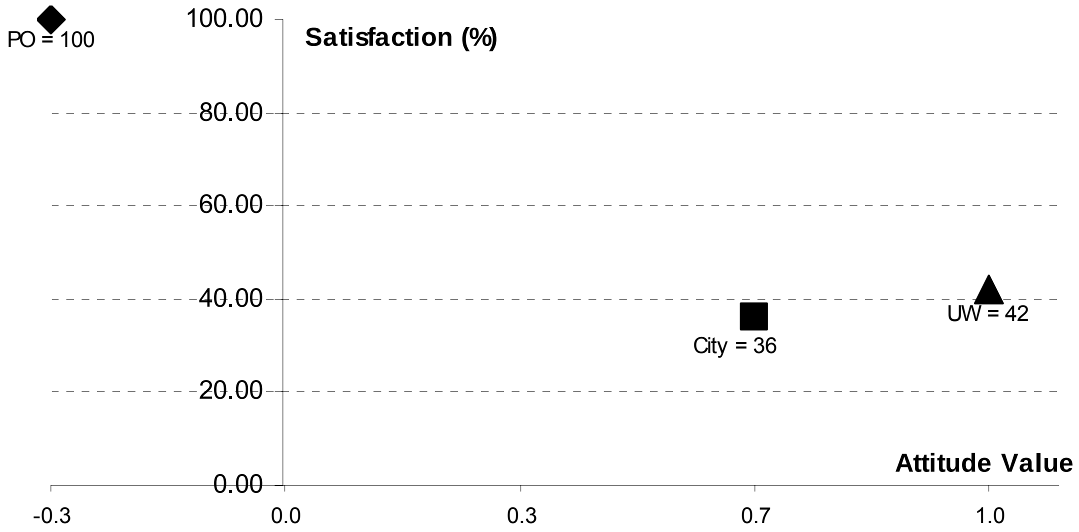


Figure 5.14: The Attitude-Satisfaction Graph for Attitude Case 6

The same quantitative procedure, as explained above for attitude case 6, was carried out for the remaining five attitude cases. The resulting values and attitude matrices are displayed in Table 5.13, and the resulting attitude-satisfaction graphs are shown in Figures 5.15 and 5.16. A brief discussion of each attitude case is also provided below.

Case 1: With respect to attitude case 1, the DMs involved have gained almost the same satisfaction with the same positive attitude value (+0.33), as shown in Figure 5.13. This type of attitude scenario is reasonable and encouraging for the DMs since every DM gains almost equally and no DM loses. It should be noted that the level of satisfaction of the DMs is also reasonable.

Table 5.13: Attitude and Satisfaction Values for Six Attitude Cases

Attitude Case 1

DMs	PO	City	UW	DM's Attitude	Ave. DM's Satisfaction
PO	+	0	0	0.33	59
City	0	+	0	0.33	81
UW	0	0	+	0.33	77

Attitude Case 2

DMs	PO	City	UW	DM's Attitude	Ave. DM's Satisfaction
PO	+	–	0	0.00	50
City	–	+	0	0.00	59
UW	0	0	+	0.33	59

Attitude Case 3

DMs	PO	City	UW	DM's Attitude	Ave. DM's Satisfaction
PO	+	–	+	0.33	50
City	0	+	0	0.33	71
UW	–	–	+	-0.33	67

Attitude Case 4

DMs	PO	City	UW	DM's Attitude	Ave. DM's Satisfaction
PO	+	–	–	-0.33	51
City	–	+	–	-0.33	16
UW	–	–	+	-0.33	18

Attitude Case 5

DMs	PO	City	UW	DM's Attitude	Ave. DM's Satisfaction
PO	+	+	+	1.00	81
City	+	+	+	1.00	77
UW	+	+	+	1.00	75

Attitude Case 6

DMs	PO	City	UW	DM's Attitude	Ave. DM's Satisfaction
PO	+	–	–	-0.33	100
City	+	+	0	0.67	36
UW	+	+	+	1	42

Case 2: In attitude case 2, UW and the City have achieved better level of satisfaction because of UW's positive attitude value. In this case PO and the City have a negative attitude toward each other and PO's overall gain is thus

diminished, whereas UW has gained because of its neutral attitude. In other words, if the DMs possess a negative attitude toward other DMs, they may lose.

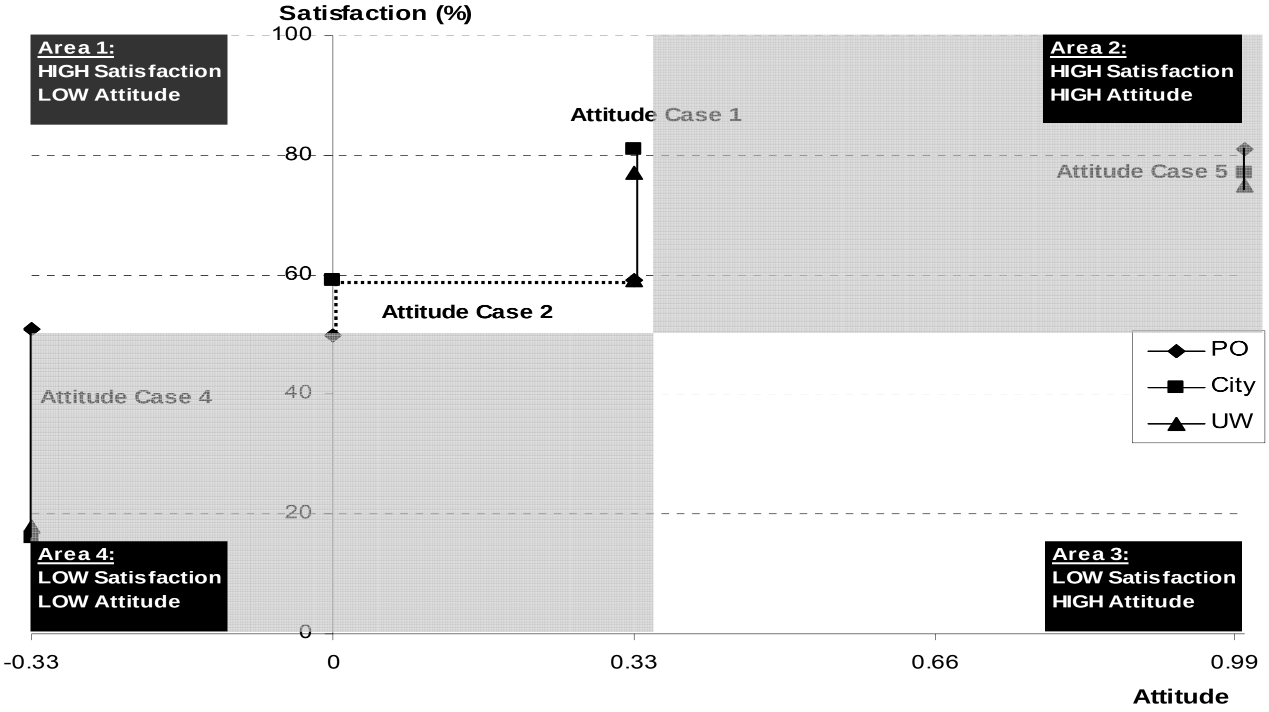


Figure 5.15: Attitude Satisfaction Relationship for Attitude Cases 1, 2, 4, and 5

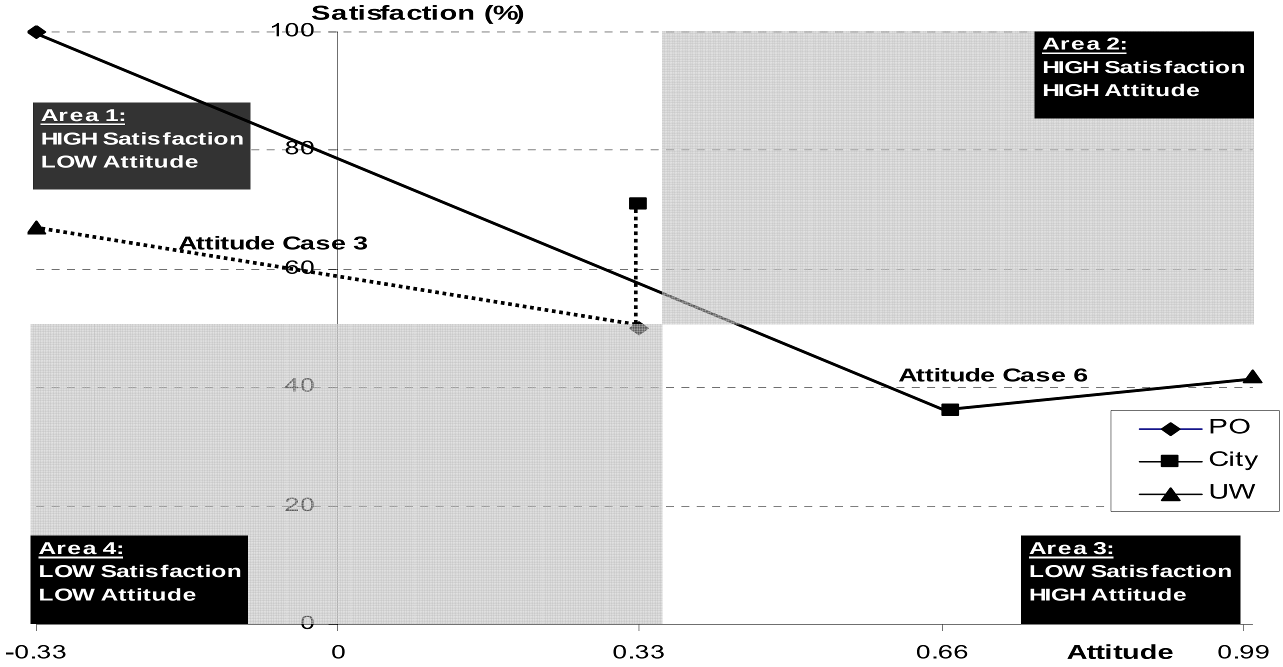


Figure 5.16: Attitude Satisfaction Relationship for Attitude Cases 3 and 6

It should be mentioned that to facilitate the analysis, Figures 5.15 and 5.16 are divided into four distinct areas:

- Areas 1: *low* attitude value and *high* level of satisfaction,
- Area 2: *high* attitude value and *high* level of satisfaction,
- Area 3: *high* attitude value and *low* level of satisfaction, and
- Area 4: *low* attitude value and *low* level of satisfaction.

<u>Case 3</u>: In this case, the City has a neutral attitude toward the other DMs and has therefore gained slightly more than PO and UW. The attitude situation in this case indicates that PO has a positive attitude toward UW, whereas UW has a negative attitude toward PO. In other words, the attitudes of the DMs toward one another are not necessarily logical, and consequently, when UW, for example, has a negative attitude value, its satisfaction level exceeds that of PO whose attitude value is positive.

<u>Case 4</u>: This attitude case is the most hostile attitude scenario, in which the DMs have a negative attitude toward one another and a positive attitude toward themselves. The DMs' attitude values are therefore similarly (-0.33). Interestingly, the PO's satisfaction level is much higher than the City's and UW's. This result means that when the DMs negotiate in a hostile situation, PO can benefit, while UW and the City may lose significantly. Although this situation may be beneficial for PO, it is certainly not preferable for all the DMs involved.

Case 5: This case represents situation opposite to that in Case 4, in which the DMs all have a positive attitude toward one another. Therefore, both their attitude and their satisfaction level have reached the highest value (Figure 5.13). Because all DMs gain almost equally and no DM loses, this situation is very encouraging for DMs who are involved in cooperative negotiations.

Case 6: In this case, PO has a negative attitude toward the other DMs, whereas UW has a positive attitude toward the other DMs. The result of negotiating in this situation is that PO, who has the lowest attitude value (-0.33), has gained significantly, and UW, who has the highest attitude value (+1), has lost considerably, as shown in Figure 5.13. This situation is therefore very useful for DMs who find out that other DMs in negotiations have a positive attitude toward other DMs no matter how the other DMs' attitudes may change during negotiations.

5.7.3. Determining the Most Beneficial Strategic Decision

The results of the qualitative and quantitative analyses explained in the previous subsections were used to determine which equilibrium state is the most beneficial decision option in the multiple-DM brownfield negotiation. In Subsection 5.7.2, the relationship between satisfaction level and the DM's attitude was described from each DM's perspective. Six distinct attitude cases were considered for each of which the satisfaction level of each individual DM was discussed and compared with the levels of satisfaction for the other DMs. In this subsection, the influence of a DM's attitude on the level of satisfaction is analyzed from the perspective of an analyst (e.g., a mediator). In other words, it is assumed that an analyst examines the results regardless of the perspective of each DM, and provides the DMs with advice that indicates the best outcome of the negotiation at the strategic level.

To determine the best strategic solution, the equilibrium states are examined. Table 5.14 shows the resulting values for the DMs' attitude and level of satisfaction and Figure 5.17 shows the six attitude cases represented by gray column bars that list their corresponding equilibrium states. The upward arrow in each column indicates for each attitude case the preference for the equilibrium states, based on Figure 5.13. The dotted line in the graph represents continuous changes and the gray columns represent the discrete changes in the combined level of the DM's satisfaction.

Table 5.14: Values of the DMs' Attitude and Satisfaction

Attitude Case	PO		The City		UW		Sum of DMs' Attitudes	Ave. DMs' Satisfaction
	Attitude	Satisfaction	Attitude	Satisfaction	Attitude	Satisfaction		
1	0.33	59	0.33	81	0.33	77	**1.00**	**72**
2	0	50	0	59	0.33	59	**0.33**	**56**
3	0.33	50	0.33	71	-0.33	67	**0.33**	**63**
4	-0.33	51	-0.33	16	-0.33	18	**-1.00**	**28**
5	1	81	1	77	1	75	**3.00**	**78**
6	-0.33	100	0.67	36	1	42	**1.33**	**59**

The attitude cases and their associated states are placed in the graph based on the average of the satisfaction levels and the algebraic sum of the attitude values for the three DMs. In other words, the values in Figure 5.17 are not calculated for an individual DM, but represent the combined position for all DMs, assuming that the valuation of satisfaction is the same for all the DMs. The satisfaction and attitude values for every attitude case, as shown in Figure 5.17, are determined using the two columns on the right-hand side of Table 5.14 and the matrices shown in Table 5.13. For example, with respect to attitude case 6, the algebraic sum of the attitude values and the average combined satisfaction values are calculated as shown in Table 5.15. It can be noted that the sums of the attitude values for cases 2 and 3 are similar and are both equal to 0.33 (Figure 5.17).

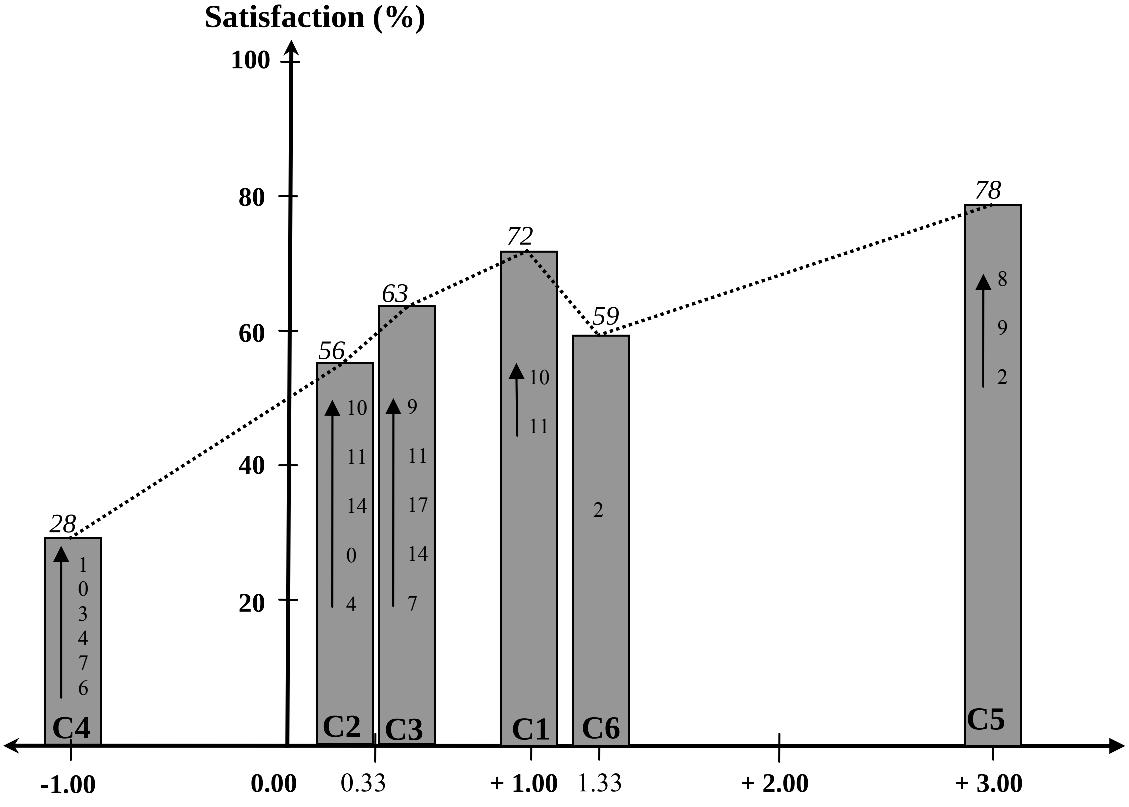


Figure 5.17: Satisfaction and Attitude Values for the Six Attitude Cases

Table 5.15: Combined DMs' Satisfaction and Attitude Values for Attitude Case 6

DMs	PO	The City	UW	Attitude	Satisfaction
PO	+	–	–	-0.33	100
The City	+	+	0	0.67	36
UW	+	+	+	1	42
				SUM = 1.33	**Ave. = 59**

Once the equilibrium states have been prioritized for each attitude case, the overall preference for the equilibrium states can be examined using the following equation:

$$\begin{array}{l}\text{Overall Preference} \\ \text{for an Equilibrium State}\end{array} = \underbrace{\left[\sum_{i=1}^{n}(attitude-based\_satisfaction)\right]}_{\text{Figure 5.17}} \times \underbrace{(preference\_value)}_{\text{Figure 5.13}}$$

where i stands for the attitude case and n represents the number of attitude cases (i.e., n = 6). Using the above equation, the overall preference for every equilibrium state can be calculated as shown in Table 5.16. The sorted results are shown in Figure 5.18.

The overall preference for the equilibrium states includes the attitudes of the DMs and shows the significance of their attitudes in determining the overall outcome of the negotiation (Figure 5.18). As shown in Figure 5.18, equilibrium state 11 has the highest preference value and is therefore the most preferred by the DMs involved in the case study negotiation.

Table 5.16: Overall Preference for the Equilibrium States

Equilibrium State	Calculations	Result
0	(28 + 56) × 36	3,024
1	(28) × 36	1,008
2	(59 + 78) × 59	8,083
3	(28) × 32	896
4	(28 + 56) × 28	2,352
6	(28) × 18	504
7	(28 + 63) × 20	1,820
8	(78) × 90	7,020
9	(63 + 78) × 83	11,703
10	(56 + 72) × 81	10,368
11	(56 + 63 + 72) × 75	14,325
14	(56 + 63) × 61	7,259
17	(63) × 69	4,374

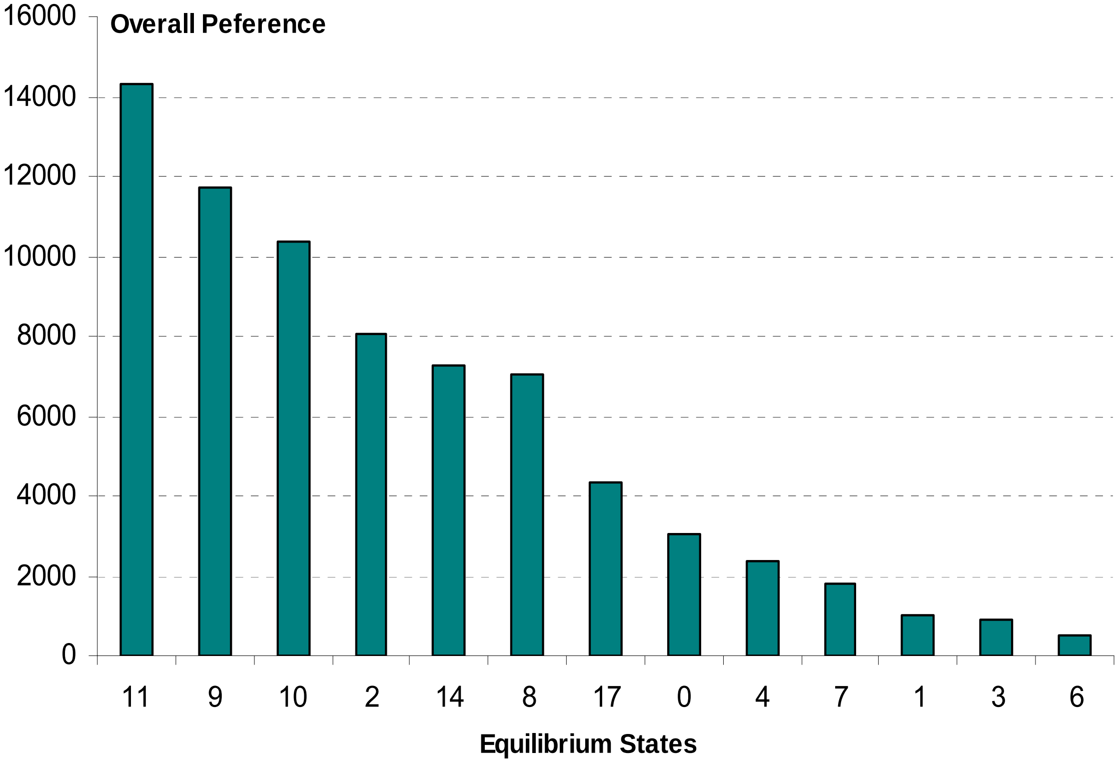


Figure 5.18: Overall Preference Sorted for the Resulting Equilibrium States

State 11 represents a situation in which PO cleans up the site quickly, the City neither provides incentives nor takes legal action, and UW does not construct a school of pharmacy. On the other hand, equilibrium state 6 has the lowest preference value and is therefore least preferred by the DMs. Equilibrium state 6 represents a situation in which PO cleans up the site slowly, the City both provides incentives and takes legal action, and UW does not construct a school of pharmacy in the decontaminated site.

5.7.3.1. Updated level of information for the case study

As mentioned in Section 5.3, this real-life brownfield negotiation was modeled and analyzed based on the amount of information available in 1997 at the beginning of the multiple-DM negotiations among PO, the City and UW. Therefore, the overall results obtained and shown in Figure 5.18 are based on the amount of information available at that time and are also based on the attitudes of the DMs during the negotiations that took place in 1997. Because this particular real-life brownfield negotiation was very lengthy, and many rounds of negotiation took place, a number of new circumstances arose and a great deal of the information (e.g., the attitudes of the DMs toward one another) was updated. Based on this updated information, the brownfield negotiation was therefore remodeled and reanalyzed using the proposed negotiation methodology.

The overall results show that equilibrium state 8 has the highest preference among the DMs involved and therefore, equilibrium state 8 was selected as the final most beneficial decision option at the strategic level for the real-life brownfield negotiation. Equilibrium State 8 represents a situation in which PO cleans up the land quickly, the City does not take legal action and provides incentives for PO and UW, and UW constructs a school of pharmacy on the decontaminated site. This strategic outcome was further negotiated in detail by the DMs at the tactical level. The proposed negotiation methodology at the tactical level involving multiple DMs is discussed in Chapter 7.

5.8. Evolution of the Brownfield Conflict

The best overall strategic decision, obtained in the previous sections was found using the proposed strategic negotiation methodology. The objective of this section is to present discussions about how this real-life conflict was actually resolved over time. To achieve this objective, a state transition chart is used as shown in Table 5.17. To interpret this table, the states are considered from left to right for which an arrow indicates an option change between two adjacent states.

Table 5.17: State Transitions for the Brownfield Conflict

DM	Options	Status Quo State →				Final State
		1	**3**	**14**	**10**	**8**
PolyOne	1) Slow	Y	Y →	N	N	N
	2) Fast	N	N	N →	Y	Y
City	3) Incentives	N →	Y	Y	Y	Y
	4) Legal Action	N	N	N	N	N
UW	5) Construction	N	N	N	N →	Y

As shown in Table 5.17, state 1 represents the status quo of the conflict or the initial situation of the conflict among PolyOne, the city, and UW. It should be noted that state 1 was also one of the equilibrium states when attitude case 4 is assumed (Figure 5.10). Attitude case 4 represents a situation in which the DMs have negative attitudes towards one another. After initial rounds of negotiations, the city decided to provide incentives for the other DMs and, thus, the conflict moved from state 1 to state 3. As shown in Figure 5.10, although state 3 is an equilibrium under attitude case 4, there was less degree of hostility among the DMs at this stage of the conflict. Due to further rounds of negotiations, PolyOne decided to stop slow remediation and, hence, the conflict moved to state 14, which is also one of the equilibrium states for attitude case 2, which represents a situation in which the DMs do not have negative attitudes towards one another anymore.

The cooperative negotiations among the DMs continued until PolyOne decided to remediate the site quickly and, therefore, the conflict moved to state 10 (Table 5.17) which is one of the equilibrium states for attitude cases 1 and 2. In the final stage of cooperative negotiations, UW decided to construct a school of pharmacy at the decontaminated site and eventually the conflict moved to state 8 or the final stage of the conflict, as shown in Table 5.17. State 8 represents the situation that actually occurred with respect to this case study. Therefore, the following two insights can be concluded:

1. The conflict resolution proposed by the negotiation methodology, developed in this chapter, is consistent with the real resolution for this real-life conflict; and
2. As shown in Figure 5.10, state 8 is an equilibrium state for only attitude case 5 which represents a situation when all of the DMs have positive attitudes towards one another. In other words, when the DMs decide to have positive attitudes towards one another, a more beneficial and preferable outcome (i.e., state 8) is reached.

The results of coalition analysis of this real-life case study show that PolyOne and UW have a possible joint move from state 14 to state 8 (Table 5.17). In other words, PolyOne could accept to remediate the brownfield site quickly and at the same time, UW could accept to build a school of pharmacy at the decontaminated site. If such possible move could happen, state 10, which was an equilibrium state, would be unstable because of an equilibrium jump and could not be considered as an equilibrium state when coalition analysis is carried out. More discussion about coalition analysis is provided by Kilgour et al. (2001), Inohara and Hipel, (2008a), and Inohara and Hipel, (2008b).

5.9. Summary

This chapter has presented an attitude-based strategic negotiation methodology that was developed with multiple DMs. The Graph Model for Conflict Resolution (GMCR) was systematically employed in order to study the negotiations at two stages: modeling and analysis. In the modeling stage, the DMs and their options were determined, infeasible states were removed, and the DMs' state rankings were determined. In the analysis stage, stability analysis that considered the attitudes of the DMs was conducted. Algorithms were proposed for removing infeasible attitude cases in negotiations involving multiple DMs. From the resulting feasible attitude cases, six relevant cases were selected, and attitude-based stability analysis was performed.

To discuss the results of the stability analysis, two approaches were applied: qualitative and quantitative. In the qualitative approach, which is the regular method used in GMCR, the resulting equilibrium states were examined and the preference for the states was investigated. To support the qualitative approach, a quantitative approach or an ad hoc analysis has been performed for discussing and examining the resulting equilibrium states in order to determine a quantitative relationship between the DMs' attitudes and the DMs' satisfaction values. The quantitative approach supports the qualitative approach in determining which equilibrium state is most preferred in overall by the DMs when the influence of the attitudes of the DMs on the outcome of the negotiation is taken into account.

The results of the analyses were used to determine the most beneficial outcome of the negotiations at the strategic level. The findings of the discussion were summarized in a proposed equation for obtaining the overall preference for every equilibrium state. Based on the updated amount of information for this real-life brownfield negotiation, the final result indicates that equilibrium state 8 is the most preferred and beneficial decision option at the strategic level. To examine the proposed resolution, a state transition table was developed and the real-life conflict evolution was discussed. The results of the discussions indicate that state 8 represents the situation in which this real-life case study was actually resolved over time and, thus, the proposed resolution can be confirmed. Therefore, equilibrium state 8 will be further negotiated at the tactical level as proposed in Chapter 7.

This research provides valuable insight into the influence of the attitudes of the DMs on the outcome of strategic negotiations. The importance of the research in this chapter lies in proposal of a negotiation methodology that helps DMs determine which attitudes are needed in order to guide negotiations to more preferable decisions and prevent attitudes that can result in unwanted consequences for all participants concerned.

CHAPTER 6:
Attitude-Based Tactical Negotiation Involving Two Decision Makers

6.1. Introduction

This chapter presents the tactical level of the attitude-based negotiation methodology for resolving construction conflicts when two decision makers are involved. To demonstrate the benefits of the proposed methodology, the brownfield negotiation case study, introduced in Chapter 4, is used to develop the methodology. The tactical level of the negotiation methodology complements the strategic level developed in Chapter 4 and therefore, this chapter supports and complements Chapter 4 where a brownfield conflict case study with two Decision Makers (DMs) was used to model the strategic level of the negotiation methodology. The DMs considered their attitudes toward each other and interactively negotiated in order to reach strategies that would improve their own positions in their pair-wise negotiation. Using GMCR approach, three negotiation situations, corresponding to the three types of DMs' attitudes toward each other, were modeled. Three sets of possible outcomes, expressed as strategic solution options for the conflict, were then obtained and evaluated by the DMs in order to find the most beneficial decision. Consequently, the DMs chose equilibrium state 2 as the strategic decision.

Although it is crucial for the DMs to agree on a strategic decision, it is not the final and sustainable solution for the conflict. The strategic decision identifies only a DM’s best course of action and advises the DM which actions are in a particular DM’s interest and which responses would be in the interests of the other DM. The strategic decision does not provide further detailed information (e.g., the specific amount of the redevelopment costs) about the resulting strategic decision for which a detailed mutual agreement can be reached. Therefore, a tactical negotiation approach is needed with the goal of specifying the specific amount of compromise that each DM should make with respect to each conflicting issue. The primary objective of Chapter 6 is to propose such complementary tactical negotiation approach when only two DMs are involved in the tactical negotiation.

6.2. Tactical Negotiation Methodology: A Brownfield Case Study

The brownfield negotiation case study presented in Chapter 4 is further developed in this section to model the tactical negotiation methodology. It is assumed that the negotiations between the DMs (i.e., the owner and the government) in the case study, take place before the start of the brownfield redevelopment. It is also assumed that both DMs have agreed on outcome 2 as the most beneficial strategic outcome obtained from the strategic analysis using GMCR. The development of tactical negotiation consists of some steps demonstrated in the following subsections.

6.2.1. Step 1: Identify Conflicting Issues within the Strategic Decision

The outcomes chosen at the strategic level as possible solutions for the conflict include one or more negotiating issues that can be further negotiated at a more detailed level. The negotiation issues can be continuous (numeric or accurate; as it is in this case study), discrete (nonnumeric or linguistic) or the combination of both continuous and discrete issues. Because the owner and the government have strategically decided to consider outcome 2 as the possible solution, they need to explicitly identify and define the conflicting issues involved in outcome 2 and develop a scale for each issue to represent potential points of compromise between their initial negotiation positions. Outcome 2 represents a scenario in which the owner does not accept liability and sells the property, and the government neither shares the costs nor takes the case to court. Hence, the selling price of the owner’s property is the only numeric negotiation issue involved in outcome 2. It is reasonable to presume that the owner expects to sell her property at the highest price and that the government prefers to buy it at the lowest price. The goal of the proposed negotiation approach is to provide the owner and the government with the amount of compromise needed to reach a reasonable mutual agreement about the selling price. To achieve this goal, the concept of utility function is employed and explained as follows,

6.2.2. Step 2: Determine the DMs’ Utility Functions

Utility analysis deals generally with relative satisfaction from the results of decision making. A utility is a function of an action and the state of the environment (i.e., U (A, E)). If a DM has to rank the consequences in order of his preferences, it is convenient to represent preferences with a utility function and reason indirectly about the preferences by means of these utility functions. Utility function forms represent and describe, for each DM, the tradeoffs between consequences (Keeney and Raiffa, 1976). If an appropriate utility is assigned to each possible consequence and the expected utility of each alternative is calculated, then the best course of action is the alternative with the highest expected utility (Du and Chen, 2007). In other words, when cardinal utility analysis is used, DMs try to maximize their own expected utility, and if they cooperatively negotiate, they strive to maximize their joint expected utility value. More discussions about utility theory are provided by Keeney and Raiffa (1976) and Kilgour (2006).

The key characteristic of utility functions is that they are often monotonic, which means that they are constantly increasing and never decreasing or constantly decreasing and never increasing in value (Keeney and Raiffa, 1976). For example, when a monetary asset position is appropriate for summarizing consequences, most DMs prefer a greater amount to a lesser amount, and the utility function increases monotonically. When the preferences for response time to calls for emergency services are considered, a smaller response time is always preferred to a larger one. Such a utility function is monotonically decreasing.

The expected utility theory was originally developed by Von Neumann and Morgenstern (1944). The theory states that a DM chooses between risky or uncertain prospects by comparing their expected utility values (i.e., the weighted sums obtained by adding the utility values of outcomes multiplied by their respective probabilities). A critical step in many applications of decision analysis under the utility hypothesis is the specification and estimation of a suitable utility function form. For this purpose, several studies have been carried out such as those by Du and Chen (2007), Halter and Dean (1971), Cheung and Suen (2002), Musser et al. (1984), Keeney and Raiffa (1976), Pena-Mora and Wang (1998), Mumpower (1988), Darling and Mumpower (1991), Zuhair et al. (1992), Lin et al. (1974), Kersten (2001), Ji et al. (2007), Zhang et al. (2005), Lin and Chang (1978), and Zeleznikow et al. (2007). The form of a utility function depends on the characteristics of the DMs who have a specific attitude with respect to their risk and preferences for consequences. These attitudes can be mathematically expressed in terms of some of the properties of the DMs' utility functions. For example, a DM's utility function can be considered to be an exponential function such as $f(x) = -e^{-bx}$. If parameter "b" represents the attitude of the DM, then changes in the value of "b" cause changes in the exponential function form, so the expected utility value for the DM changes. If a DM subscribes to a specific attitude, his utility function is restricted to a degree, and hence, the real assessment of his utility function is simplified.

Of the utility functional forms suggested in the literature, the polynomial and exponential functions seem to be the most popular (Zuhair et al., 1992). Buccola (1982) reported that polynomial and exponential functions give the same optimal portfolio. Keeney and Raiffa (1976) extensively studied the form and properties of some utility functions. Kirkwood (1997) believed that exponential utility functions are convenient to work with but they may not reflect all DMs' preferences. Additionally, some researchers, such as Howard (1971) and Savage (1971), considered exponential utility functions as reasonable approximations of the preferences of the DMs. On the other hand, Eliashberg and Winkler (1978) studied the linear and nonlinear forms of utility functions. They reported that some nonlinear graphs, such as polynomial function forms, may provide a better understanding of the effect of utility functions on the solutions to the conflict. In contrast to the exponential utility function, which imposes only risk aversion on all DMs, the polynomial utility functions are more flexible for assigning risk attitudes (either risk aversion or risk preference) to DMs (Zuhair et al., 1992; Pena-Mora and Wang, 1998). Accordingly, the utility function forms proposed for the DMs involved in this case study are derived from Polynomial functions defined in the following:

Polynomial function: $f(x) = a_n x^n + a_{n-1} x^{n-1} + ... + a_1 x + a_0$ [1]

Where f(x) is the utility function, "x" is an input variable, "a" is a real number coefficient, and "n" is the power of function. The value of "n" must be a nonnegative value and the degree of the polynomial function is the highest value for “n” where “a” is not equal to zero. Polynomial utility functions have some appealing properties and characteristics that make them attractive as preferred utility function forms. These characteristics can also help an analyst ensure the accuracy of a selected polynomial function form for a DM. The following properties of polynomial functions were pointed out by Hanoch and Levy (1981):

- The sum of polynomials is a polynomial;
- The product of polynomials is a polynomial;
- The derivative of a polynomial is a polynomial;
- The primitive or anti-derivative of a polynomial is a polynomial;
- The expected utility depends on the skewness of the distribution;
- They provide greater flexibility and better approximation; and
- They can represent risk preference (convexity).

A DM’s preferences and the utility function that accurately reflects these preferences are unique to each DM, so it is unlikely that one form of utility function will correctly predict the behavior of all DMs. At best, a utility function which predicts behavior correctly for the DMs, such as the reformatted polynomial utility function in this study, may be identifiable. However, the DMs may prefer different utility function forms other than polynomial functions. Once the utility function forms are selected for the DMs, the following assumptions are applied for using utility functions in this research (Figure 6.1):

1. Utility values vary with function forms and conflicting issues;
2. Utility values reflect the same monetary valuation for various DMs;

3. DMs rationally make positive concessions when they negotiate; and
4. DMs try to maximize their own payoffs and at the same time, their joint utility value.

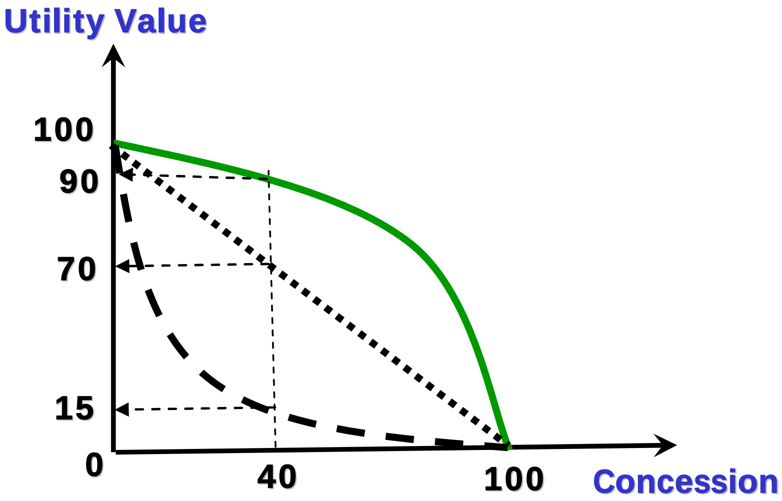


Figure 6.1: Changes in Utility Value with Changes in Function Form

When the proposed utility function is used in this research, some constraints and boundary conditions for the utility function need to be defined (Pena-Mora and Wang, 1998) as mathematically expressed in the following:

1. $\frac{dU}{dx} \prec 0$: The first derivative of the utility function (U) is less than zero. It means that the payoff is always reduced when positive concessions (x) are made.
2. $\frac{d^2U}{dx^2} \leq 0$: The second derivative of the utility function is less than or equal to zero. It means that the marginal payoff in the concession is decreasing, assuming a convex shape for the function (Figure 6.2).

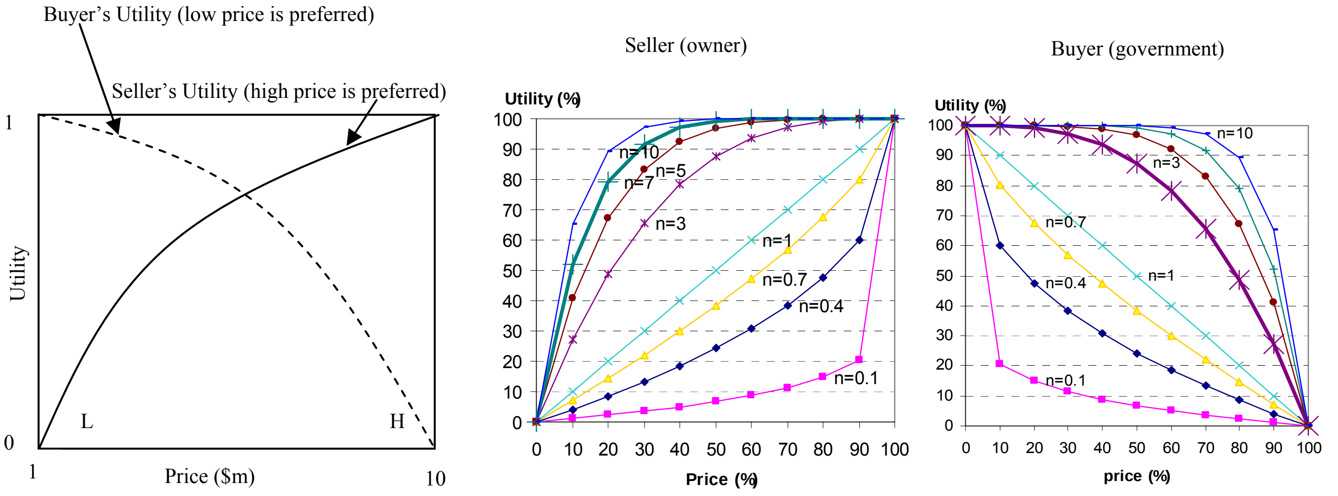
3. $0 \le x \le 100$: The concession value is normalized between zero and 100.
4. $0 \le U \le 100$: The maximum and minimum values for the expected utility are 100 and zero, respectively. It means that if 100% of the payoff has to be made, no compromise should be made (x = 0); that is, U(0) = 100. The payoff is minimized to zero if a complete concession is made; that is, U(100) = 0.

It can be noted that the above assumptions, constraints, and boundary conditions can also assist DMs in selecting an appropriate utility function form which is calibrated based on the DMs' attitudes preferences. Moreover, an analyst (e.g., a mediator) can provide a questionnaire for each DM who can describe their behavior with respect to the other DMs involved in a dispute. The analyst can then collect the questionnaires and select an appropriate form of utility function for every DM involved.

According to the above discussion and with respect to the brownfield negotiation case study, the DMs start their tactical negotiation by selecting a proper utility function. The general form of utility function for the seller (owner) and the buyer (government) is shown in Figure 6.2a. These shapes reflect the seller's highest preference to get the highest price and, at the same time, the buyer's highest preference to pay the lowest price. Generalizing these functions, various polynomial forms can be generated for the owner and the government, as shown in Figures 6.2b and 6.2c, respectively. Because the government's position on the price of the property is in contrast to the owner's position, the government's utility function is a mirror image of the owner's function (Du and Chen, 2007; Pena-Mora and Wang, 1998).

6.2.3. Step 3: Obtain an Integrated Utility Function for Each Issue

Once an appropriate utility function was selected for the owner and the government, the interactive negotiation process between the DMs is modeled. An approach to the modeling is presented below. In this approach, the utility functions of the DMs are integrated to one coordinated system, as shown in Figure 6.3.



$$U_{(owner)} = (100^{1-n})(x^n)$$

$$U_{(government)} = (100^{1-n})(100-x)^n$$

(a) **(b)** **(c)**

Figure 6.2: The DMs' Utility Functions for the "Price" Issue

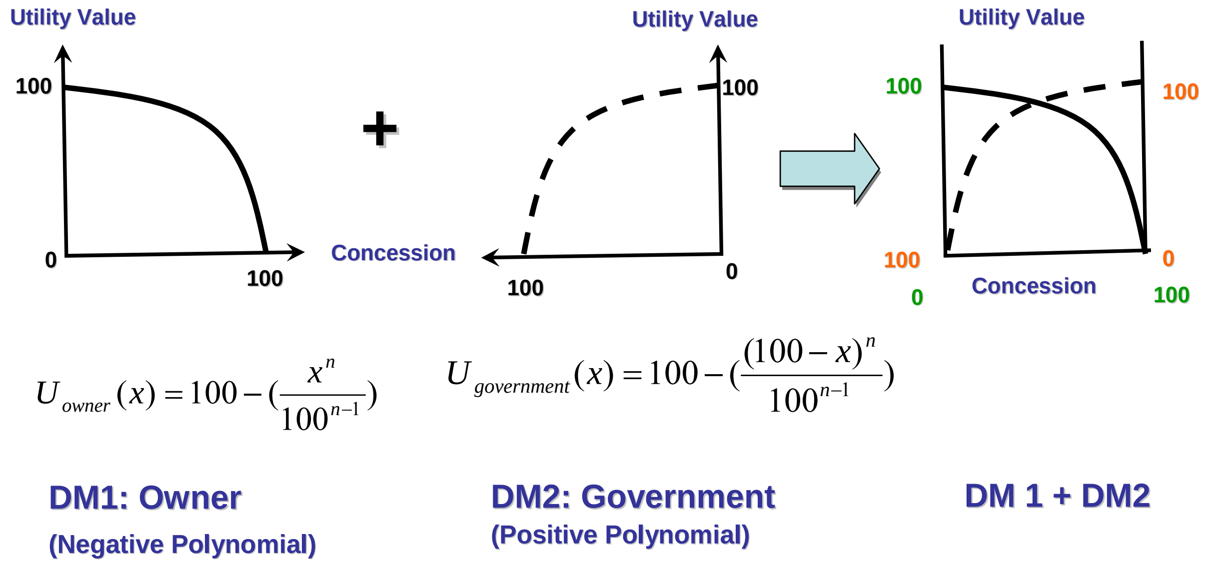


Figure 6.3: The Process of Integrating Utility Function Forms

Once the DMs' utility functions are integrated into a joint coordinate system, the integrated utility function is obtained considering the following assumptions (Darling and Mumpower, 1990):

1. The DMs make an initial offer that maximizes their self-interest payoff for the conflicting issue;
2. After a DM has made a concession for a given issue, he or she never retracts that concession;
3. DMs do not have any time constrains (e.g., negotiation deadline) when they negotiate;
4. The negotiating situation is distributive although the DMs cooperatively continue their offers and counteroffers. Hence, gains for one DM translate into losses (not necessarily equal in magnitude) for the other. Agreement

is needed, and neither DM can abdicate or withdraw from the dispute prior to reaching an agreement;

5. The DMs engage in a negotiation in which each alternately makes a new offer that changes by the same amount each time. Each DM can make only a 10-unit concession on a scale of 0 – 100, and neither can bypass the concession process; and
6. When the integrated utility function reaches the maximum point, the DMs jointly gain the maximum payoff (i.e., satisfaction). The maximum point is used to determine the DMs' concession. No further concessions by either DM with respect to that issue can be made, and the tactical negotiation is concluded.

The above assumptions are used to conduct a pair-wise tactical negotiation using the DMs' utility functions to obtain an integrated utility function. According to the above assumptions, an integrated utility function is used to obtain the exact amount of the concession each DM should make with respect to conflicting issues (Ji, et al. 2007; Mumpower, 1991; Pena-Mora and Wang, 1998).

To generalize and clarify the integrating process, it is assumed that the owner represents DM 1 and the government represents DM 2 as shown in Figure 6.4. Both DMs intend to cooperatively negotiate to obtain the optimum resolution for the conflicting issue (i.e., the owner's selling price). In other words, they want to cooperatively negotiate and sequentially reach to a point in which their joint satisfaction is maximized.

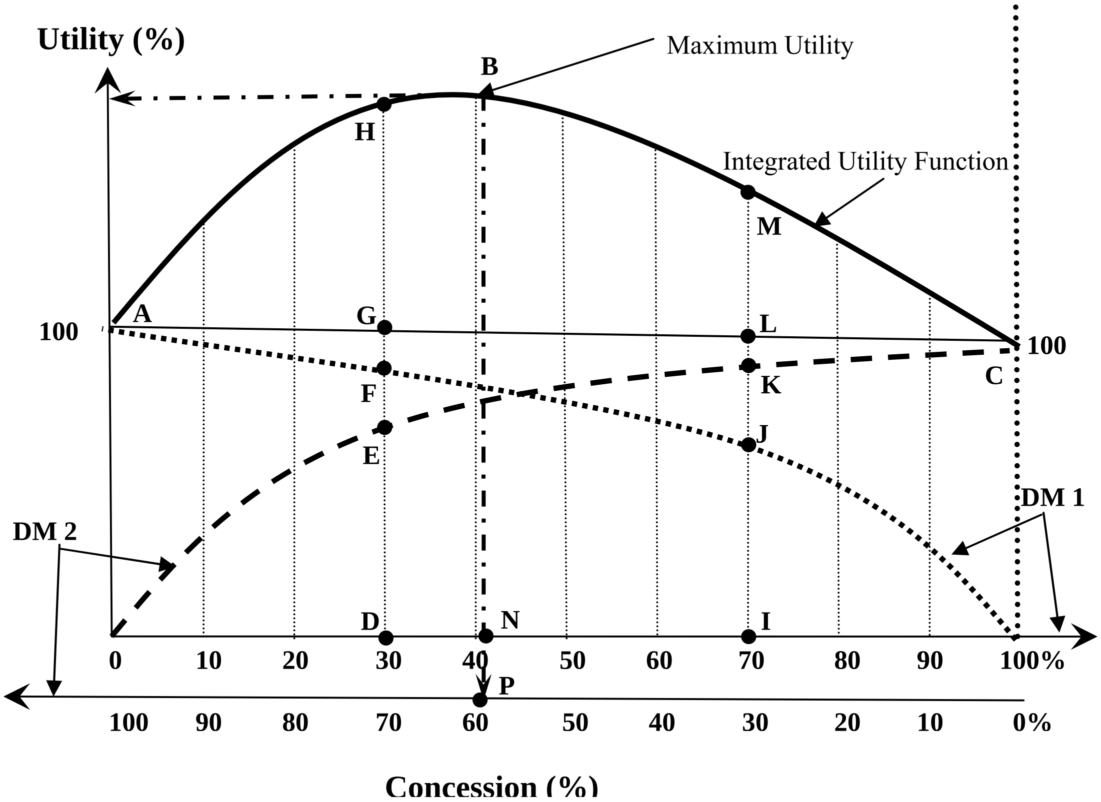


Figure 6.4: Tactical Negotiation Process Involving Two DMs

The negotiation process opens with DM 1 proposing an offer that initially maximizes her individual utility function with a zero concession level, indicated as point A in Figure 6.4. Point A stands for 100% integrated gain for both DMs in which $U_{DM1}(0)$ = 100% gain for DM 1 and $U_{DM2}(100)$ = 0% gain for DM 2. Similarly, DM 2 makes an initial counteroffer to maximize his payoff with zero concession as shown with point C in Figure 6.4. Point C also stands for 100% integrated gain for both DMs in which $U_{DM2}(0)$ = 100% gain for DM 2 and $U_{DM1}(100)$ = 0% gain for DM 1. Points A and C thus constitute the first and last points of the integrated utility function. Because the negotiation process is cooperative and both DMs want to reach an agreement, each time DM 1 proposes a 10% concession, DM 2 also makes a counteroffer with a 10%

concession. Each concession made by each DM corresponds to one point on the integrated utility function. Continuing this process, the integrated utility function shape is sequentially drawn from both sides.

Point H, for example, on the integrated utility function, shown in Figure 6.4, is considered. Line DF in Figure 6.4 represents the marginal payoff gain for DM 1 when a 30% concession is made by DM 1, whereas line DE represents the marginal payoff gain for DM 2 when a 70% concession is made by DM 2. To obtain the position of point H (i.e., the DMs' joint gain or satisfaction), the gains by the DMs are algebraically summed to calculate the height of DH = DE + DF. The same procedure is carried out to obtain point M (Figure 6.4). In this case, I J represents the payoff gain by DM 1 when a 70% concession is made by DM 1 and I K represents gain for DM 2 when a 30% concession is made by DM 2. The position of M is obtained by summing up the gains by the DMs. That is, I M = I J + I K.

Following this procedure, the DMs continue to compromise sequentially until the maximum point on the total utility function (B) is eventually reached. The maximum point represents the settlement point or the point of agreement because both DMs receive the highest joint payoff. This means that both DMs have reached the highest degree of satisfaction for their cooperative effort. The settlement point is used to obtain the concession indicated on the horizontal axis. In Figure 6.4, point N indicates the concession (40%) that DM 1 should make and point P indicates the concession (60%) that DM 2 should make to reach a mutual agreement regarding the selling price of the owner's property. The settlement point can also be mathematically obtained by optimizing the following equation:

$$\bar{U}_i(x_i) = \sum_{j=1}^{k} (W_{ji}) \times U_{ji}(x_i) \qquad [2]$$

Where $\bar{U}_i(x_i)$ is the integrated utility function for issue i, W_{ji} is the weight for issue i of DM j, U_{ji} is the utility function for issue i of DM j, and x_i is the concession variable for issue i.

6.2.4. Step 4: Select the Best Decision Value

Figure 6.5 represents a situation in which the owner prefers to have a cooperative attitude and a desire to sell the property and avoid all risks involved with the brownfield property. Therefore, a utility function with n = 7 is a good representation of the owner who is willing to compromise more than the government. On the other hand, the government prefers to be cooperative but has no great interest in buying the contaminated property. As such, a utility function form with n = 2 is a good representation of the government who is willing to concede less than the owner.

The integrated utility function obtained graphically in Figure 6.5, can be mathematically expressed as follows:

$$U_{\text{int}\,egrated} = (w_o \times U_o) + (w_g \times U_g) \qquad [3]$$

	Govern.	Owner	Integrated
n =	2	7	
x			
0	100	0	100
10	99	52	151
20	96	79	175
30	91	92	183
40	84	97	181
50	75	99	174
60	64	99	164
70	51	100	151
80	36	100	136
90	19	100	119
100	0	100	100

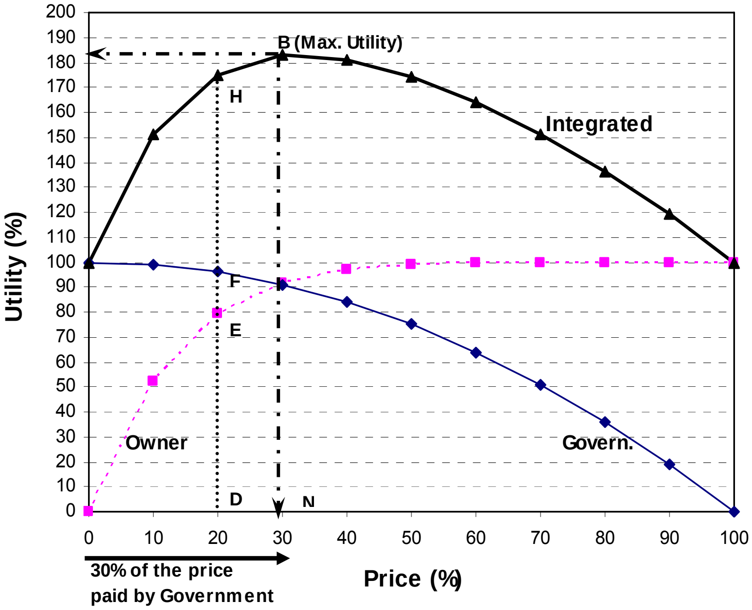


Figure 6.5: Decision with the Maximum Utility Value

Where w_o and w_g stand for the weights assigned to the issue by the owner and the government, respectively, and they both equal 1 since there is only one negotiating issue (the selling price of the owner's property). U_o and U_g also represent the utility functions for the owner and the government, respectively.

As shown in Figure 6.5, the maximum point on the integrated utility function represents the maximum utility value or the maximum level of satisfaction for DMs (Darling and Mumpower, 1990). As shown in Figure 6.5, point B represents the settlement point or the point of agreement because both DMs have reached the highest degree of satisfaction for their cooperative effort in this case. The settlement point is used to obtain the percentage of price (indicated on the horizontal axis) that each DM should pay. In Figure 6.5, point N indicates 30% of the price is paid by the government and 70% (100%-30%) of the price is conceded by the owner. If the initial price of the property is $200,000, for example, the government should pay $60,000 (0.3 × $200,000) and the owner should concede $140,000 (0.7 × $200,000).

As it can be seen, the proposed tactical negotiation methodology assists the DMs to determine the specific concession needed to reach a mutual tactical resolution. It should be mentioned that disagreement point “d” (Kilgour, 2006) was not considered in this case study. The disagreement point represents the DMs’ minimum utility values that the DMs can count on it if they do not reach any agreement. The individual rationality condition is that no DM receives less utility than he or she would receive at “d”. Of course, it is guaranteed that the DMs can achieve “d”. The disagreement point will be considered in the tactical negotiation methodology involving multiple DMs proposed in Chapter 7. Moreover, in this case study only one conflicting issue (i.e., the selling price of the owner’s property) was considered. Considering multiple conflicting issues will be also discussed in Chapter 7.

6.3. Sensitivity to the DMs’ Attitudes

A major contribution of this chapter is related to the incorporation of the DMs’ attitudes into the proposed negotiation methodology. As the influence of DMs’ attitudes on strategic negotiations was investigated in Chapters 4 and 5, it is important to assess the effect of DMs’ attitudes on tactical negotiation outcomes.

In the proposed negotiation methodology, the attitudes of the DMs can be reflected by the power of the reformatted polynomial utility function (n):

$$U(x) = 100 - (\frac{x^n}{100^{n-1}})$$

As shown in Figure 6.2, the shape of utility function changes with the value of "n". When 0 < n < 1, then the polynomial function has a negative convex shape for the government and positive convex shape for the owner. When 1 < n ≤ 10, then the utility function has a negative concave shape for the government and positive concave shape for the owner. The function shape is linear when n = 1. (Ji et al. 2007). It can be noticed that each value of "n" reflects the specific attitude of a DM. Moreover, the function forms when 1 < n ≤ 10 reflect decreasing marginal improvements in the utility as the values of the concessions approach the DM's ideal. Thus, the shape of the integrated utility function form depends on the power of the DMs' utility functions. When the shape of integrated utility function changes, the position of the maximum point on the integrated function also changes, and this change in maximum point indicates a different settlement point and thereby, different concession values for each DM. In other words, the change in the position of maximum point on the integrated utility function indicates that the maximum level of satisfaction for both DMs has changed. Figure 6.6 displays four scenarios in the tactical negotiation case study in which the owner and the government express different attitudes toward each other (i.e., different function forms corresponding to different attitudes were selected). These attitude scenarios are analyzed below. It should be noted that several other scenarios with different utility function forms can arise during negotiations between the two DMs.

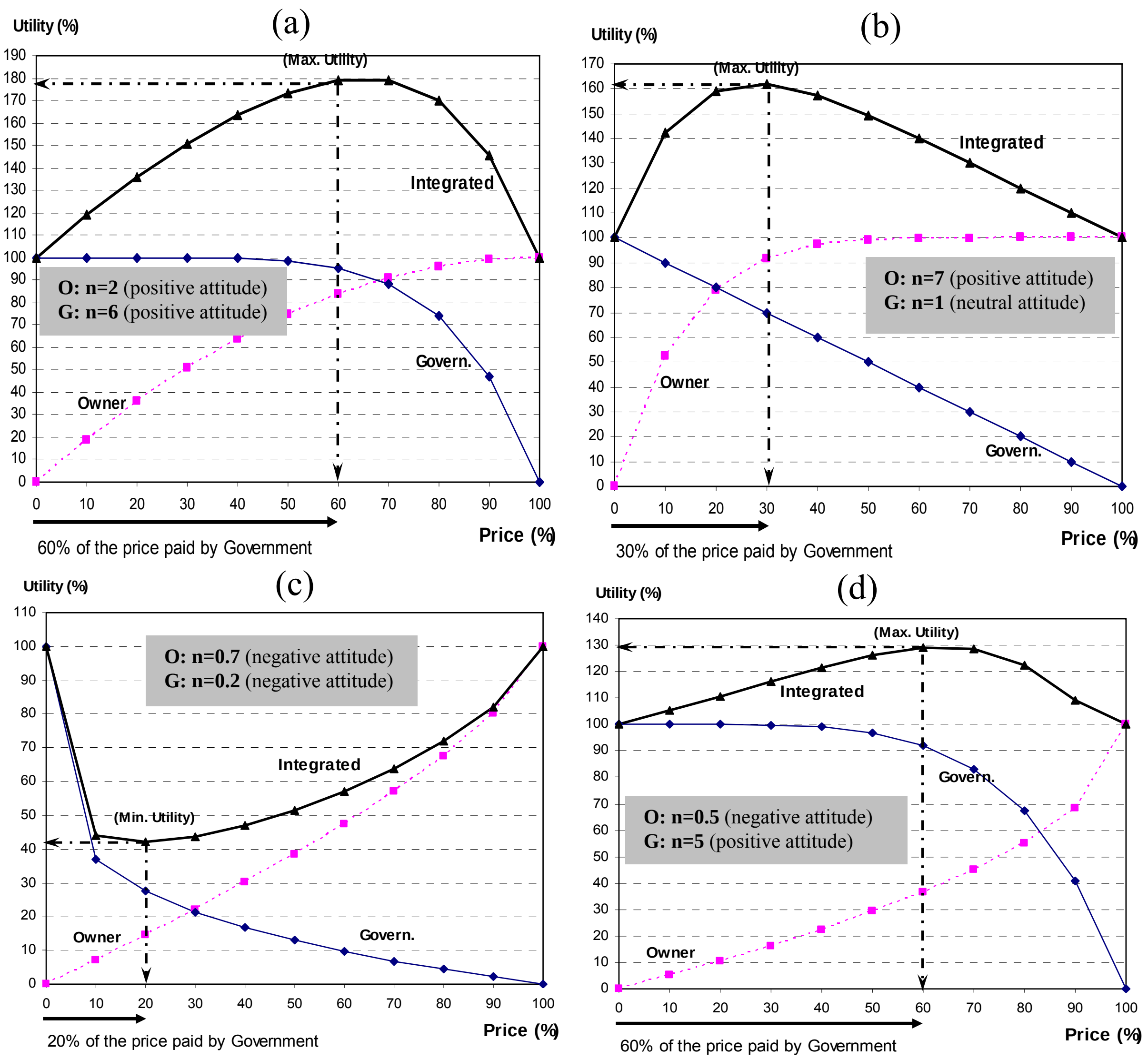


Figure 6.6: The Sensitivity of the DMs' Attitudes to Negotiation Results

Figure 6.6a displays a scenario in which the "n" values of the utility functions are more than one for both DMs. The government has a utility function with n = 6 and that he feels that he can pays even 40% of the price without detriment to his position because if he pays 40% of the price, he can still receive a 100% payoff. On the other hand, the owner has a utility function with the power value of n = 2. Considering the owner's graph, it can be seen that the owner is able to reduce only 10% of the initial price of its property without detriment to her position because if she makes up to a 10% concession to sell its property, she can still receive a 100% payoff. The individual payoff values for both DMs thus start to decrease after 40% and 10% concessions made by the government and the owner, respectively. It can be concluded for this case that the government, with a higher "n" value, is more cooperative than the owner, who has a lower "n" value. The "integrated" graphs in Figure 6.6 have been drawn using the procedure illustrated in Figure 6.4. It can also be seen that the maximum point on the integrated graph represents the settlement point of the negotiation which is 179% for this scenario shown in Figure 6.6.a. This settlement point indicates on the horizontal axis that the government pays for the 60% of the price and the owner reduces its initial offer by 40% and sells its property.

When Figure 6.6.b is considered, $n_{(owner)}$ = 7 is higher than $n_{(government)}$ = 1. It can be seen that the owner can reduce its initial offer by 50% without detriment to its position, whereas the government starts losing its utility when any concession is made. It means that the government has a less cooperative attitude with respect to the owner, who feels that the initial offer can be reduced without significantly damaging its position. The maximum expected joint utility value for this scenario is 162%, which is less than that in the previous scenario (179%). If the results of the two scenarios are compared, the following two observations can be made:

1. Reduction of the expected joint utility value in the second scenario to 162 % comparing with the first scenario (179%) indicates that the combination of "n" values in the first scenario ($n_{(owner)}$ = 2 and $n_{(government)}$ = 6) is resulted in a higher expected joint utility value than that in the second scenario ($n_{(owner)}$ = 7 and $n_{(government)}$ = 1); and
2. The location of maximum joint utility on the integrated curve is shifted from right side of the plot in Figure 6.6a to the left side of the plot in Figure 6.6b. In other words, in the first scenario, the government is more cooperative (n = 6) and the owner is less cooperative (n = 2) so that the maximum utility point is placed on the right side; whereas, in the second scenario, the owner is more cooperative (n = 7) and the government is less cooperative (n = 1) so that the maximum utility point is placed on the left side.

The two bottom plots in Figure 6.6c and 6.6d depict situations for which the "n" value for one or both DMs is less than 1 and, as can be seen, the shape of the utility function changes from concave to convex when the "n" value is reduced from more than 1 to less than 1. Such reduction of "n" value to less than 1 not only can reduce the cooperative attitudes of the DMs, but can also significantly decrease the total utility value to even less than 100%, which means that the negotiation process is unproductive (Figure 6.6c). In other words, it would be better paid off for the DMs who have negative attitudes towards each other not to start negotiating since the results after negotiation is worse than the results before negotiation. Following the above procedure, other scenarios can be considered and the sensitivity of the DMs' attitudes to the negotiation process can be examined. These attitude scenarios have been analyzed and the results are summarized in a categorized format, as shown in Table 6.1.

Table 6.1: The Results of the Sensitivity of the DMs' Attitudes

DM 1 (Owner)			DM 2 (Government)			Result	Settlement Point (SP) (%)
n	**Graph**	**Attitude**	**n**	**Graph**	**Attitude**		
0 < n < 1	Negative Convex	Noncooperative	0 < n < 1	Positive Convex	Noncooperative	Very Negative	13 ≤ SP ≤ 93
0 < n < 1	Negative Convex	Noncooperative	1 < n ≤ 10	Positive Concave	Cooperative	Negative / Positive	40 ≤ SP ≤ 166
0 < n < 1	Negative Convex	Noncooperative	1	Linear	Neutral	Negative	31 ≤ SP ≤ 96
1 < n ≤ 10	Negative Concave	Cooperative	1 < n ≤ 10	Positive Concave	Cooperative	Very Positive	150 ≤ SP ≤ 200
1 < n ≤ 10	Negative Concave	Cooperative	1	Linear	Neutral	Positive	125 ≤ SP ≤ 169
1	Linear	Neutral	1	Linear	Neutral	Neutral	SP = 100

6.4. Discussion of the Results

As displayed in Table 6.1, the "n" value falls within one of the three ranges: 0 < n < 1, 1 < n ≤ 10, or n = 1. Since there are two DMs in this case, there can be six (2 × 3) attitude situations (Table 6.1). In the first situation, both DMs have negative attitudes toward each other and, thus, the range of 0 < n < 1 is selected for the DMs' utility functions. If the negotiation should proceed, the result of the negotiation is expected to be "very negative" and the Settlement Point (SP) will be in the lowest range (13 ≤ SP ≤ 93). This means that the total (i.e., joint) utility value reduces to even less than 100% in this case, and such a negotiation is not productive because the joint satisfaction level for both DMs at the end of negotiation is even lower than the individual satisfaction level for each DM at the beginning of the negotiation. It should be remembered that the objective of the DMs is to maximize their total utility value and when they negotiate, they try to maximize their cooperative satisfaction.

In the second situation, DM 1 has a negative attitude (0 < n < 1) toward DM 2, whereas DM 2 has a positive attitude (1 < n < 10) toward DM 1, and thus, 40 ≤ SP ≤ 166, and the total utility value falls within a range of positive and negative values. Accordingly, this situation results in a better total utility value than that of the previous situation. Following this procedure, the same discussion can be provided for the other four attitude situations shown in Table 6.1.

It can be inferred from the six attitude situations in Table 6.1 that the higher value for the power (n) of the utility functions is selected, the more cooperative the DMs intend to be in their tactical negotiations. In other words, the DMs who both have a positive attitude toward each other can expect to achieve higher satisfaction level with higher total utility values and, as such, they may reach a “win-win” solution with the highest satisfaction for their joint efforts. The highest total utility value in the joint negotiation (Row 4 in Table 6.1) is called Nash equilibrium point where both DMs have positive attitudes towards each other and have reached the highest value for their joint SP. In Nash equilibrium point the DMs have no incentive to move to other states or other attitude cases in Table 6.1.

The power of the polynomial utility function can also reflect the DMs' risk attitudes. In terms of the DMs' attitudes towards risk, three types of DM are considered: risk avoider, risk taker, and risk neutral (Keeney and Raiffa, 1976). The results of the proposed negotiation methodology show that:

1. DMs who are more risk-averse and perhaps less cooperative prefer to select lower values for the power (n) of their utility function;
2. DMs who are more risk-prone and perhaps more cooperative prefer to select higher values for the power (n) of their utility function; and
3. DMs who are neutral towards risk prefer to select the power (n) of their utility function as $n = 1$.

It can be seen in Table 6.1 that when $0 < n < 1$, a utility function has a convex shape and when $1 < n \leq 10$, a utility function takes a concave shape. There are proven mathematical theorems (Kilgour, 2006; Keeney and Raiffa, 1976) that correlate the DMs' risk aversion level to the shape of the utility function. Risk avers, risk prone, and risk neutral are represented by a convex, concave, or linear function, respectively. The utility function shapes proposed in this research are driven by those mathematical theorems. Therefore, the results of the proposed methodology in this chapter are consistent with other research in this area.

6.5. Summary

In this chapter, the development of the proposed attitude-based negotiation methodology at the tactical level involving two decision makers was demonstrated using the concept of utility function. The proposed methodology supports and complements the strategic level of the negotiation methodology developed in Chapter 4 when two decision makers were involved in the strategic negotiation. The brownfield negotiation case study, introduced in Chapter 4, was used in this chapter to develop the methodology. Also, the sensitivity of decision makers' attitudes to the outcome of tactical negotiation was discussed. The results of the tactical negotiation of the case study prove that the tactical negotiation was needed to support and complement the strategic negotiation of the case study and thereby, the DMs were able to complete their negotiation and reach to a more sustainable resolution for their brownfield conflict.

The concepts, techniques, and approaches used in this chapter will be used in Chapter 7 to develop a tactical negotiation methodology when multiple decision makers and multiple negotiation issues are involved. A real-life negotiation case study will be also used to better demonstrate the advantages of the negotiation methodology.

CHAPTER 7:
Attitude-Based Tactical Negotiation Involving Multiple Decision Makers

7.1. Introduction

The chapter describes the generalization of the tactical negotiation methodology developed in Chapter 6 so that the attitudes of the decision makers (DMs) can be considered in the case of multiple DMs and multiple negotiation issues. The tactical negotiation methodology proposed in this chapter thus complements the strategic negotiation methodology involving multiple DMs, as presented in Chapter 5.

This chapter introduces a generalized tactical negotiation methodology, and a real-life brownfield negotiation case study is then used to clearly demonstrate the advantages of the proposed negotiation methodology. Finally, the influence of the DMs' attitudes on the outcomes of the negotiations at the tactical level is elaborated, and the results are discussed.

7.2. Generalized Tactical Negotiation Methodology

Building upon the two-DM tactical negotiation methodology discussed in Chapter 6, it is possible to generalize such methodology to include cases that involve multiple DMs and multiple negotiation issues are involved. Using the concept of a utility function, pair-wise negotiations are conducted between each pair of DMs, for each issue. The generalized tactical negotiation consists of a total number of pair-wise negotiations, as follows (Figure 7.1):

$$\text{Number of pair-wise negotiations} = (n) \times \frac{(N)\times(N-1)}{2} \qquad [1]$$

where n represents the number of issues and N represents the number of DMs.

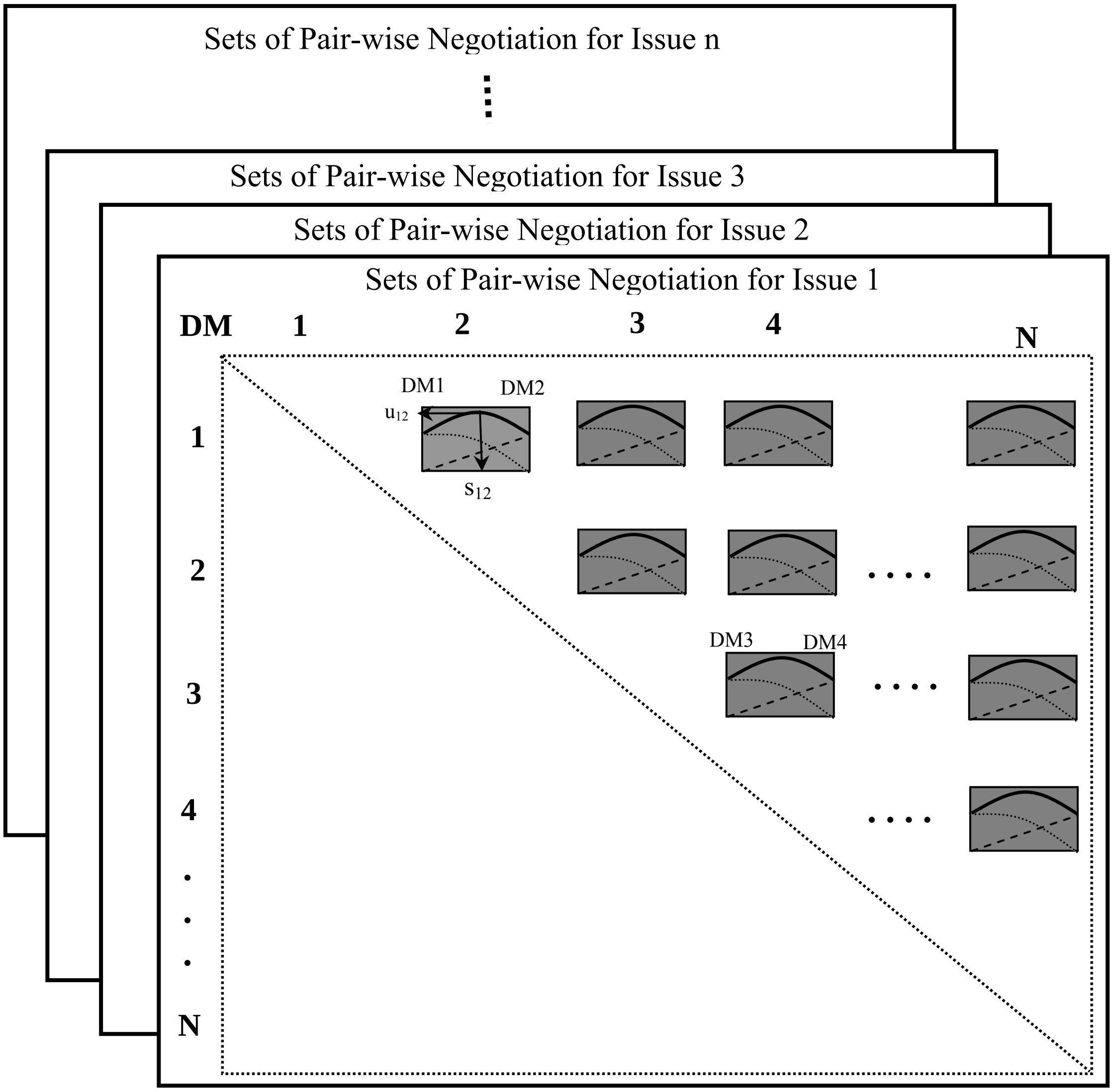


Figure 7.1: Pair-wise Negotiations Used to Formulate Generalized Tactical Negotiation Methodology

In each pair-wise negotiation, both DMs consider the negotiation issues and take into account their attitudes toward each other. Accordingly, for each DM, a utility function is selected from the variety of the utility functions proposed in Subsection 6.2.2. The pair-wise negotiation is then begun and continued until it results in an integrated utility function. The highest point on the integrated utility function indicates the highest level of satisfaction for both DMs and represents the settlement point needed for them to reach mutual consensus with respect to each negotiation issue. For example, in the tactical negotiation between DM 1 and DM 2 with respect to issue 1 (the top left-hand graph in Figure 7.1), u_{12} represents the maximum utility (satisfaction) and s_{12}, reflected on the horizontal axis, represents the settlement point indicating the concessions DM 1 and DM 2 should make in order to reach mutual agreement with respect to issue 1.

7.3. Tactical Negotiation Process: Multiple DMs and Issues

In real world, when multiple DMs negotiate multiple issues, many unprecedented events can occur during the negotiation and can influence the outcome. To accurately model a real tactical negotiation process, the following assumptions have been made:

- When DMs begin negotiating at the tactical level, they already have complete information about the other DMs’ options and strategies because they have already carried out many rounds of negotiation at the strategic level, as explained in previous chapters, which complements the negotiation at the tactical level.

- There are no time constraints for tactical negotiation, and the DMs are not restricted to completing the negotiation by any particular deadline.
- There must be at least one issue for negotiating, and the number of issues must be limited to a specified number n.
- All DMs have the same power and importance. In other words, the weight of each DM equals to one. According to Fisher et al. (1991), negotiation focus should be on interests, not the DMs' positions, and the DMs should be separated from the problem.
- Once two DMs begin their bilateral (pair-wise) negotiation, the negotiation must continue until they reach a settlement (s).
- With respect to the summation of DMs' utility values to obtain the total utility value, it is assumed that the valuation of utility is the same for all the DMs involved in the tactical negotiation.
- All DMs must complete their bilateral negotiations with respect to all negotiable issues in order to reach an overall settlement.

Two approaches exist for conducting a tactical negotiation that involve multiple DMs and multiple issues: Approach 1 which addresses one issue at a time, and Approach 2 which addresses two DMs at a time. These two approaches for a case involving three DMs (i.e., DM 1, DM 2, and DM 3) are shown in Figure 7.2 and explained in the following subsections. It should be noted that before beginning to negotiate, every DM (x) rates and prioritizes the issues to be negotiated with any other DM (y) by allocating a numerical weight to each issue (i). Thus, the greater the weight value of an issue, the more important the issue is for a DM, provided that $0 \leq w_{xy(i)} \leq 1$ and $\sum_{i=1}^{n} w_{xy(i)} = 1$, where n is the total number of issues. Some studies (Alfares and Duffuaa, 2008; Belton and Stewart, 2001; Keeney and Raiffa, 1976; Lootsma, 1999; Saaty, 1980, 1990, 1994) have been conducted with the goal of determining proper numerical values for the weights of the issues.

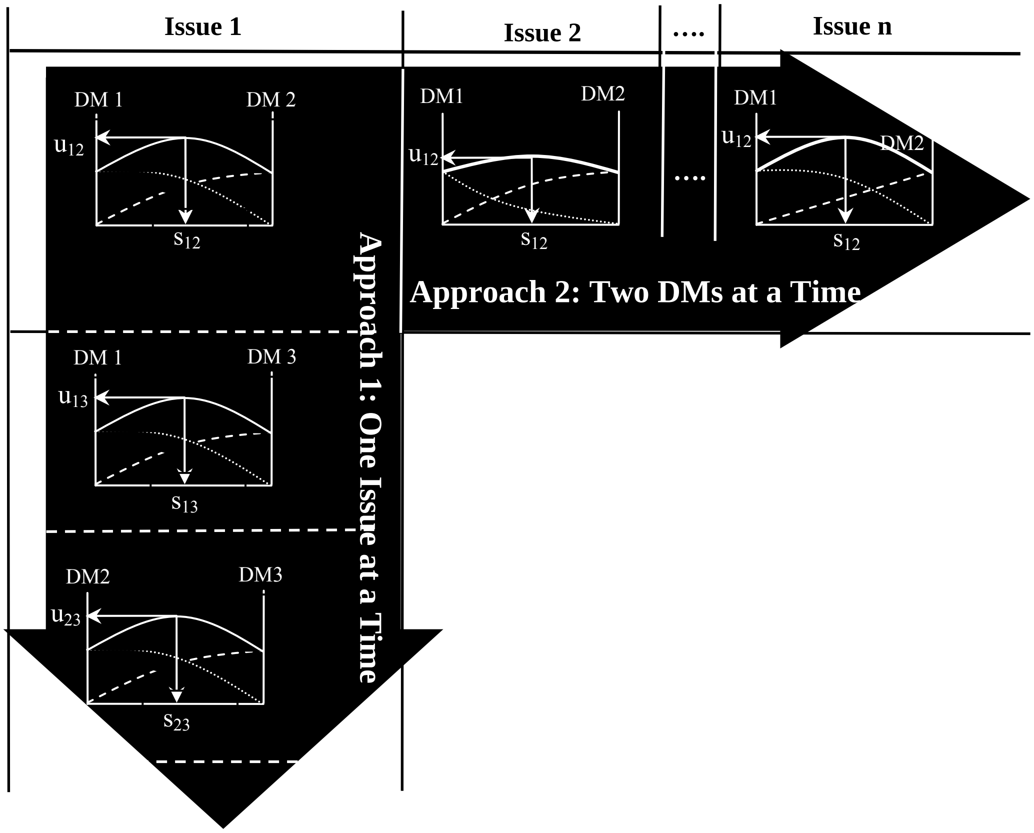


Figure 7.2: Two Approaches for Conducting Tactical Negotiation

7.3.1. Approach 1: One Issue at a Time

With this approach, DMs conduct a pair-wise negotiation with respect to one issue at a time (e.g., DM 1 - DM 2; DM 1 - DM 3; etc.) until a settlement point (s_{12}, s_{13}) is reached. When every DM conducts its pair-wise negotiation with other

DMs with respect to Issue 1, an average settlement point (S_{issue1}) can be determined for every DM. Upon completing the pair-wise negotiations for Issue 1, the DMs then begin pair-wise negotiations for Issue 2, and an average settlement point (S_{issue2}) is also calculated for each DM. This negotiation process continues until the DMs involved reach mutual agreement (i.e., an average settlement point) with respect to all the negotiation issues.

The above negotiating process is used for a situation in which three DMs are involved in tactical negotiations with respect to multiple issues. The average settlement point for each DM that results from negotiating issue i is determined using the following equations:

$$S_{DM1-issue-i} = \frac{[w_{12-issue-i}(s_{12-issue-i}) + w_{13-issue-i}(s_{13-issue-i})]}{2} \quad [2]$$

$$S_{DM2-issue-i} = \frac{[w_{21-issue-i}(s_{21-issue-i}) + w_{23-issue-i}(s_{23-issue-i})]}{2} \quad [3]$$

$$S_{DM3-issue-i} = \frac{[w_{31-issue-i}(s_{31-issue-i}) + w_{31-issue-i}(s_{31-issue-i})]}{2} \quad [4]$$

where:
$S_{DM1-issue-i}$: DM 1’s average settlement point resulting from negotiating issue i
$w_{12-issue-i}$: DM 1’s weight for issue i when negotiating with DM 2
$s_{12-issue-i}$: DM 1’s settlement point resulting from negotiating with DM 2
$w_{13-issue-i}$: DM 1’s weight for issue i when negotiating with DM 3
$s_{13-issue-i}$: DM 1’s settlement point resulting from negotiating with DM 3

The above settlement points represent the amount of concession that each DM should make to reach agreement about issue i. To determine the average settlement point for each DM that results from negotiating n issues, the following equations are used:

$$S_{DM\,1(ave)} = \frac{\sum_{i=1}^{n} S_{DM\,1-issue-i}}{n} \qquad [5]$$

$$S_{DM\,2(ave)} = \frac{\sum_{i=1}^{n} S_{DM\,2-issue-i}}{n} \qquad [6]$$

$$S_{DM\,3(ave)} = \frac{\sum_{i=1}^{n} S_{DM\,3-issue-i}}{n} \qquad [7]$$

The one-issue-at-a-time negotiation approach is useful when negotiable issues are not correlated. Thus, regardless of the influence of other issues, the DMs can determine the type of their attitudes (i.e., positive, negative, or neutral) toward the other DMs and, accordingly, select a proper n value for their utility function. In other words, this negotiation approach can be used when the involved DMs can negotiate the issues separately. However, in some situations the issues are correlated. For example, when the cost of a brownfield site remediation and the duration of the same brownfield site remediation are two negotiable issues, the two issues (i.e., cost and duration) are correlated so that the shorter the desired duration, the higher the cost that should be paid. Therefore, when the issues are mutually related to one another, another tactical negotiation approach is needed in order to take into account the correlations among the issues, as proposed in the following subsection.

7.3.2. Approach 2: Two DMs at a Time

With this approach, as shown in Figure 7.2, two pairs of DMs (e.g., DM 1 - DM 2; DM 3 - DM 4) conduct pair-wise negotiations with respect to all the issues at a time and continue their negotiation until a settlement point is reached with respect to every issue. In contrast with the first approach, the correlations among the issues influence the selection of the n value for the DMs' utility function. In other words, the n values selected for two the DMs' utility functions for negotiating issue i using Approach 1 are different from the n values selected for the same DMs and the same issue when Approach 2 is used. Different settlement points may therefore result from using different approaches.

Once the two DMs complete their negotiations for all issues, each DM will start pair-wise negotiation with another DM (e.g., DM 1 - DM 3; DM 2 - DM 4) for all issues. With this approach, two DMs may negotiate the issues one by one, or they may negotiate all issues simultaneously. The advantage of this approach is that it takes into account the correlations among the issues. The negotiation process is complete when every DM has completed its pair-wise negotiation with all the other DMs.

This negotiating process is used for a situation in which three DMs are involved and two DMs conduct a pair-wise negotiation for n issues at a time. The average settlement point for each DM is then determined using the following equations:

$$S_{DM\ 1(ave)} = \frac{\left[\sum_{i=1}^{n}(w_{12} \times s_{12})_{issue-i}\right] + \left[\sum_{i=1}^{n}(w_{13} \times s_{13})_{issue-i}\right]}{2n} \qquad [8]$$

$$S_{DM\ 2(ave)} = \frac{\left[\sum_{i=1}^{n}(w_{21} \times s_{21})_{issue-i}\right] + \left[\sum_{i=1}^{n}(w_{23} \times s_{23})_{issue-i}\right]}{2n} \qquad [9]$$

$$S_{DM\ 3(ave)} = \frac{\left[\sum_{i=1}^{n}(w_{31} \times s_{31})_{issue-i}\right] + \left[\sum_{i=1}^{n}(w_{32} \times s_{32})_{issue-i}\right]}{2n} \qquad [10]$$

where:
$S_{DM1(ave)}$: DM 1's average settlement point resulted from negotiating n issues
$S_{DM2(ave)}$: DM 2's average settlement point resulted from negotiating n issues
$S_{DM3(ave)}$: DM 3's average settlement point resulted from negotiating n issues
$w_{12\text{-issue-i}}$: DM 1's weight for issue i when negotiating with DM 2
$w_{21\text{-issue-i}}$: DM 2's weight for issue i when negotiating with DM 1
$w_{13\text{-issue-i}}$: DM 1's weight for issue i when negotiating with DM 3
$w_{31\text{-issue-i}}$: DM 3's weight for issue i when negotiating with DM 1
$w_{23\text{-issue-i}}$: DM 2's weight for issue i when negotiating with DM 3
$w_{32\text{-issue-i}}$: DM 3's weight for issue i when negotiating with DM 2
$s_{12\text{-issue-i}}$: DM 1's settlement point resulting from negotiating with DM 2
$s_{21\text{-issue-i}}$: DM 2's settlement point resulting from negotiating with DM 1
$s_{13\text{-issue-i}}$: DM 1's settlement point resulting from negotiating with DM 3
$s_{31\text{-issue-i}}$: DM 3's settlement point resulting from negotiating with DM 1
$s_{23\text{-issue-i}}$: DM 2's settlement point resulting from negotiating with DM 3
$s_{32\text{-issue-i}}$: DM 3's settlement point resulting from negotiating with DM 2
n: number of issues

It should be noted that the set of equations [8], [9], [10] and the set of equations [5], [6], [7] result in the same values for the settlement point only when all issues are negotiated by the DMs. Therefore, when all issues are negotiated, either set can be used to determine the average settlement point for each DM. It should also be mentioned that equations [8], [9], and [10] are used only when the DMs conduct pair-wise negotiations for all issues. If two DMs negotiate only some of the issues, then equations [2], [3], [4], [5], [6], and [7] must be used in order to determine the average settlement point with respect to each DM.

The application of the two proposed approaches depends on the negotiation situations, the DMs' attitudes toward the other DMs, and the negotiation issues. Although the first negotiation approach (one issue at a time) is fast and easy to conduct among multiple DMs, the second approach (two DMs at a time), while lengthy, is more accurate because the correlations among the issues can be considered. The latter approach is particularly useful when the issues are monetarily related to one another. Because the tactical negotiations for the present case study deal with cost-based issues, the second approach was used in order to consider the correlation of the issues, as explained in the next section.

7.4 Application to the School of Pharmacy Tactical Negotiation

The process of tactical negotiation involving multiple DMs and multiple issues, as proposed in the previous section, was implemented, as discussed in this section, in order to develop a tactical negotiation methodology for the UW School of Pharmacy case study. It should be remembered that a strategic decision had already been agreed upon by the DMs involved using the strategic negotiation methodology presented in Chapter 5. The proposed tactical negotiation methodology complements this strategic negotiation methodology.

The strategic negotiation for the school of pharmacy resulted in a mutual agreement in which PolyOne completes the site remediation quickly, the city does not take legal action and provides incentives for UW and PolyOne, and UW constructs a school of pharmacy in the decontaminated site. This strategic decision includes multiple issues that can be further negotiated in details in order to determine the specific concessions needed for all the DMs to reach mutual agreement. The tactical issues within the agreed-upon strategic solution are indicated in Table 7.1. Implementing the proposed negotiation methodology at the tactical level for the UW School of Pharmacy required three steps, as explained in the following subsections.

Table 7.1: Tactical Issues Identified within the Strategic Decision

DM	Agreed-upon Strategic Solution		Negotiation Issue
	State 8	Description	
PolyOne	N	Slow Remediation	
	Y	Fast Remediation	Fast-Remediation Costs
The city	Y	Brownfield Incentives	Financial Incentives
	N	Legal Action	
UW	Y	Building Construction	Construction Costs

7.4.1. Step 1: Decompose the Negotiation Issues into Sub-Issues

Some issues in multi-issue tactical negotiations are complex and difficult to negotiate and should therefore be broken down into sub-issues. This method increases the number of issues, which facilitate negotiation process and also helps the DMs prioritize their issues for negotiation. Keeney (1992) believed that breaking down the issues into sub-issues allows the involved DMs to solve the least complicated issues first, and they will then be more engaged and encouraged to negotiate the remaining issues. Bellucci and Zeleznikow (2005) also recognized that there may be sub-issues within the issues on which agreement can be attained. Each sub-issue can also be decomposed into other sub-issues so that a hierarchy of issues and sub-issues is formed. It is important to note that the larger the number of issues in negotiation, the easier it may be to allocate them, since the possibility of trade-offs between the issues increases. However, decomposing a negotiable issue depends on the negotiation conditions, and there are cases in which an issue can not be decomposed into sub-issues. Figure 7.3 shows a flowchart of the issues and sub-issues identified for the school of pharmacy case study.

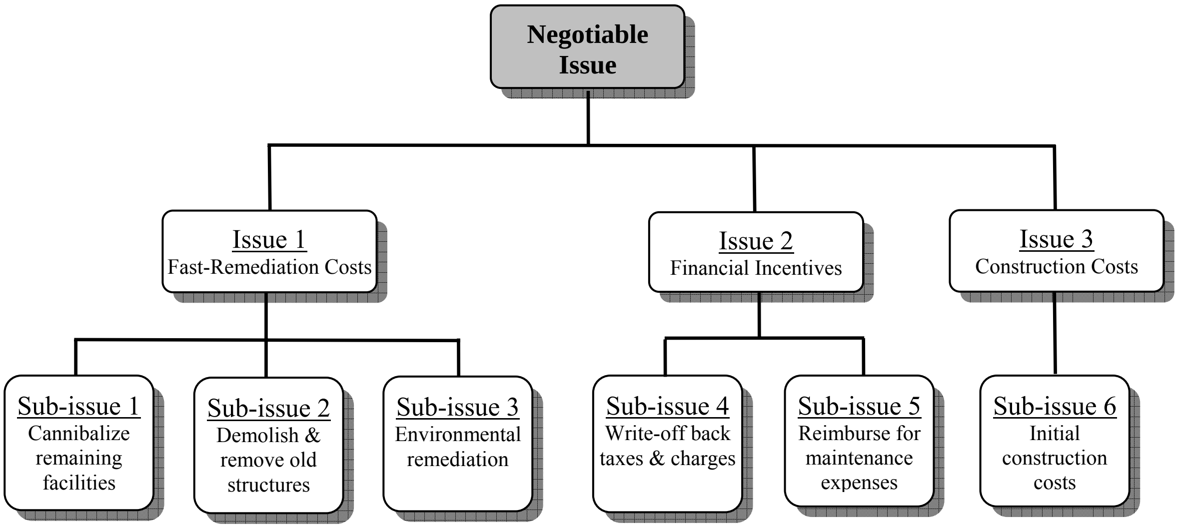


Figure 7.3: The Hierarchy of Issues for the School of Pharmacy Negotiations

According to the agreed-upon strategic solution (Table 7.1), PolyOne agreed to remediate the site fast, and thus PolyOne's negotiable issue is the fast-remediation cost. In other words, because extra costs were involved in fast remediation, PolyOne intended to negotiate the extra costs with the other DMs with a view to determining how much the other DMs would be able to help. The process of fast site remediation consists of three steps: 1) cannibalize the remaining facilities (i.e., take salvageable parts of disabled machines or facilities and use them in building or repairing other equipment or facilities); 2) demolish and remove the old buildings; and 3) perform the environmental remediation. Therefore, as shown in Figure 7.3, fast-remediation costs can be broken down into three cost-related sub-issues that correspond to these three steps.

The city's issue was brownfield incentives, which consisted of two sub-issues: 1) write off the back taxes and unpaid charges, and 2) reimburse the other DMs for maintenance expenses. Because of the threats to environment and the health hazards, the city, as a municipal organization, was the most cooperative DM because of the need to make sure that the contaminated site was redeveloped as soon as possible. Therefore, the city intended to provide incentives for the other DMs who were faced with financial difficulties. Due to the huge amount of unpaid charges that had been accumulated because the contaminated site had been abandoned for such a long time, the city was engaged in tactical negotiations with the other DMs in order to pay (i.e., write off) some of the unpaid charges and taxes that were owed to the city. There was also conflict about the site maintenance expenses, and the city was involved in detailed negotiation to pay (i.e., reimburse) a reasonable amount of the expenses to the other DMs.

Finally, UW's negotiation issue was the initial construction costs. Although UW was the primarily responsible for constructing the school of pharmacy, some of the initial construction activities were costly, and UW needed financial help from the other DMs. Therefore, UW was engaged in pair-wise negotiations with the other DMs with respect to the initial construction costs.

7.4.2. Step 2: Identify the DMs' Least Expectations

Prior to the start of a tactical negotiation, the involved DMs identify their minimum expectation with respect to each issue. The minimum expectation in tactical negotiation is referred to as the disagreement point (d) which represents each DM's minimum level of satisfaction on which the DMs count if they do not reach any agreement. The individual rationality condition is that no DM receives less satisfaction than he or she would receive at point d (Kilgour 2006). It is thus guaranteed that the DMs can achieve at least d. Therefore, to maximize their negotiation position, every DM considers the other DMs and the negotiable issues, and attempts to find a disagreement point before the beginning of a pair-wise negotiation. For example, when the city and PolyOne negotiate the extra cost (e.g., $1,000,000) associated with the fast site remediation, the city may not accept more than a 60% concession, or $600,000, which represents the city's disagreement point. In other words, the city will not accept any tactical solution that requires a payment greater than $600,000.

7.4.3. Step 3: Simulate the Tactical Negotiation

With respect to the tactical negotiation approaches proposed in Figure 7.2, the two-DMs-at-a-time negotiation approach was employed in order to simulate the tactical negotiations for the school of pharmacy. Because the issues in this case study are monetarily and mutually related to one another, the selected approach is more suitable for considering the interrelationships between the issues and the correlation among the sub-issues. The simulated tactical negotiation methodology for the school of pharmacy is shown in Figure 7.4.

As can be seen, the DMs first consider the correlations among the issues and accordingly determine the weight of the issues as well as their minimum expectation (i.e., the disagreement point) with respect to each issue. The DMs then conduct pair-wise negotiation only for the issues that relate to both DMs, and therefore, they do not negotiate for the issues related to the third DM. For example, PO and UW will not conduct pair-wise negotiations for sub-issues 4 and 5, which are the city's issues (Figure 7.4). Also, there is no single issue to be negotiated by all the DMs. In this case study, three sets of pair-wise negotiations were conducted: between PO-City, PO-UW, and the City-UW. The three sets of negotiations are described in the following subsections.

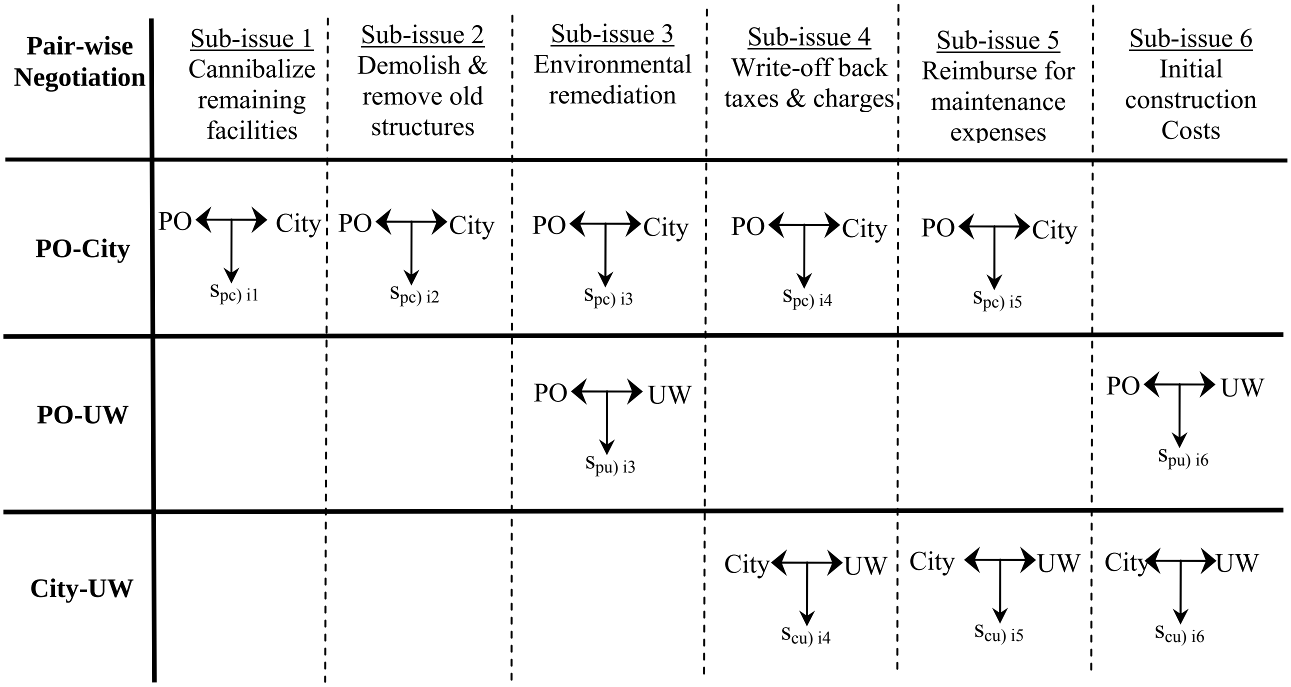


Figure 7.4: Simulation of the Tactical Negotiations for the School of Pharmacy

7.4.4. Step 3a: Tactical Negotiations between PolyOne and the City

The tactical negotiation between PolyOne and the city is modeled using the concept of utility theory and utility function. The procedure for conducting a tactical negotiation using utility function is described in Chapter 6, Section 6.2 for cases in which two DMs and only one issue are involved. The same procedure was employed to conduct pair-wise negotiations when multiple issues are negotiated in detail.

As shown in Figure 7.4, PolyOne and the city conduct pair-wise negotiations for five of the six negotiable issues listed. The engagement of PolyOne and the city in negotiating most issues indicates that both DMs have found a rational motivation for further negotiating most of these issues identified in the agreed-upon strategic solution. The background of this case study also indicates that the city and PolyOne participated in many rounds of negotiations and meetings to determine each DM’s share of the costs of remediation of the brownfield site.

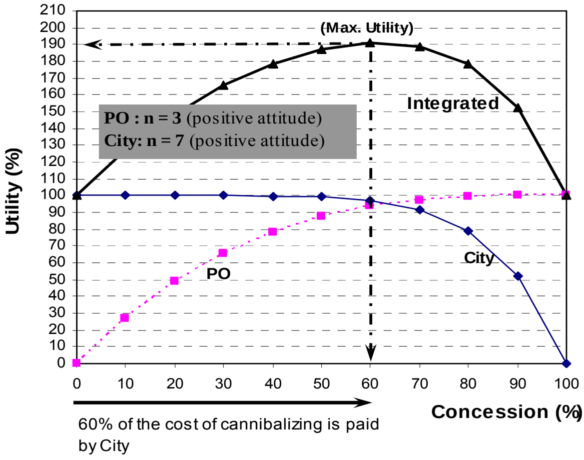
The pair-wise negotiation begins with the two DMs first evaluating all the issues and determining the weight and the disagreement point, or the minimum expectation, with respect to each negotiable issue. They then take into account the correlations among the issues to discuss whether they can make more concessions with respect to one issue in order to receive more benefits with respect to another issue. In other words, understanding the relationship between issues allows the DMs to find the most suitable range of concessions (i.e., an appropriate n value for the utility function) they can make in order to reach a more stable agreement. Understanding the interrelationships among the issues also helps the DMs to adjust their attitudes during their pair-wise negotiations.

After determining the preliminary considerations, such as the weight of issues and the disagreement points, an appropriate utility function form is assigned to each DM for each issue, and an integrated utility function is then developed. The maximum point on the integrated utility function represents the highest level of satisfaction in a joint decision and also represents the settlement point which represents the concessions the DMs need to make in order to reach mutual agreement with respect to each issue. The five pair-wise negotiations between PolyOne and the city were simulated as shown in Figure 7.5.

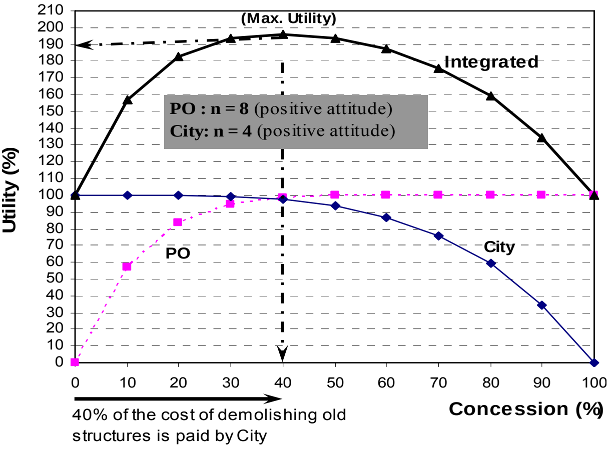
$$U_{(PolyOne)} = (100^{1-n})(x^{n})$$

$$U_{(City)} = (100^{1-n})(100-x)^{n}$$

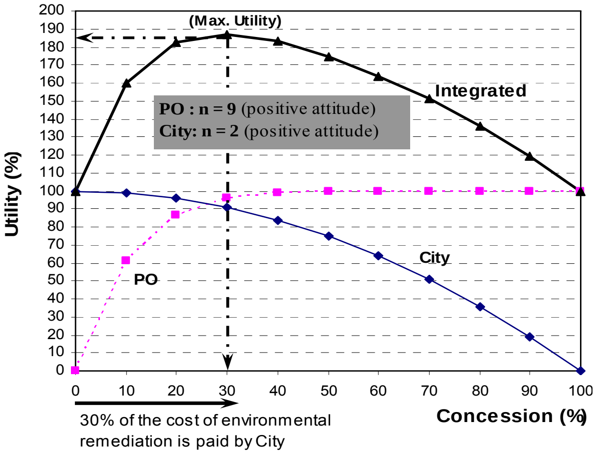
a) Sub-issue 1: Cannibalize Remaining Facilities



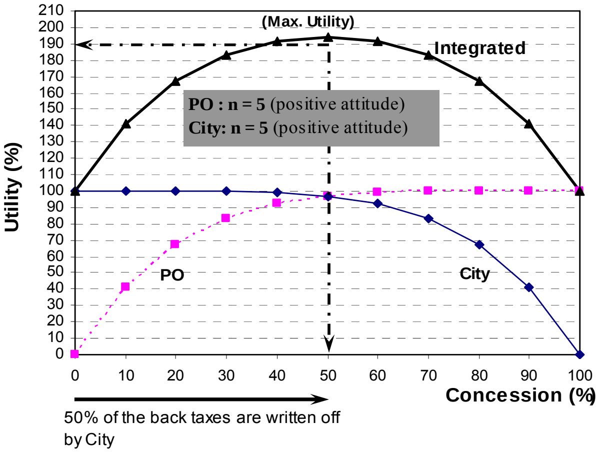
b) Sub-issue 2: Demolish & Remove Old Structures



c) Sub-issue 3: Environmental Remediation



d) Sub-issue 4: Write-off Back Taxes & Charges



e) Sub-issue 5: Reimburse for Maintenance Expenses

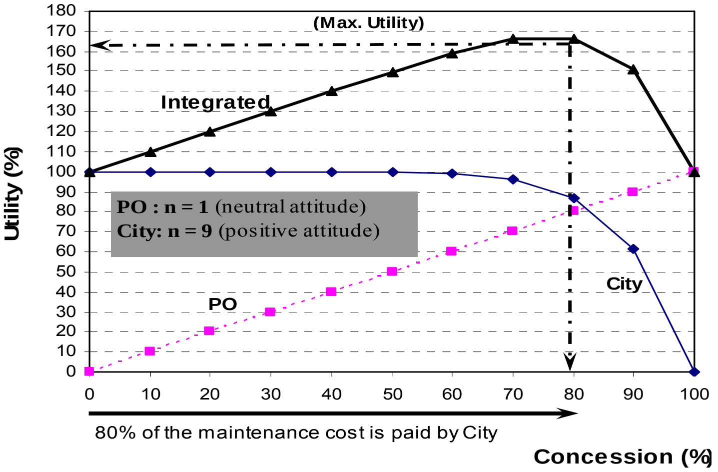


Figure 7.5: Tactical Negotiations between PolyOne and the City

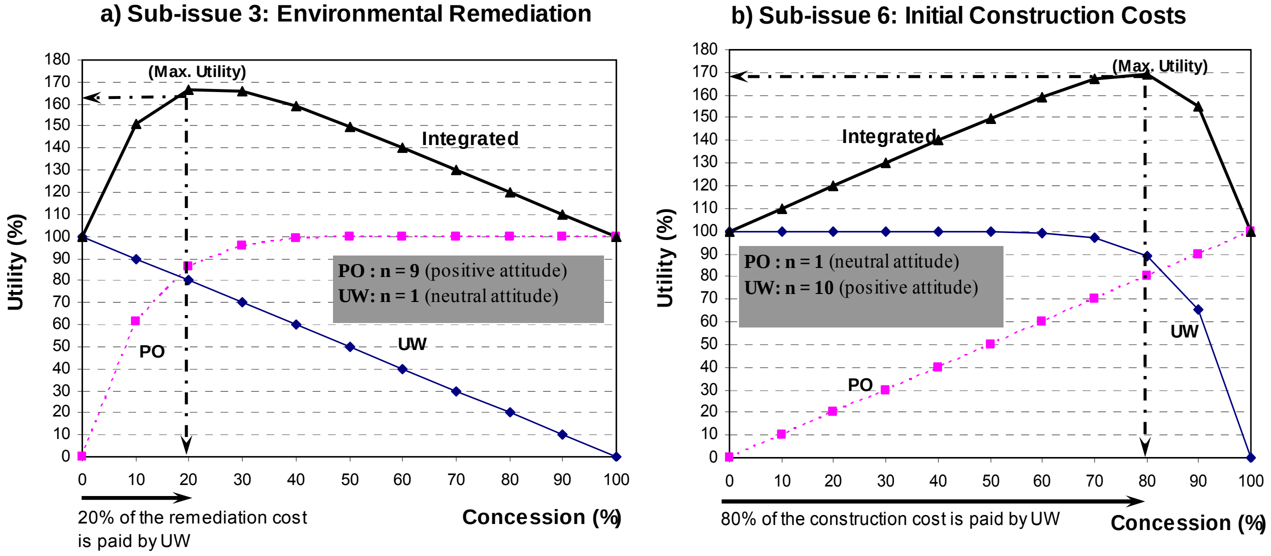
It can be noted that the utility functions, shown in Figure 7.5, were selected for PolyOne and the city in which x represents the amount of the concessions made by the DMs and *n* represents the power term of the utility function.

7.4.5. Step 3b: Tactical Negotiations between PolyOne and UW

PolyOne and UW had two negotiable issues: 1) the cost of the environmental remediation, and 2) the initial cost of constructing the UW school of pharmacy. In this case study, the site was transferred to UW as the new owner of the site. As PolyOne negotiated the cost of the environmental remediation with the city, as discussed in the previous subsection, PolyOne was also willing to negotiate some of the remediation costs with UW. Because a lengthy remediation process would continued beyond the point at which UW became the site owner, UW did not want any interruption in the remediation process established by PolyOne, and UW was therefore engaged in the negotiation process.

With respect to the third issue, the initial construction costs, UW was the DM mainly responsible for the costs of construction. However, because PolyOne had already assembled a great deal of suitable construction equipment on the site, UW was willing to negotiate the costs of the initial construction activities with PolyOne. The activities were overlapped with the PolyOne's construction activities. The two pair-wise negotiations between PlyOne and UW are modeled as shown in Figure 7.6. The following utility functions were selected for PolyOne and UW in which x represents the amount of concession made by DMs and n represents the power term of the utility function.

$$U_{(PolyOne)} = (100^{1-n})(x^{n}) \qquad U_{(UW)} = (100^{1-n})(100-x)^{n}$$


a) Sub-issue 3: Environmental Remediation

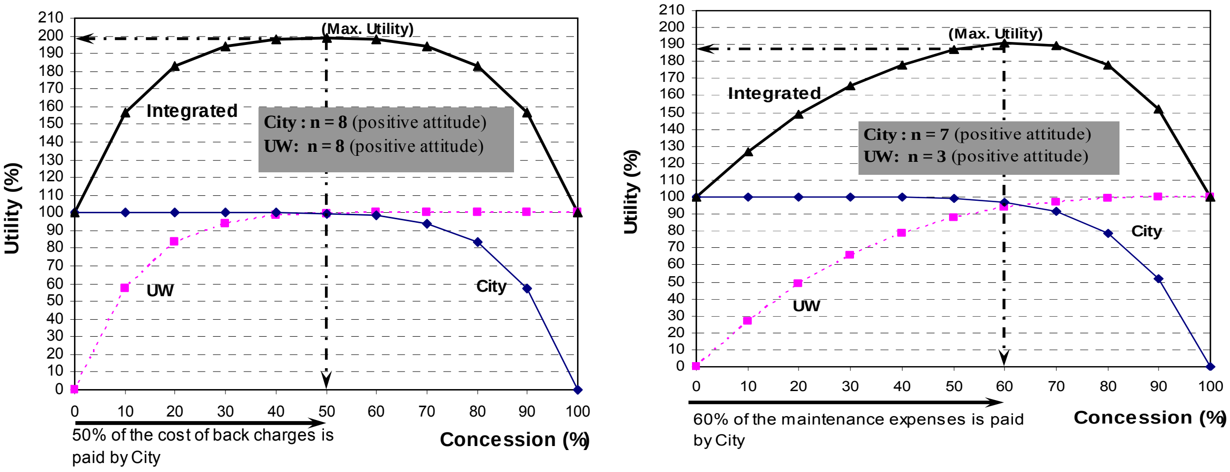
b) Sub-issue 6: Initial Construction Costs

Figure 7.6: Tactical Negotiations between PolyOne and UW

7.4.6. Step 3c: Tactical Negotiations between the City and UW

The City and UW had three negotiable issues: 1) the amount of back taxes and unpaid charges with respect to the redeveloped site, 2) the amount of reimbursement paid by the city for the extra maintenance expenses already paid by UW, and 3) the cost of the initial construction preparation for the construction of the school of pharmacy. With respect to the first issue, both DMs decided to cooperatively negotiate the unpaid taxes and hydro charges that had accumulated during the transfer of ownership. With respect to the second issue, UW was willing to cooperatively negotiate some of the extra maintenance charges that were paid by UW before the transfer of ownership. UW's positive attitude in negotiating the second issue encouraged the city to negotiate the costs of the initial construction activities and to accept a portion of these costs. The three pair-wise negotiations between the city and UW were modeled as shown in Figure 7.7. The following utility functions were selected for both DMs, in which x represents the amount of the concessions made by the DMs and n represents the power term of the function.

$$U_{(UW)} = (100^{1-n})(x^{n}) \qquad U_{(City)} = (100^{1-n})(100-x)^{n}$$



a) Sub-issue 4: Write-off Back Taxes & Charges

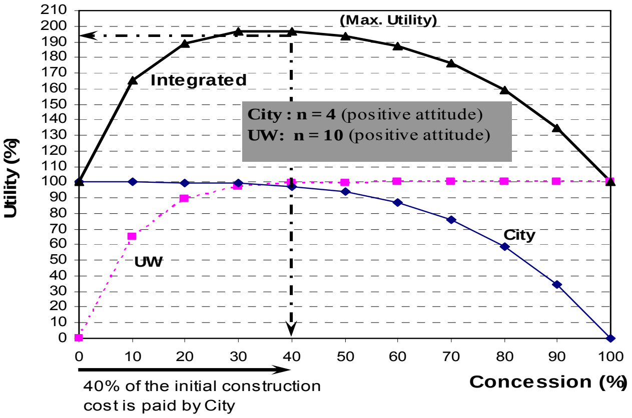
City : n = 8 (positive attitude)
UW: n = 8 (positive attitude)

50% of the cost of back charges is paid by City

b) Sub-issue 5: Reimburse for Maintenance Expenses

City : n = 7 (positive attitude)
UW: n = 3 (positive attitude)

60% of the maintenance expenses is paid by City



c) Sub-issue 6: Initial Construction Costs

City : n = 4 (positive attitude)
UW: n = 10 (positive attitude)

40% of the initial construction cost is paid by City

Figure 7.7: Tactical Negotiations between the City and UW

7.4.7. Discussion of the Tactical Negotiation Results

As described in the previous subsections, the tactical negotiation methodology involving six issues and three DMs (i.e., PolyOne, the city, and UW) was developed for the present case study. The concept of utility function was used to model and illustrate the pair-wise negotiations between PolyOne - City, PolyOne - UW, and City – UW, as set out in Subsections 7.4.4, 7.4.5, and 7.4.6, respectively. In this subsection, the outcomes resulting from the tactical negotiations are summarized as shown in Table 7.2, and a brief discussion of the results is provided as follows.

As previously explained, after mutually agreeing on a strategic decision, the involved DMs continued their tactical negotiations very cooperatively and preferred to avoid any negative attitudes toward one another during the negotiations. The DMs realized that negative attitudes are not beneficial and would threaten the agreed-upon strategic solution which had been achieved after many years of intensive meetings and negotiations. Accordingly, when the DMs' tactical negotiations were modeled using utility function, the n values (i.e., the power term of the utility functions) selected for the DMs were equal to or greater than one, which means that each DM's attitude toward the other DMs was either neutral or positive. The city, PolyOne, and UW all had a positive attitude except in three situations in which PolyOne and UW had neutral attitudes toward other DM during their pair-wise negotiations, as shown in Table 7.2.

Table 7.2: The Tactical Negotiations Results for the School of Pharmacy

	DMs' Negotiations	**PolyOne**	**The city**	**PolyOne**	**UW**	**The city**	**UW**	**Normalized Average**		
								PolyOne	**The city**	**UW**
Sub-Issue 1: Cannibalize remaining facilities (Cost:$ 100,000)	Disagreement Point (%)	50	80							
	weight	0.03	0.03							
	n	3	7							
	Attitude	Less Positive	More Positive							
	Joint Utility (%)	191								
	Settlement (%)	40	60					40	60	
Sub-issue 2: Demolish & remove old structures (Cost: $250,000)	Disagreement Point (%)	90	45							
	weight	0.08	0.08							
	n	8	4							
	Attitude	More Positive	Less Positive							
	Joint Utility (%)	196								
	Settlement (%)	60	40					60	40	
Sub-issue 3: Environmental remediation (Cost: $550,000)	Disagreement Point (%)	90	40	90	20					
	weight	0.18	0.18	0.18	0.18					
	n	9	2	9	1					
	Attitude	More Positive	Less Positive	Positive	Neutral					
	Joint Utility (%)	187		167						
	Settlement (%)	70	30	80	20			60	24	16
Sub-issue 4: Write-off back taxes & charges (Cost: $800,000)	Disagreement Point (%)	50	60			70	60			
	weight	0.26	0.26			0.26	0.26			
	n	5	5			8	8			
	Attitude	Positive	Positive			Positive	Positive			
	Joint Utility (%)	194				199				
	Settlement (%)	50	50			50	50	33	34	33
Sub-issue 5: Reimburse for maintenance expenses (Cost: $700,000)	Disagreement Point (%)	20	95			80	50			
	weight	0.23	0.23			0.23	0.23			
	n	1	9			7	3			
	Attitude	Neutral	Positive			More Positive	Less Positive			
	Joint Utility (%)	167				191				
	Settlement (%)	20	80			60	40	15	54	31
Sub-issue 6: Initial construction costs (Cost: $650,000)	Disagreement Point (%)			20	90	50	90			
	weight			0.22	0.22	0.22	0.22			
	n			1	10	4	10			
	Attitude			Neutral	Positive	Less Positive	More Positive			
	Joint Utility (%)			169		197				
	Settlement (%)			20	80	40	60	15	31	54
Normalized Total Average (%)								**37**	**41**	**22**

The six negotiation issues and their approximate costs are shown in the first column on the left in Table 7.2. The input information (e.g., disagreement point, weight) and the output results (e.g., joint utility, settlement) are shown in the second column from the left in Table 7.2. The two rows at the bottom of the table display the suggested average share that each DM should pay with respect to the total cost of the six issues.

The final results of the tactical negotiation (the last row in Table 7.2) indicate that the city agrees to pay a greater share of the total cost (37%) than either PolyOne (33%), or UW (30%). The results are consistent with the real-life detailed negotiations that took place. One of the main responsibilities of the City of Kitchener, as a municipal organization, is to remediate and redevelop brownfield sites as quickly as possible. The City of Kitchener (the city) was particularly very cooperative during the tactical negotiations and did not even prefer to have neutral attitudes toward PolyOne and UW, in the hope of helping the other DMs to reach a stable solution after the lengthy negotiations.

With respect to the City-PolyOne pair-wise negotiations, both DMs considered the preconditions of the negotiation, assessed the correlations among the negotiating issues, and decided to negotiate five issues as, listed in Table 7.2. Negotiation of the first issue (i.e., cannibalize the remaining facilities) took place only between the city and PolyOne since UW was not involved with that issue. When the fast site remediation was decided on at the strategic level, PolyOne preferred to reuse some of the existing facilities, and therefore, the process of cannibalization was considered. PolyOne negotiated the cost of the process ($100,000) with the city. The results of the negotiation of the demolition and removal of the old structure on the contaminated site (issue 2) was that PolyOne pays 60% of the cost and the city pays 40% of the cost because some of the old structures and equipment belonged to the city and it was the city's responsibility to contribute to the cost. Both DMs conducted a very successful tactical negotiation with respect to this issue and reached a higher level of satisfaction (joint utility of 196) than they achieved with respect to their other issues (Table 7.2). On the other hand, in negotiating the issue of reimbursing for maintenance expenses (issue 5), both DMs reached the lowest level of satisfaction (joint utility of 167). This low level is due mainly to the fact that although the city had a positive attitude toward its opponent, PolyOne had a neutral attitude toward the city, which caused the lower level of joint satisfaction.

With respect to the PolyOne-UW bilateral negotiations, both DMs reviewed the available negotiation issues and agreed to negotiate two of them, as shown in Table 7.2. In negotiating the issue of environmental remediation (issue 3), UW preferred to negotiate the issue with PolyOne because the lengthy process of remediation had been continued during the period when UW was the new owner of the site. The outcome of the negotiation was that 20% of the cost is to be paid by UW. UW's cooperative attitude in negotiating the cost of the remediation encouraged PolyOne to accept UW's request to negotiate the initial costs of the construction of the school of pharmacy, for which UW was mainly responsible. Therefore, PolyOne negotiated with UW, having a neutral attitude toward UW, and agreed to share 20% of the cost according to the negotiation outcome.

With respect to the City-UW bilateral negotiations, both DMs reviewed the available negotiation issues and preferred to negotiate the costs of three issues: 1) write off back taxes and unpaid charges, 2) provide reimbursement for the site maintenance expenses, and 3) contribute to the costs of initial construction activities. Both the city and UW held very successful negotiations with respect to the unpaid charges for the abandoned site, and for the cost of the initial construction activities. In particular, the highest level of satisfaction (joint utility of 199) was achieved when both DMs very positively negotiated the cost of the back taxes and previous charges (Table 7.2). One of the reasons for such a high level of cooperation between the city and UW is that when construction of an educational building on the remediated site was agreed upon, the city realized that the sooner the building could be constructed, the more benefits downtown Kitchener businesses will gain. In other words, the city envisioned the cooperative tactical negotiation with UW as a beneficial investment for the taxpayers, who were asking for a better business in downtown Kitchener. Using the proposed tactical negotiation methodology, each DM’s share of the costs with respect to each issue is listed in Table 7.3. The tactical negotiation issues and their associated costs are shown in the two columns at the left in Table 7.3. The percentage share and corresponding monetary share of the costs with respect to each DM are also displayed in Table 7.3. The results shown in Table 7.3 are the exact amount of the concessions that must be made by the DMs in order for them to reach mutual agreement at the tactical level of negotiation in this case study. In other words, to complement the strategic negotiation and to complete the negotiation process for the case study, the concessions proposed in Table 7.3 should be made by the DMs involved in the brownfield negotiation.

Table 7.3: DMs' Shares of the Costs of the Tactical Issues

Sub-issue	Cost ($)	DM's Share (%)			DM's Share ($)		
		PolyOne	The city	UW	PolyOne	The city	UW
1	100,000	40	60		40,000	60,000	
2	250,000	60	40		150,000	100,000	
3	550,000	60	24	16	330,000	132,000	88,000
4	800,000	33	34	33	264,000	272,000	264,000
5	700,000	15	54	31	105,000	378,000	217,000
6	650,000	15	31	54	97,500	201,500	351,000
Average	508,333	37	41	22	164,400	190,600	153,300
Total ($)	**3,050,000**				**986,500**	**1,143,500**	**920,000**

The resulting sharing of the costs on the part of the DMs involved in the tactical negotiations of the school of pharmacy lead to the following considerations:

1. With respect to the total cost of all six issues ($3,050,000), the city will pay the largest share ($1,143,500), followed by PolyOne with the second largest share ($986,500), and UW, with the third largest share ($920,000).

The proposed cost sharing is consistent with the background of the negotiation with respect to the school of pharmacy, in which the City of Kitchener showed the highest level of cooperation along with a positive attitude toward both PolyOne and UW. The City of Kitchener knew that PolyOne and UW were not responsible for the whole redevelopment costs of the brownfield site, which had been abandoned for many years. Therefore, the city took bold action during the tactical negotiations and accepted a large share of the costs.

2. According to the proposed results shown in Table 7.3, PO's largest cost is \$330,000 for issue 3 (environmental remediation), the city's largest share is \$378,000 for issue 5 (reimbursement for maintenance expenses), and UW's largest share is \$351,000 for issue 6 (initial construction costs). The results indicate that the three DMs were ready to negotiate and to make a large contribution with respect to the issues that concerned them the most: issues 3, 5, and 6 for PO, the city, and UW, respectively.
3. The amounts of the cost sharing indicate that the three DMs have contributed fairly to the negotiation of the cost of the issues, except for issues 1 and 2, in which UW made no contribution to the negotiations, and PolyOne and the city were solely responsible for the costs. Because the DMs mutually accepted the strategic solution and agreed to continue their negotiations cooperatively at the tactical level, none of them had a negative attitude toward the other DMs during the tactical negotiations. The DMs preferred to complete their lengthy tactical negotiations and

accept the costs in order to receive the future benefits of redevelopment and to avoid additional costs of remediation by abandoning the contaminated site.

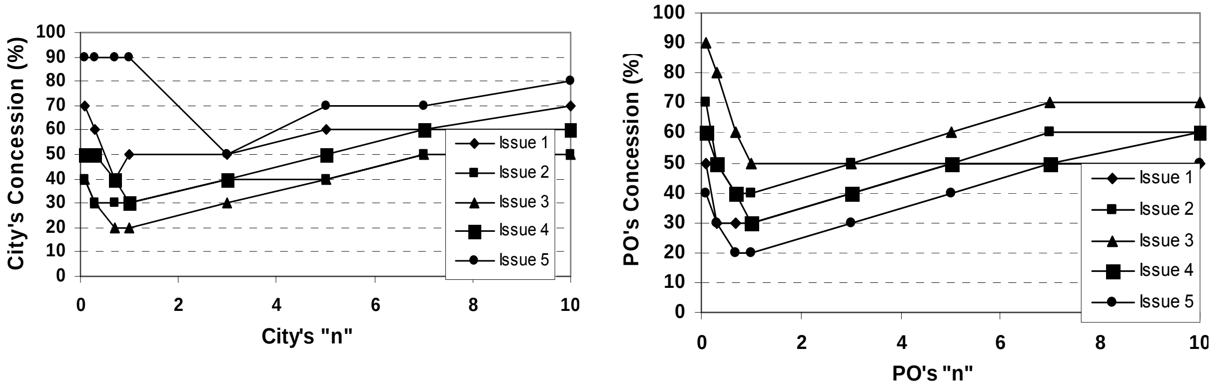
7.5. Attitude-Based Sensitivity Analysis

As discussed in Chapter 6, the power term (n) of utility function can represent DMs’ attitudes toward themselves and other DMs when a utility function is used in tactical negotiation. When $0 < n < 1$, $1 < n \leq 10$, or $n = 1$, a DM has a negative, positive, or neutral attitude, respectively, toward itself and/or other DMs. It was also explained that if two DMs have less cooperative attitudes (i.e., a lower n value is selected for their utility function), then a lower joint utility (i.e., joint satisfaction) will result from their pair-wise negotiation.

The proposed attitude-based utility function was employed for the pair-wise negotiations explained in Section 7.4. Before the commencement of the pair-wise tactical negotiations, an appropriate n value was assigned to each DM’s utility function according to the DMs’ attitudes toward itself and the other DMs. Based on the n values assigned to the DMs’ utility functions, the outcomes of the pair-wise negotiations were obtained, as summarized in Table 7.2.

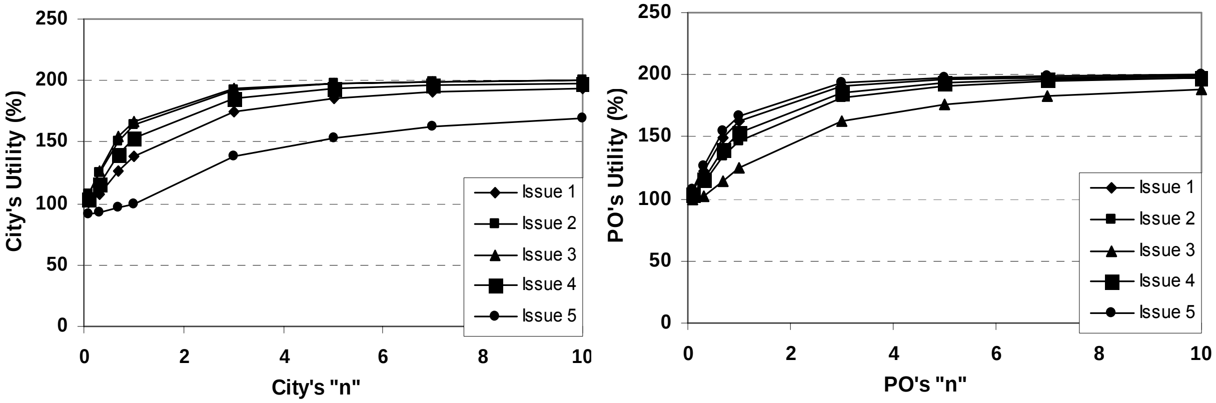
The objective of the attitude-based sensitivity analysis presented in this section is to assess the sensitivity of the negotiation outcomes (output information) to changes in the n values (input variables). In other words, it is important to investigate the effects of changes in the attitudes of the DMs toward the other DMs during the pair-wise tactical negotiations. It is also important to know how changes in attitude influence the negotiation settlement point and the level of joint satisfaction. To achieve these objectives, the attitudes of the DMs involved in the negotiations for the school pf pharmacy were analyzed. The outcomes resulting from the tactical negotiations were the settlement point and the joint utility for each issue, as shown in Figures 7.5, 7.6, and 7.7 as well as in Table 7.3. To examine the sensitivity of the output values to changes in the n value as input data, the possible range of the DMs' n values ($0 < n \leq 10$) was considered, and the corresponding settlement points and joint utilities were obtained.

To facilitate the analysis of the results, the set of values for each output was plotted separately against the set of n values. Therefore, with respect to each negotiation issue and each pair-wise negotiation, two plots have been systematically examined: 1) the variation in the settlement point with the n value and 2) the variation in the joint utility value with the n value. The two plots have been developed for the three pair-wise negotiations between the DMs: pair-wise negotiations between PolyOne and the City, pair-wise negotiations between PolyOne and UW, and pair-wise negotiations between the City and UW. The resulting plots of the pair-wise negotiations between PolyOne and the City are shown in Figure 7.8, between PolyOne and UW are shown in Figure 7.9, and between the City and UW are shown in Figure 7.10.



a) The impact of City's attitude changes on its concession when PO's attitude is unchanged

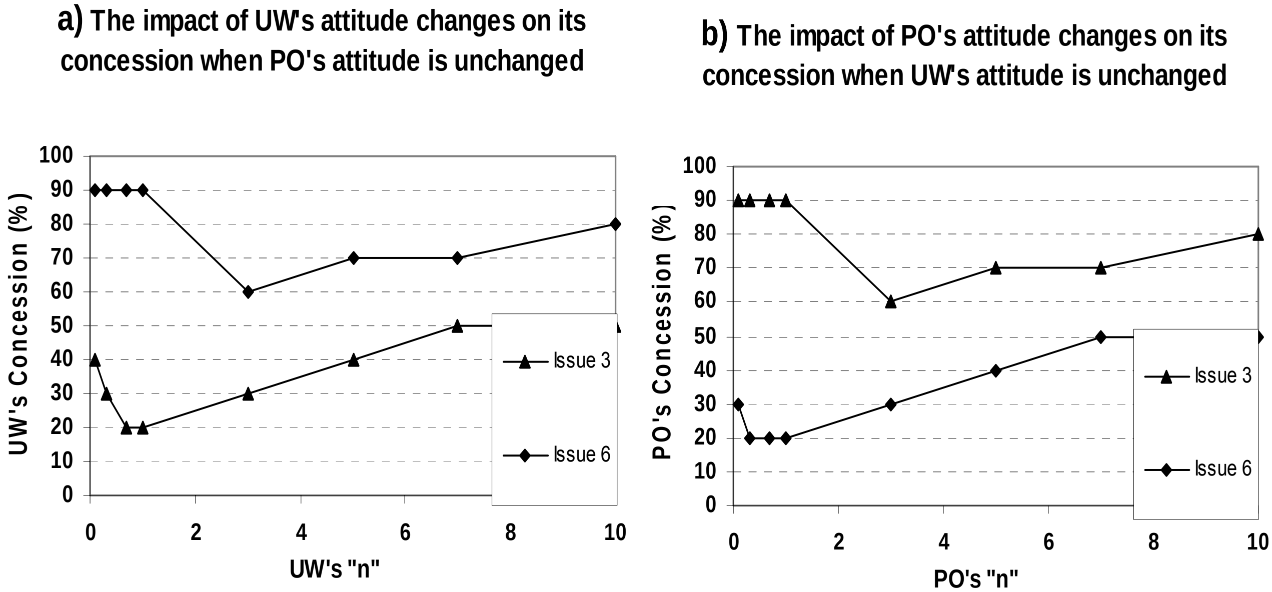
b) The impact of PO's attitude changes on its concession when City's attitude is unchanged



c) The impact of City's attitude changes on its utility when PO's attitude is unchanged

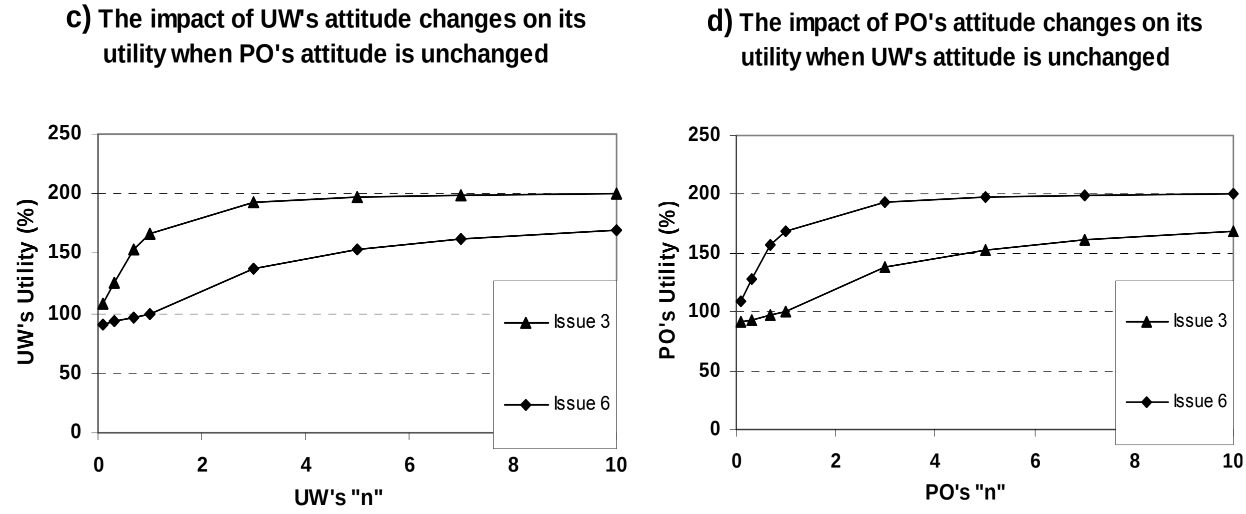
d) The impact of PO's attitude changes on its utility when City's attitude is unchanged

Figure 7.8: Sensitivity Analysis for a Specific DM in the PolyOne – City Negotiations



a) The impact of UW's attitude changes on its concession when PO's attitude is unchanged

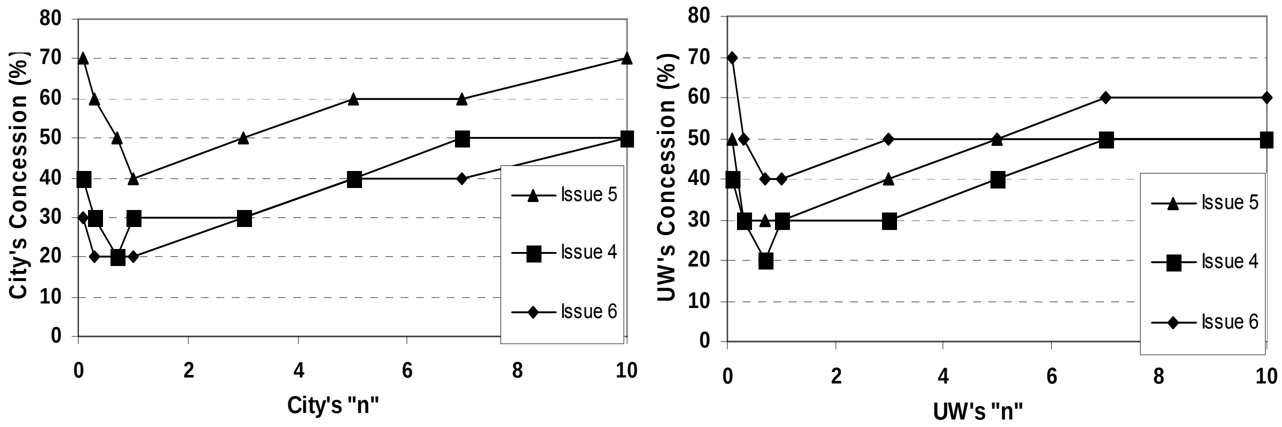
b) The impact of PO's attitude changes on its concession when UW's attitude is unchanged



c) The impact of UW's attitude changes on its utility when PO's attitude is unchanged

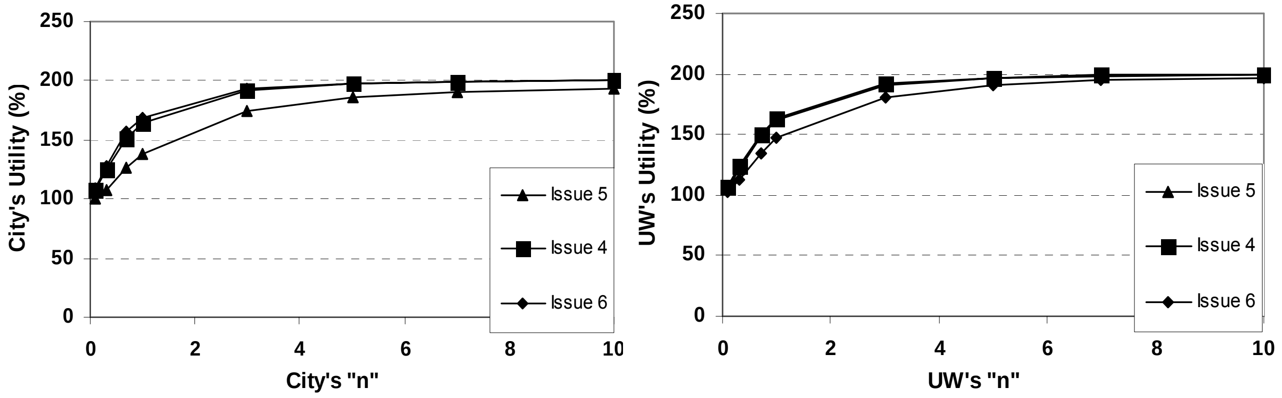
d) The impact of PO's attitude changes on its utility when UW's attitude is unchanged

Figure 7.9: Sensitivity Analysis for a Specific DM in the PolyOne – UW Negotiations



a) The impact of City's attitude changes on its concession when UW's attitude is unchanged

b) The impact of UW's attitude changes on its concession when City's attitude is unchanged



c) The impact of City's attitude changes on its utility when UW's attitude is unchanged

d) The impact of UW's attitude changes on its utility when City's attitude is unchanged

Figure 7.10: Sensitivity Analysis for a Specific DM in the City – UW Negotiation

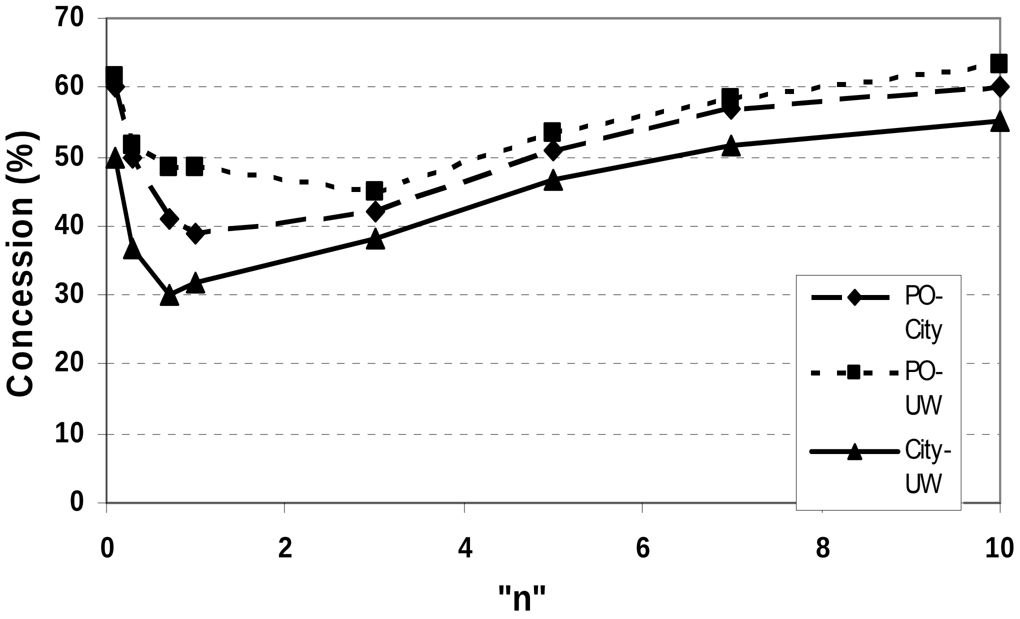
As shown, each figure consists of two plots: the first represents changes in the settlement point, or the amount of concession each DM should make, and the second represents changes in the joint utility value. To assess the sensitivity of the two outputs of the negotiations with respect to each DM, the n value for one DM is changed while the other DM's n value remained fixed.

The plots in the figures are particularly useful when the sensitivity of the output from the negotiation for a DM is required with respect to a particular issue, as can be illustrated by considering the pair-wise negotiation between the city and UW. With respect to sub-issue 6 (initial construction costs), one may examine the effect of UW's n value changing from n = 10 to n = 1 on the settlement point and the joint utility value. In other words, when UW's attitude toward the city changes from positive to neutral, the range of reduction in the settlement point and the joint utility level can be determined. The right-hand plots in Figure 7.10 show that when UW's n value changes from 10 to one during the negotiation for sub-issue 6, UW's concession is then reduced from 60 % to 40 % with respect to that issue. The joint utility value is also reduced from 197 to 147, which indicates that the level of joint satisfaction drops considerably when UW changes its positive attitude to a neutral attitude toward the city.

7.5.1. Discussion of the Attitude-Based Sensitivity Results

The plots included in the previous subsection can be used to assess changes in the negotiation parameters and can be summarized in two plots (Figure 7.11). The overall impact of the DMs' attitudes on their average amount of concession is shown in Figure 7.11a, and the impact of the DMs' attitudes on the DMs' average level of satisfaction is shown in Figure 7.11b.

a) Overall Impact of DMs' Attitude on DMs' Concession



b) Overall Impact of DMs' Attitude on DMs' Utility

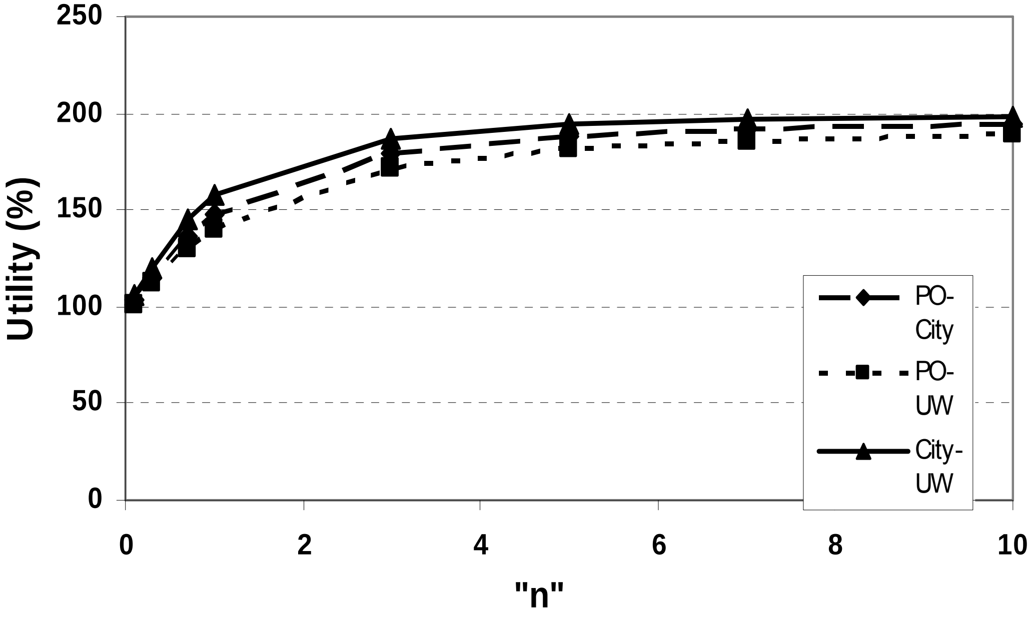


Figure 7.11: Overall Results of the Sensitivity Analysis for the Tactical Negotiations for the School of Pharmacy

As shown in Figure 7.11a, when 0 < n < 1, the DMs have a negative attitude toward themselves and/or toward the other DMs, and the amount of concession is considerably reduced. The steep slope of the graphs in that area indicates that the settlement point is very sensitive to the selection of an n value of 0 < n < 1 for a DM's utility function. When the n value changes from less than one (i.e., a negative attitude) to a value more than one (i.e., a positive attitude), the slope of the graphs then increases positively. The turning point on the graphs occur when n = 1, which means that the DMs have neutral attitudes. When the DMs have a positive attitude toward themselves and/or the other DMs (i.e., 1 < n ≤ 10), then the slope of the graphs increases slightly. In particular, when 2 < n ≤ 6, the increase is more than when 7 < n ≤ 10. In other words, when an n value between 2 and 6 is selected, more changes in the DMs' amount concession can be expected. On the other hand, when an n value between 7 and 10 is selected for the DMs' utility functions, no significant change in the DMs' amount of concession will result.

As shown in Figure 7.11b, the utility (i.e., level of joint satisfaction) of the three pair-wise negotiations increases when the n value is increased from 0.1 to 10. Furthermore, when 0 < n < 1, the joint utility value is low and the marginal changes in the average utility value increase. On the other hand, when 1 < n ≤ 10, the marginal changes in the joint utility value decrease although the joint utility value itself is high. In other words, the pair-wise negotiations conducted in the case study indicate that when two DMs with a positive attitude negotiate, the joint utility value that results from the selection of n = 7 for both DMs’ functions will not differ significantly from the joint utility value that results from the selection of n = 10 for both DMs’ functions.

7.5.2. Monte Carlo Simulation

In the previous subsection, the sensitivity of the DMs’ amount of concession and utility value to the whole range of changes in the DMs’ attitude (i.e., $0 < n \leq 10$) was analyzed. The objective of this subsection is to present an evaluation of the sensitivity of the DMs’ amount of concession and utility value to only a limited range of n values (e.g., ±10% of n). In other words, the objective is to verify the accuracy of the n value selected by changing the n value slightly and observing the magnitude of the changes in the DMs’ amount of concession and utility value. This objective was achieved through the use of the Monte Carlo simulation (Hegazy, 2006), which is a versatile problem-solving technique used to approximate the probability of specific outcomes by running multiple trial runs, called simulations, using random variables. The core idea of the Monte Carlo simulation is to use random samples of parameters or the input in order to explore the behavior of the output. The technique has also applications in the physical sciences, design and visual arts, finance and business, and telecommunications. As shown in Figure 7.12, with respect to the school of pharmacy negotiations, the Monte Carlo simulation was used to examine the accuracy of the output with respect to the three pair-wise negotiations (i.e., PO – City, PO – UW, and City – UW).

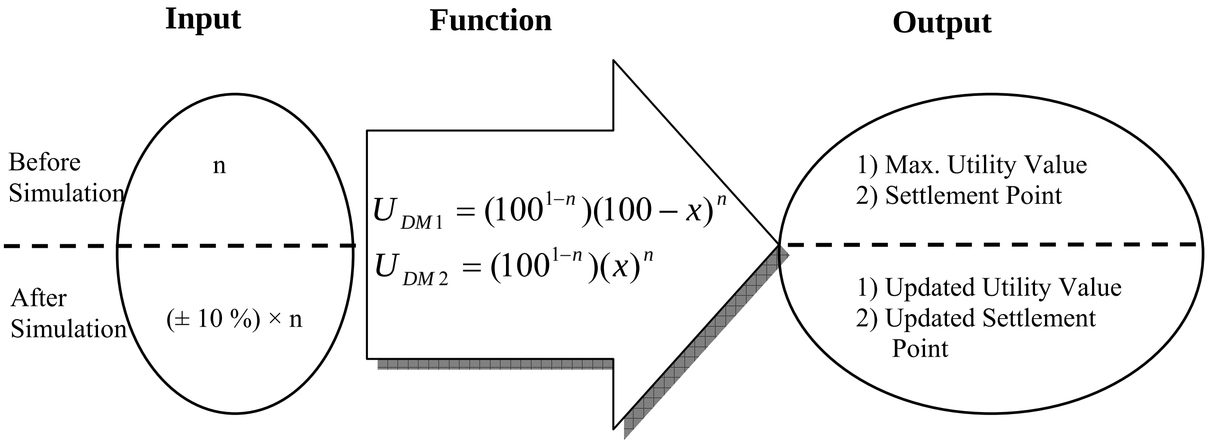


Figure 7.12: The Application of the Monte Carlo Simulation for the Case Study

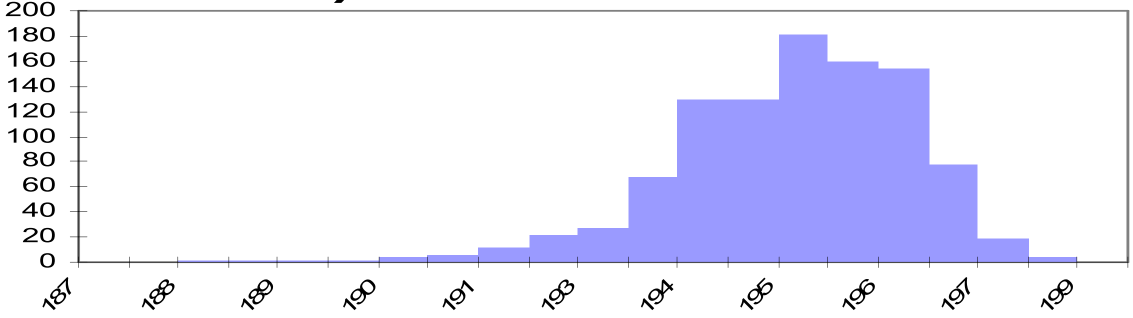
The average n value was calculated for the six issues, identified in the case study and listed in Table 7.2. A pair-wise negotiation was then simulated between the DMs, considering the average n value for each DM's utility function. For each pair-wise negotiation, a settlement point and a maximum utility value were obtained as the outputs of the negotiations before the Monte Carlo simulation was implemented (Figure 7.12).

In the first step of evaluating the accuracy of the two results, the values within 10% of the average n value are considered, and the simulated output is obtained for each randomly selected n value. The process is repeated 1000 times in order to obtain 1000 sets of output which are used to determine the average of the simulated output. The initial output is then compared with the simulated output, and any discrepancies and errors are calculated and discussed.

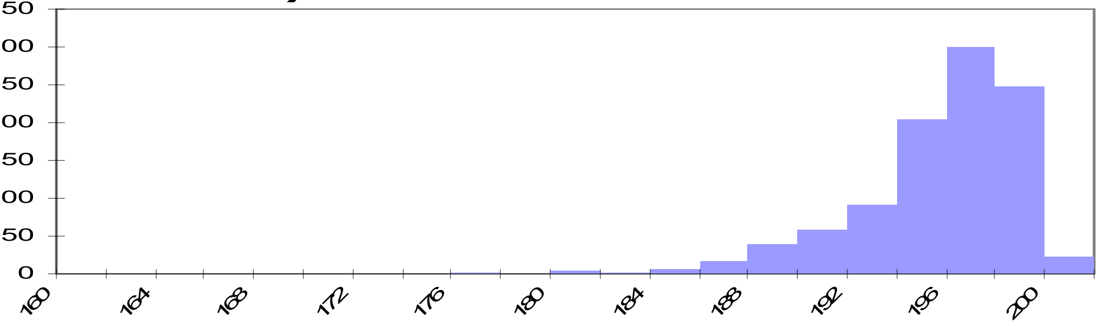
In the second step of evaluating the accuracy of the two results, the values within 20% of the average n value are considered, and the simulated output is obtained for each randomly selected n value. The same process explained in the first step is then carried out in order to obtain a different set of output. In the third and last step, the values within 40% of the average n value are considered, the simulated output is obtained for each randomly selected n value, and the results are discussed. The results of the implementation of the Monte Carlo simulation in this case study are shown in Figures 7.13, 7.14, and 7.15 for the PO – City, PO – UW, and City – UW negotiations, respectively. The statistical results of the simulations are also summarized in Table 7.4, followed by a brief discussion of the simulation results.

As can be seen, the overall results of the Monte Carlo simulation indicate that no significant change occurs in the joint utility value and the settlement point (output) when the n value (input) changes within ± 10% and ± 20 % of the initial n value. However, when the n value (input) changes within ± 40 % of the initial n value, the joint utility value and the settlement point observably change. In other words, the resulting discrepancies and errors (i.e., [initial output – simulated output] / initial output) are very small to the point of negligible when the n value changes within ± 10% or ± 20 %. On the other hand, the errors are relatively high when the n value changes within ± 40%.

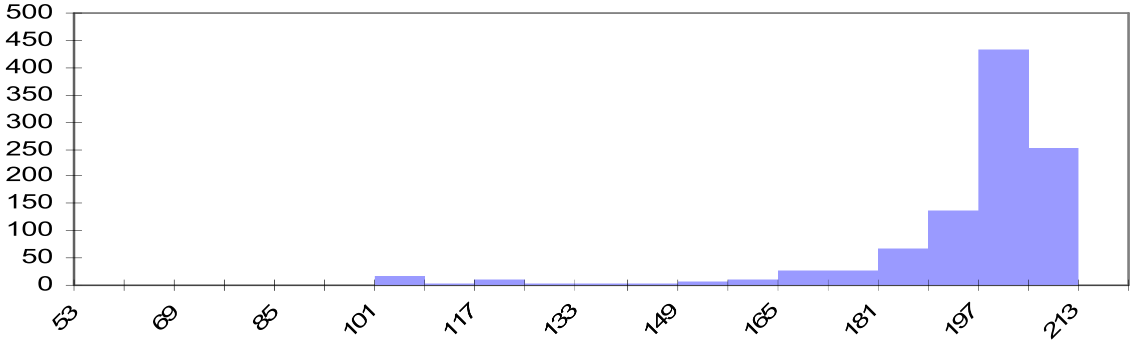
a) Within 10% of the Mean (195)



b) Within 20% of the Mean (195)



c) Within 40% of the Mean (195)



d) Distribution of the Mean (195)

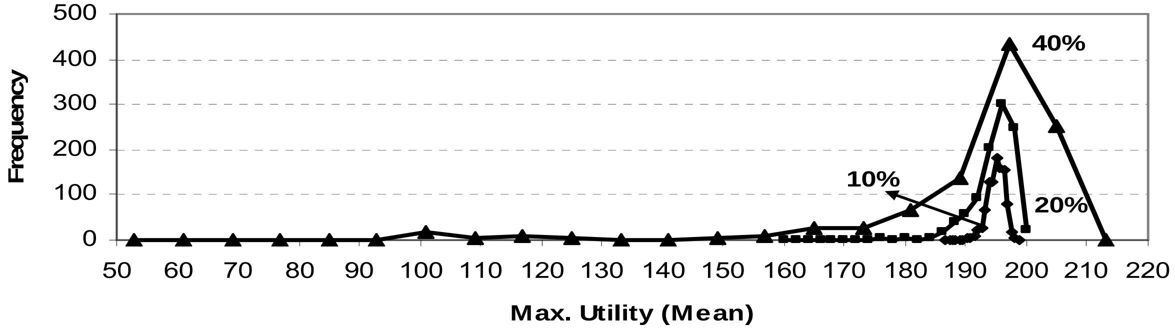
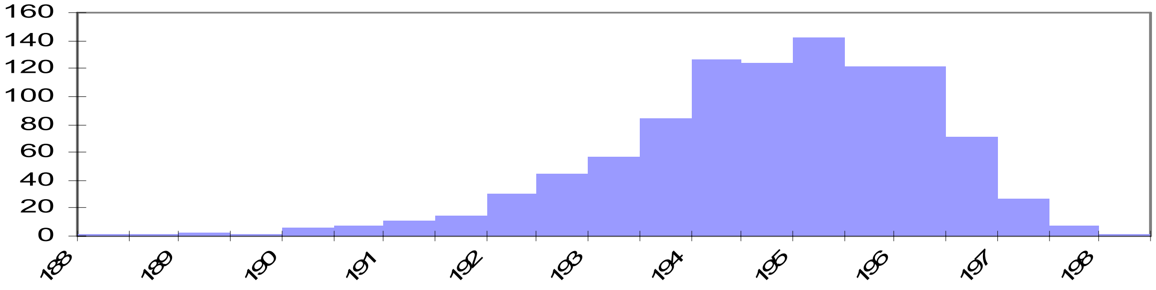
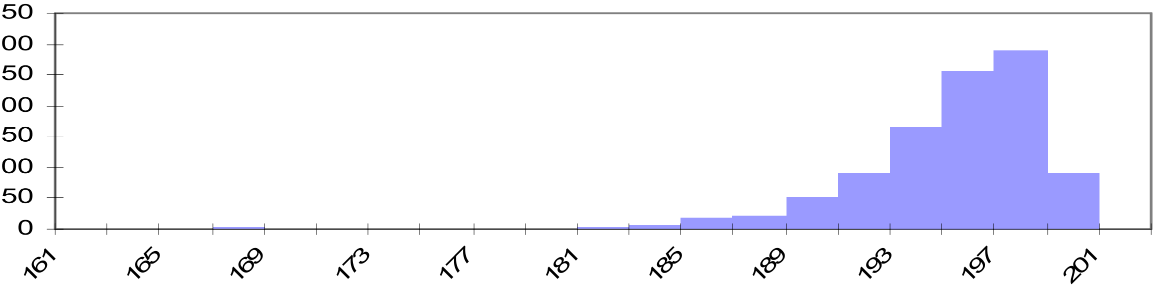


Figure 7.13: Histograms for PO - City Resulting from the Monte Carlo Simulation

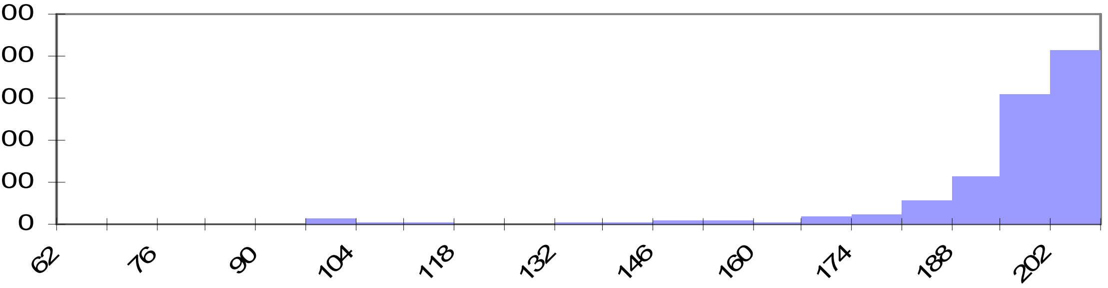
a) Within 10% of the Mean (195)



b) Within 20% of the Mean (195)



c) Within 40% of the Mean (195)



d) Distribution of the Mean (195)

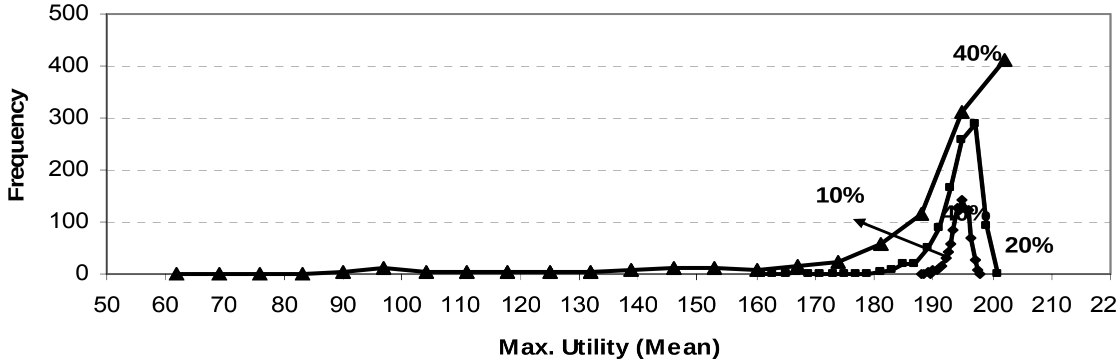
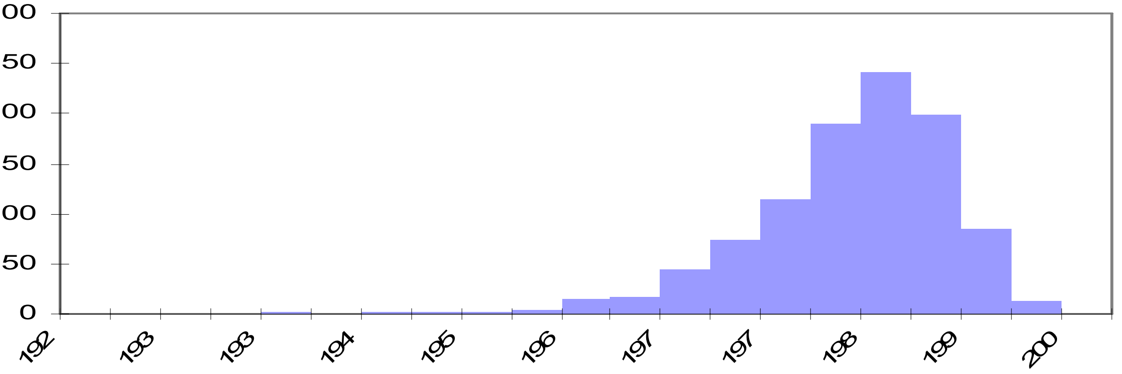
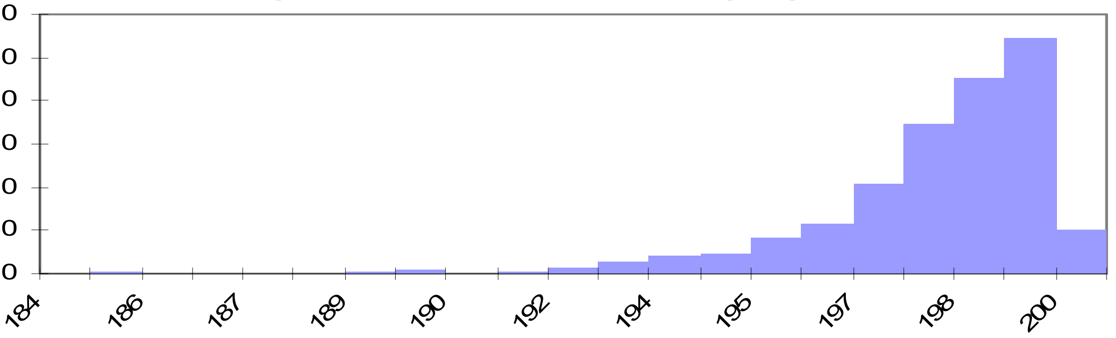


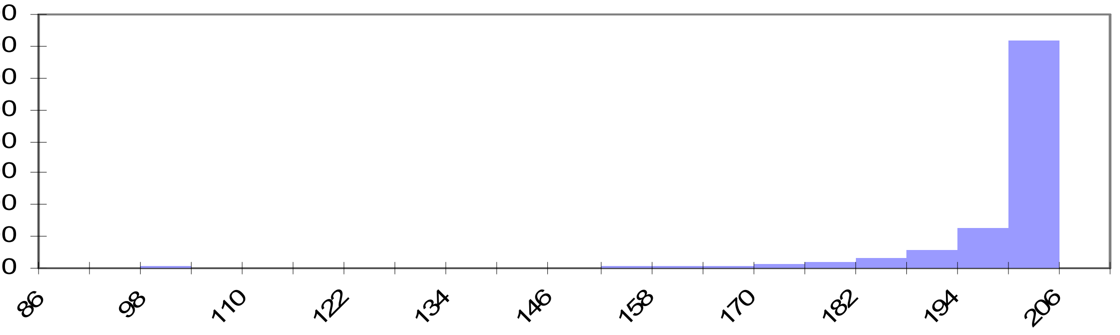
Figure 7.14: Histograms for PO – UW Resulting from the Monte Carlo Simulation



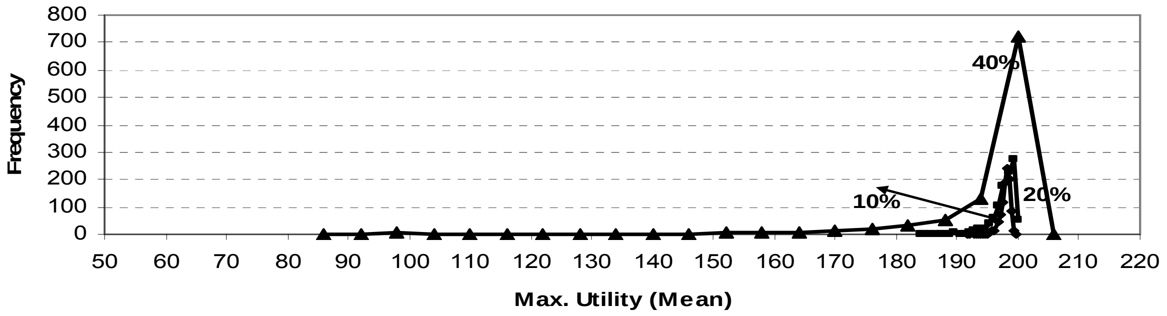
a) Within 10% of the Mean (198)



b) Within 20% of the Mean (198)



c) Within 40% of the Mean (198)



d) Distribution of the Mean (198)

Figure 7.15: Histograms for City – UW Resulting from the Monte Carlo Simulation

Table 7.4: Summary of the Monte Carlo Simulation Results for the Case Study

Simulation	Simulation Statistics for Three Pair-wise Negotiations			PO - City	PO – UW	City - UW
Before	Settlement (%)			50	50	50
	Utility			195	195	198
	Average “n” for Six Issues			PO = 5.2 City = 5.4	PO = 5 UW = 5.5	City = 6.3 UW = 7
After	Within 10% of average “n”	Settlement (%)		50	50	50
		Ave. Utility (%)		195	194	198
		Minimum		187	186	193
		Maximum		198	198	199
		Standard Deviation		1	2	1
		Error (%)	Setl.	0	0	0
			Util.	0	0.5	0
	Within 20% of average “n”	Settlement (%)		50	50	50
		Ave. Utility (%)		194	193	197
		Minimum		175	170	180
		Maximum		199	199	200
		Standard Deviation		3	4	2
		Error (%)	Setl.	0	0	0
			Util.	0.5	1.0	0.5
	Within 40% of average “n”	Settlement (%)		40	40	30
		Ave. Utility (%)		187	187	192
		Minimum		82	73	71
		Maximum		200	200	200
		Standard Deviation		18	21	16
		Error (%)	Setl.	10	10	20
			Util.	4.1	4.1	3.0

As shown in Table 7.4, when the n values within ± 40% are considered as the simulation input, the standard deviation (σ) reaches 18, 21, and 16 for the PO –

City, PO – UW, and City – UW negotiations, respectively. Such high standard deviations indicate that the output data are spread over a large range of the mean value (output) as shown in Figures 7.13d, 7.14d, and 7.15d. On the other hand, when the n values are selected within ± 10%, the standard deviation reaches 1, 2, and 1, for the PO – City, PO – UW, and City – UW negotiations, respectively. The low standard deviations indicate that all of the output data points are very close to the same value (the mean).

With respect to the situations in which the n value changes within ± 10% and ± 20%, the maximum joint utility value that results from the Monte Carlo simulation is very close to the original maximum joint utility value, so no change occurs in the settlement values after the simulation. As shown in Table 7.4, the settlement value is 50% both before and after the simulation (i.e., ±10% and ±20%) with respect to the three pair-wise negotiations. In other words, if the original n value or even the values within ±10% and ±20% of the original n value are considered, the settlement point does not change. Therefore, the results of the Monte Carlo simulation indicate that the initial n values selected for the DMs' utility function in the present case study are accurate and, thus, the results can be verified.

7.6. Case Study Updates

Once the site was reasonably remediated in 2001, it was donated for public use, which would allow easier coordination between the development of the land and the completion of the environmental remediation. The city then reviewed redevelopment plans in order to assess which projects (e.g., transportation terminal, parking lots, and educational centre) could best meet the requirements of the taxpayers. After a long investigation, the DMs involved eventually agreed on the construction of an educational centre as the redevelopment phase of the brownfield project. The DMs involved viewed an educational campus as a potential boom to downtown redevelopment. Educational institutions can help create the 24-hour-a-day, seven-day-a-week traffic the city wants to see in the core. Moreover, education institutions are growth industries that can adapt to a downtown environment. They have the greatest success in the revitalization and adaptive reuse of industrial heritage buildings and redundant industrial building space. As proposed by the methodology developed and as indicated by the final results of the tactical negotiations, the City of Kitchener contributed significantly to the negotiations by having a positive attitude as well as by providing reasonable incentives. The motivations of the city for completing the strategic and tactical negotiations and its objectives in the redevelopment of the site are outlined as follows:

1. Diversifying and expanding Kitchener's economic base and generating significant impetus toward the revitalization of downtown Kitchener and the creation of a core area;
2. Attracting the education and knowledge-creation sector to provide a critical balance for the city, which can lessen the impact of future economic downturns;
3. Stimulating Kitchener's economy through ongoing expenditures by visitors;

4. Stimulating an influx of health-related start-up businesses;
5. Stimulating residential growth in the downtown Kitchener; and
6. Redeveloping vacant and underutilized downtown buildings and lands.

In addition to the costs proposed in Table 7.3, when the construction of the UW School of Pharmacy was begun, the DMs continued their cooperative help with respect to major costs of the construction. For example, the city gave UW $30 million for the development of the project, and UW contributed $12 million as an operating endowment. Other contributions included $15 million per year operating costs, a $60 million per year research budget, and $55 million other contributions, with a total budget of $147 million (Ash, 2004). Figure 7.16 shows the UW School of Pharmacy, which was under construction and had been scheduled to be completed by the end of 2008. The DMs involved (PolyOne, the city, and UW) were working together to obtain the environmental approvals necessary to effect the final transfer of the property to the city and, ultimately, to UW.

7.7. Lessons Learned

This remarkable real-life negotiation case study represents the best opportunity for turning a brownfield project into a showcase of brownfield redevelopment. The case study also provides important lessons in negotiation. First, this case study proves how positive attitudes of the DMs involved could significantly improve the outcome of brownfield negotiations so that very beneficial and stable solution were resulted that benefits all the DMs involved. In this case study, the site was initially owned by a privately owned company (PolyOne) and was finally transferred (through the City of Kitchener) to UW, a publicly owned institution. Therefore, this situation made this case study a very interesting negotiation scenario in which the parties involved who had diverse preferences and interests, began negotiations, shared their concerns, and mutually agreed upon a beneficial outcome from their joint negotiations.

Figure 7.16: The UW School of Pharmacy under Construction

The parties involved benefited from this project in the following ways:

1. PolyOne Canada saved money.

2. The City of Kitchener and the Ministry of Environment saved time, money, and resources by dealing with a single, constant entity.
3. The City of Kitchener removed an eyesore and gained a valuable community asset in a relatively short time.
4. The University of Waterloo was successfully able to expand its educational and geographical facilities to downtown Kitchener by constructing a school of pharmacy and receiving financial and social support for the project.
5. Business gained confidence that it can work with government and the community to solve brownfield problems without being penalized for positive efforts.

The other lessons that can be learned from this brownfield case study are as follows:

1. Volunteer and take control, even if it means accepting additional financial responsibility.
2. Work for solution without waiting for governmental agencies.
3. Define the ultimate use of a brownfield project and then tailor the remediate.
4. Start by involving the community before commencing the project.
5. Focus remediation funds on site clean-up rather than on multiple-party transactions and legal costs.

6. Minimize overall costs and shorten the time frame by conducting cooperative negotiations among the parties involved.
7. Change potential the positive attitudes of the parties to practical positive attitudes.
8. Maintain and demonstrate the credibility of the parties.
9. Regard governmental institutes as a reliable ally in brownfield negotiations.

Finally, PolyOne has subsequently implemented many of the lessons learned in this case study at two U.S. superfund sites, with very promising results. The first site was a non-operating site in Wharton, NJ, that was remediated under the supervision of the U.S. EPA (Environmental Protection Agency) and the New Jersey DEP (Department of Environmental Protection) and the second site was a former site in Wilmington, DE, at which the Delaware DNREC (Delaware's Department of Natural Resources and Environmental Control) mandated a remedial investigation.

7.8. Summary

This chapter has presented a tactical negotiation methodology that was developed in order to consider multiple decision makers and multiple negotiation issues as well as the attitudes of the DMs. The tactical negotiation methodology proposed in this chapter was developed based on the generalization of the negotiation methodology presented in Chapter 6. The negotiation methodology described in this chapter complements the strategic negotiation methodology described in Chapter 5.

The generalized procedure for tactical negotiation was first introduced and explained with reference to two negotiation approaches: 1) one issue at a time and 2) two DMs at a time. To take into account the correlations among the negotiation issues, the second approach was employed in the development of a tactical negotiation methodology for the school of pharmacy negotiations, a real-life brownfield negotiation case study. In the first step of developing the methodology, the issues under the case study negotiation were identified, and the weights and least expectations were determined for each issue with respect to each DM. In the second step, the proposed tactical negotiation methodology was implemented in the case study, and three pair-wise negotiations were developed using the concept of utility functions and considering the six negotiation issues as well as the DMs' attitudes. In the third step, for each pair-wise negotiation, a settlement point, as the detailed negotiation outcome, was obtained with respect to each issue, and appropriate discussions were then provided, based on the results as presented in figures and tables. Finally, the chapter described an attitude-based sensitivity analysis that was carried out in order to evaluate the sensitivity changes in the attitudes of the DMs. In particular, Monte Carlo simulation was used to assess and validate the utility function form selected for the DMs involved in the case study negotiation.

CHAPTER 8:
Decision Support System for Construction Negotiation

8.1. Introduction

This chapter presents the implementation of the negotiation methodology described in Chapters 4 and 5 into a Negotiation Decision Support System (NDSS). The NDSS has been developed as a working prototype that can provide decision makers (DMs) with automated, speedy, and more accurate decision results with respect to the resolution of construction conflicts. The NDSS was implemented with the use of a spreadsheet program. To demonstrate the decision-support capabilities of the prototype, details of its implementation are presented using the brownfield case study conflict presented in Chapter 4.

8.2. Design of the Proposed System

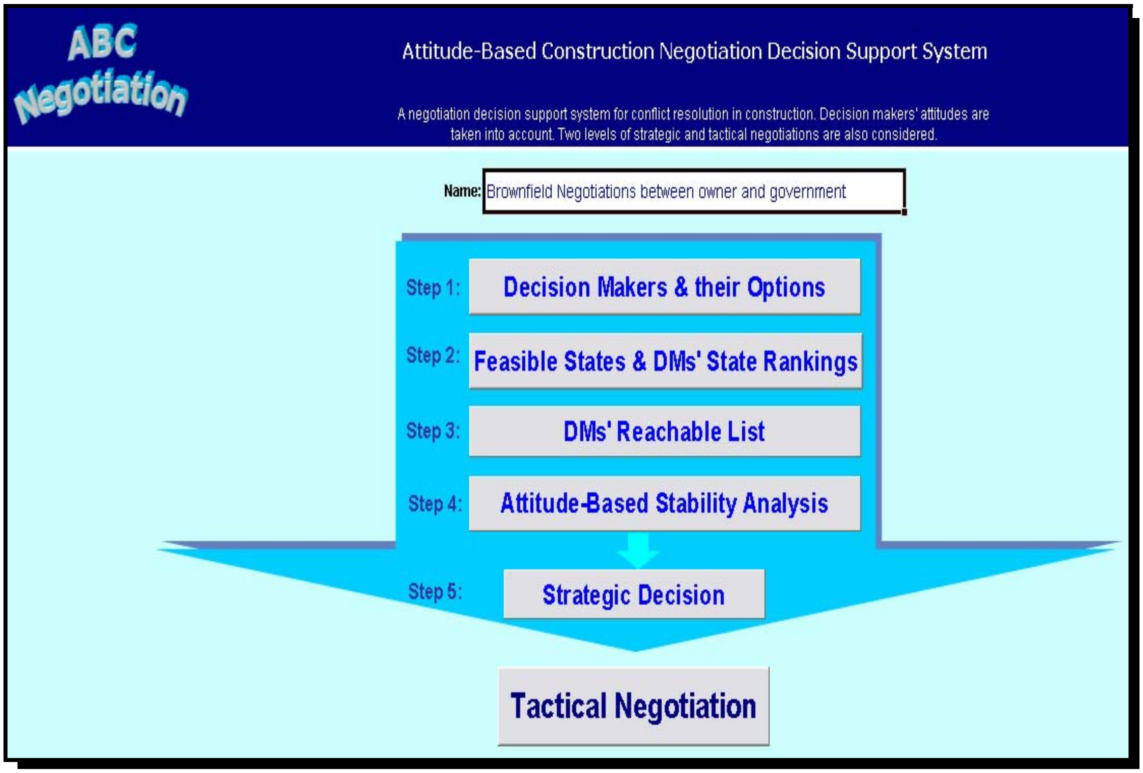
The attitude-based negotiation methodology described in this research lends itself well to spreadsheet modeling, in which each component of the methodology, such as the procedure for determining the attitudes of DMs and their state rankings, can be represented on different spreadsheets. Furthermore, spreadsheets have many advantages and powerful features that enable rapid prototyping of the proposed negotiation methodology, and the validation and testing of the results can therefore be facilitated (Yousefi et al., 2008).

For this research, Microsoft (Ms) Excel software was selected for the implementation of the proposed methodology because of its ease of use, wide range of uses in construction, helpful formulas and add-in programs, and powerful programmability features. An earlier Ms Excel spreadsheet with basic Graph Model formulations (Kassab et al., 2006) was adapted for this research in order to incorporate the attitudes of DMs and the related analysis.

8.3. Prototype Negotiation Decision Support System

The spreadsheet functions and macro language of Microsoft Excel were used to design the NDSS, called "ABCNegotiation" (ABC stands for Attitude-Based Construction). The development of the prototype involved programming and formulating efforts in order to code and test a variety of modules for developing a unified, user-friendly interface. The NDSS was basically developed as a workbook that contains several worksheets, including a main screen with a simple interface and buttons for activating the step-by-step procedures, as shown in Figure 8.1. A schematic diagram of all components of the prototype is shown in Figure. 8.2.

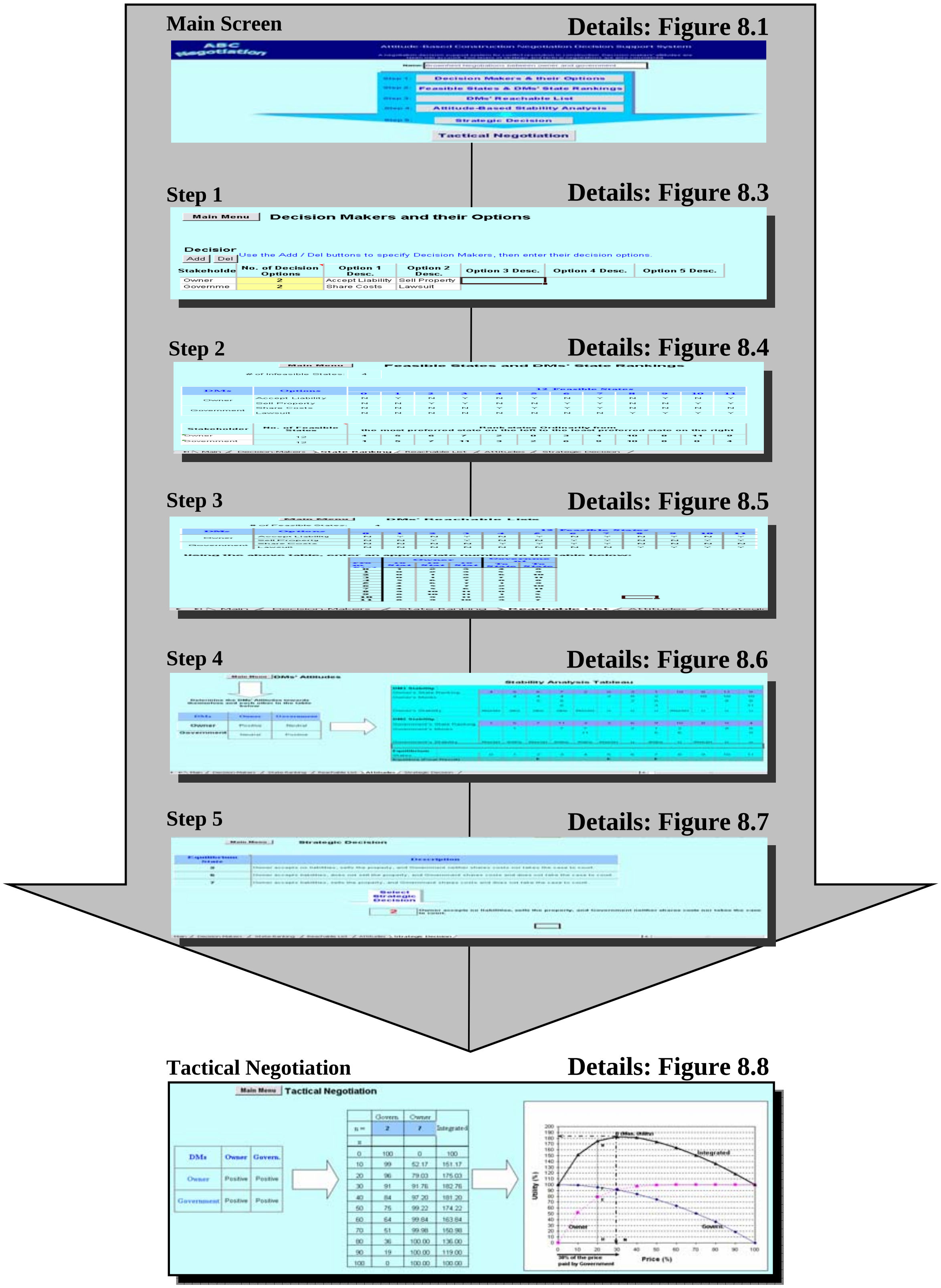
The interface automates all of the computations involved in the NDSS and allows the user (e.g., a decision maker) to interact with the prototype, to enter the appropriate input data, to navigate through the worksheets, and finally, to obtain the best strategic decision. The agreed-upon strategic decision can then be further negotiated using the tactical negotiation option of the NDSS in order to determine the specific resolution needed for the DMs to reach mutual agreement.



Name: Brownfield Negotiations between owner and government

Figure 8.1: The NDSS Main Menu Screen

The brownfield negotiation case study introduced in Chapter 4 (Section 4.5) was used in this chapter in order to clarify the design of the NDSS components and to demonstrate the steps involved in the development of the process. The facts in this case study were used to simulate the negotiations at the strategic and tactical levels as conducted between the DMs (i.e., the the owner and the the government) in order to find the best mutual resolution.



Use the Add / Del buttons to specify Decision Makers, then enter their decision options.

Stakeholde	No. of Decision Options	Option 1 Desc.	Option 2 Desc.	Option 3 Desc.	Option 4 Desc.	Option 5 Desc.
Owner	2	Accept Liability	Sell Property			
Governme	2	Share Costs	Lawsuit			

DMs	Owner	Govern.
Owner	Positive	Positive
Government	Positive	Positive

	Govern.	Owner	
n =	2	7	Integrated
x			
0	100	0	100
10	99	52.17	151.17
20	96	79.03	175.03
30	91	91.76	182.76
40	84	97.20	181.20
50	75	99.22	174.22
60	64	99.84	163.84
70	51	99.98	150.98
80	36	100.00	136.00
90	19	100.00	119.00
100	0	100.00	100.00

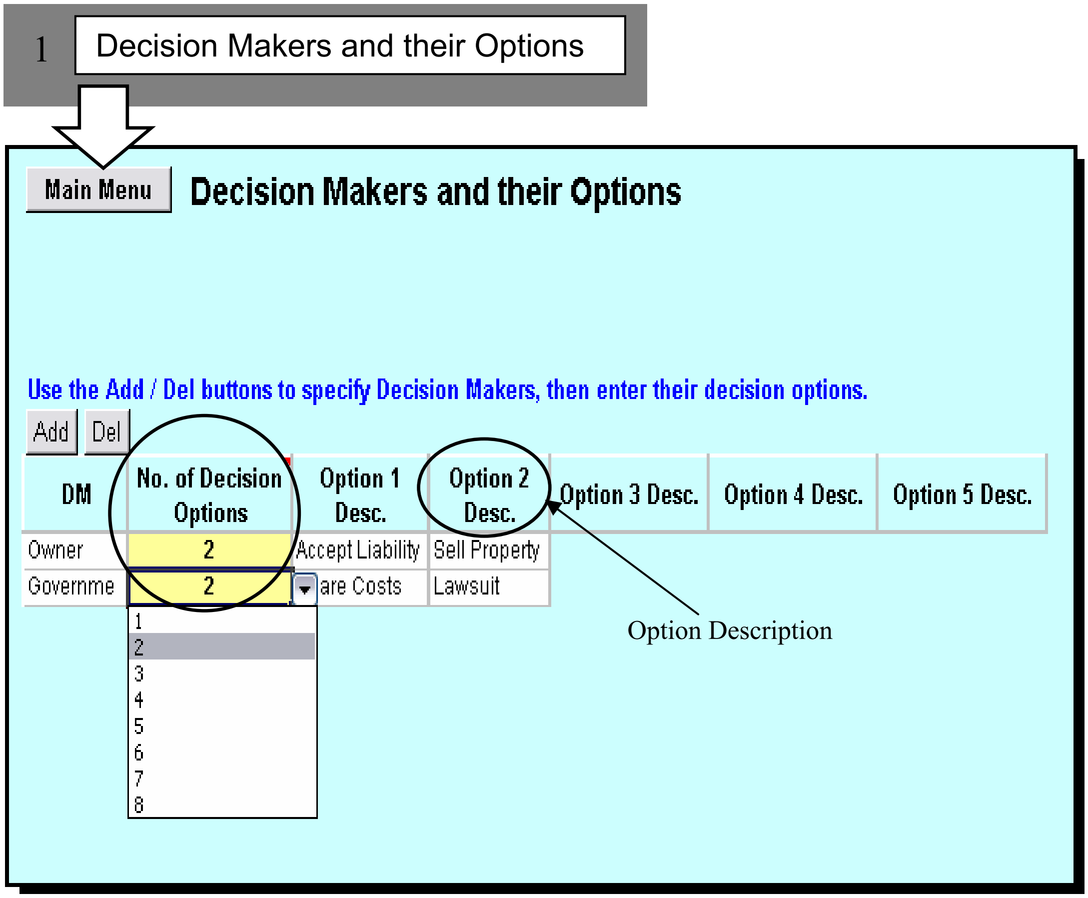
Figure 8.2: Components of the Proposed NDSS

To benefit from the proposed NDSS, a user, who can be the owner, the government, or a mediator, can use the program before and/or during the negotiation process. The proposed NDSS therefore provides speedy and accurate advice for the DMs involved so that they can make better decisions and more efficiently determine the most beneficial resolution for their brownfield conflict. The NDSS design involves several steps, as explained in the following subsections.

8.3.1. Step 1: Determine the DMs and Their Options

Once the user clicks on the “Decision Makers and their Options” button on the main screen, a worksheet appears, as shown in Figure 8.3, and the user can enter the names of DMs and the number and the names their available options. Two buttons have also been designed to allow the user to add more DMs or to delete redundant DMs, as shown in Figure 8.3.

As shown in the circles in Figure 8.3, the user can use the drop-down box to simply enter the number of decision options for each DM. Once the number is entered, the program generates boxes in which the user can type a suitable description for each option. It should be noted that specifying the DMs and their options is the most crucial step in modeling the negotiation process because the other steps depend on the number of DMs and the available options specified for them in this step. The options also need to represent realistic courses of action that each DM can take. A reasonable description can be typed based on the user's extensive consultation with its associated group, which may involve conducting surveys, consulting experts, and/or brainstorming.



Decision Makers and their Options

Use the Add / Del buttons to specify Decision Makers, then enter their decision options.

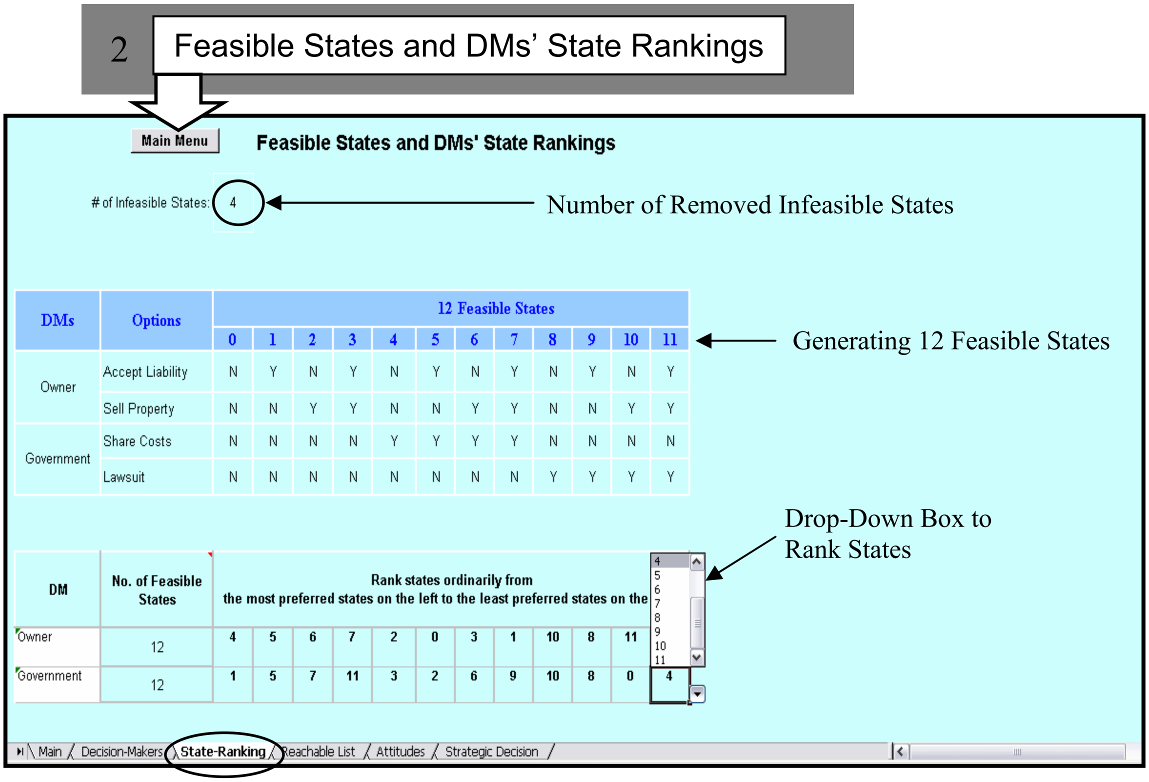
DM	No. of Decision Options	Option 1 Desc.	Option 2 Desc.	Option 3 Desc.	Option 4 Desc.	Option 5 Desc.
Owner	2	Accept Liability	Sell Property			
Governme	2	are Costs	Lawsuit			

Option Description

Figure 8.3: Decision Makers Screen in the Proposed NDSS

8.3.2. Step 2: Rank the DMs' States

In this step, shown in Figure 8.4, the list of all states (2$^{\wedge 4}$ = 16) are presented to the user, and when the user determines the number of infeasible states in the box circled in Figure 8.4, the program then deletes all the identified infeasible states, so that only feasible states are remained.



Feasible States and DMs' State Rankings

# of Infeasible States: 4

DMs	Options	12 Feasible States											
		0	1	2	3	4	5	6	7	8	9	10	11
Owner	Accept Liability	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
	Sell Property	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
Government	Share Costs	N	N	N	N	Y	Y	Y	Y	N	N	N	N
	Lawsuit	N	N	N	N	N	N	N	N	Y	Y	Y	Y

DM	No. of Feasible States	Rank states ordinarily from the most preferred states on the left to the least preferred states on the											
Owner	12	4	5	6	7	2	0	3	1	10	8	11	
Government	12	1	5	7	11	3	2	6	9	10	8	0	4

Figure 8.4: The DMs’ State Rankings Screen in the Proposed NDSS

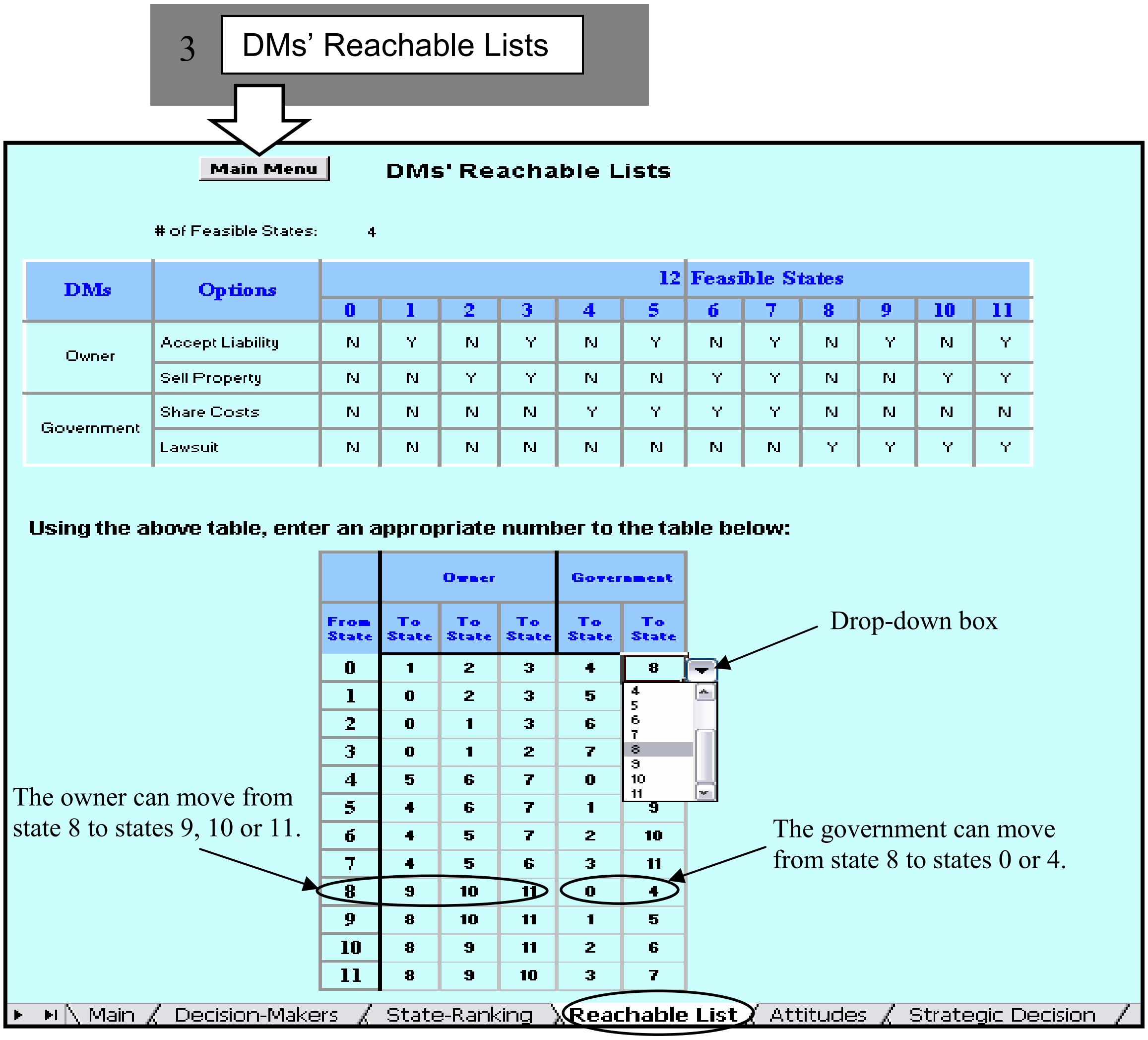
It should be mentioned that the process of removing infeasible states follows the description in Chapter 4 (Section 4.3). Once the infeasible states are determined (four infeasible states in the present case study), the program automatically generates a table of the remaining feasible states (12 in this case), as shown in the top table in Figure 8.4. Each state consists of a combination of the letters “Y” and “N,” which stand for accepting the option or not accepting the option, respectively.

Once the feasible states are determined, the user can use the lower table shown in Figure 8.4 and ordinally rank the feasible states from the most preferred states on the left to the least preferred states on the right. To facilitate the state-ranking process, the user can use the drop-down box in each cell to select an appropriate feasible state. It should be mentioned that the program cannot automatically rank the feasible states and that the user must rank the feasible states with respect to each DM's preference and considering all available feasible states. The ordinal ranking of the feasible states is a necessary step in the GMCR process.

8.3.3. Step 3: Specify the DMs' Reachable Lists

In this step, the user specifies the DMs' reachable lists (i.e., possible moves), as shown in Figure 8.5. A reachable list is a record of all the feasible states that a given DM can move to and from relative to the other feasible states. The DMs' reachable list is used to determine which states represent an improvement for each DM when their attitudes are incorporated into their decision to either move to another state or remain in the current state.

The user first considers the state rankings of the DMs involved in this case study negotiation. The drop-down box for each cell in the table allows the user to easily find the available feasible states and select one appropriate state number for each cell. As shown in Figure 8.5, the owner can move from state 8, for example, to states 9, 10, or 11, and the government can move from state 8 to states 0 or 4, as shown and indicated by two circles in the DMs' state rankings in Figure 8.5. It should be noted that according to a DMs' moves, the DM shifts from one state to another state, either better or worse.



DMs' Reachable Lists

# of Feasible States: 4

DMs	Options	12 Feasible States											
		0	1	2	3	4	5	6	7	8	9	10	11
Owner	Accept Liability	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
	Sell Property	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
Government	Share Costs	N	N	N	N	Y	Y	Y	Y	N	N	N	N
	Lawsuit	N	N	N	N	N	N	N	N	Y	Y	Y	Y

Using the above table, enter an appropriate number to the table below:

	Owner			Government	
From State	To State	To State	To State	To State	To State
0	1	2	3	4	8
1	0	2	3	5	
2	0	1	3	6	
3	0	1	2	7	
4	5	6	7	0	
5	4	6	7	1	9
6	4	5	7	2	10
7	4	5	6	3	11
8	9	10	11	0	4
9	8	10	11	1	5
10	8	9	11	2	6
11	8	9	10	3	7

Drop-down box

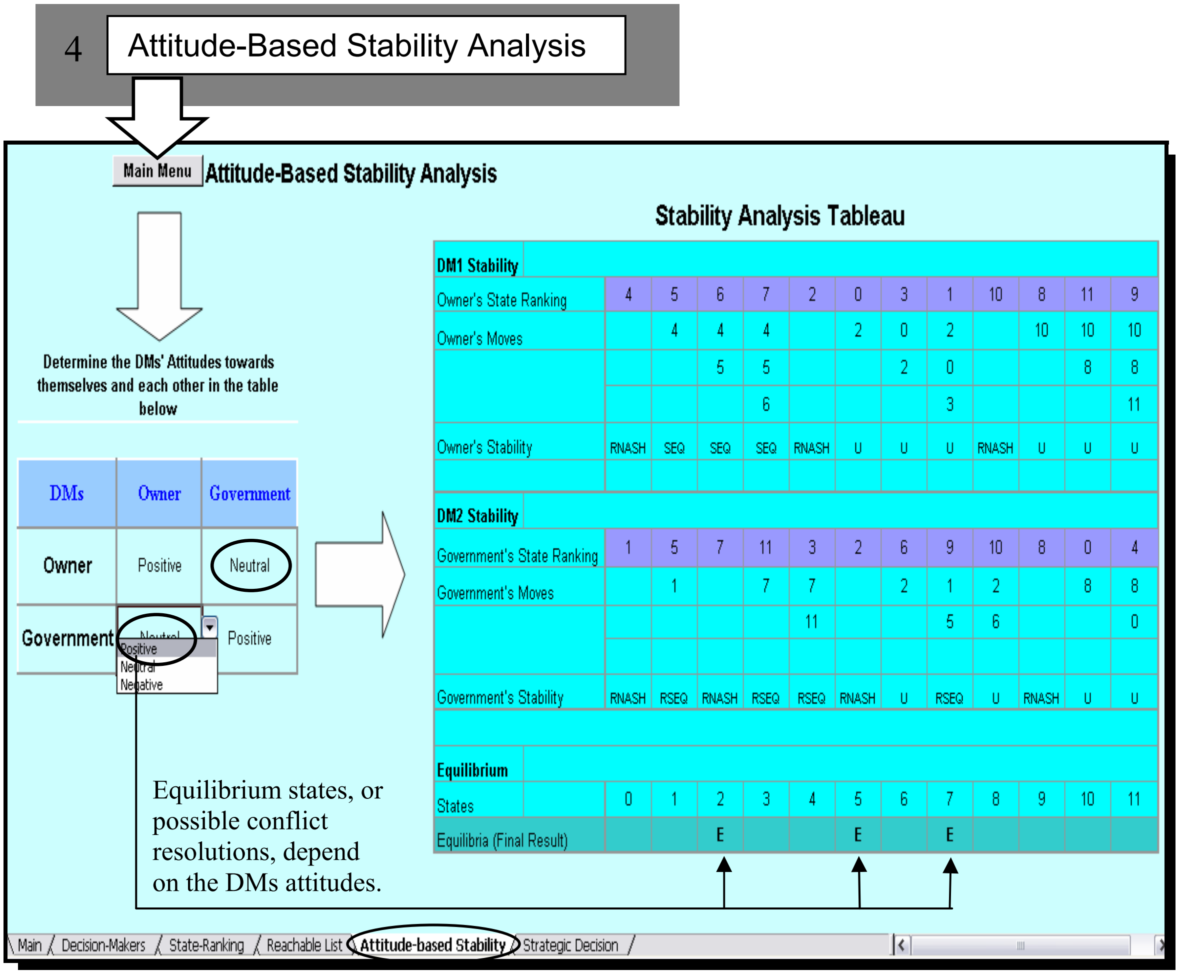
The owner can move from state 8 to states 9, 10 or 11.

The government can move from state 8 to states 0 or 4.

Figure 8.5: Reachable Lists Screen in the Proposed NDSS

8.3.4. Step 4: Perform the Attitude-Based Stability Analysis

Once the DMs' reachable lists are specified, the stability analysis, defined within the paradigm of GMCR, is carried out. The attitude-based solution concepts (i.e., stability types), and the attitude-based definitions provided in Chapter 4 (Section 4.4) are implemented in a tableau that is used to model the moves and countermoves of the DMs according to the attitudes of the DMs toward themselves and one another. Figure 8.6 shows the DMs’ attitude matrix and the stability analysis tableau for the present case study.



Determine the DMs' Attitudes towards themselves and each other in the table below

DMs	Owner	Government
Owner	Positive	Neutral
Government	Neutral Positive Neutral Negative	Positive

Stability Analysis Tableau

DM1 Stability												
Owner's State Ranking	4	5	6	7	2	0	3	1	10	8	11	9
Owner's Moves		4	4	4		2	0	2		10	10	10
			5	5			2	0			8	8
				6				3				11
Owner's Stability	RNASH	SEQ	SEQ	SEQ	RNASH	U	U	U	RNASH	U	U	U
DM2 Stability												
Government's State Ranking	1	5	7	11	3	2	6	9	10	8	0	4
Government's Moves		1		7	7		2	1	2		8	8
					11			5	6			0
Government's Stability	RNASH	RSEQ	RNASH	RSEQ	RSEQ	RNASH	U	RSEQ	U	RNASH	U	U
Equilibrium												
States	0	1	2	3	4	5	6	7	8	9	10	11
Equilibria (Final Result)			E			E		E				

Equilibrium states, or possible conflict resolutions, depend on the DMs attitudes.

Figure 8.6: Automated Attitude-Based Stability Analysis Using the Proposed NDSS

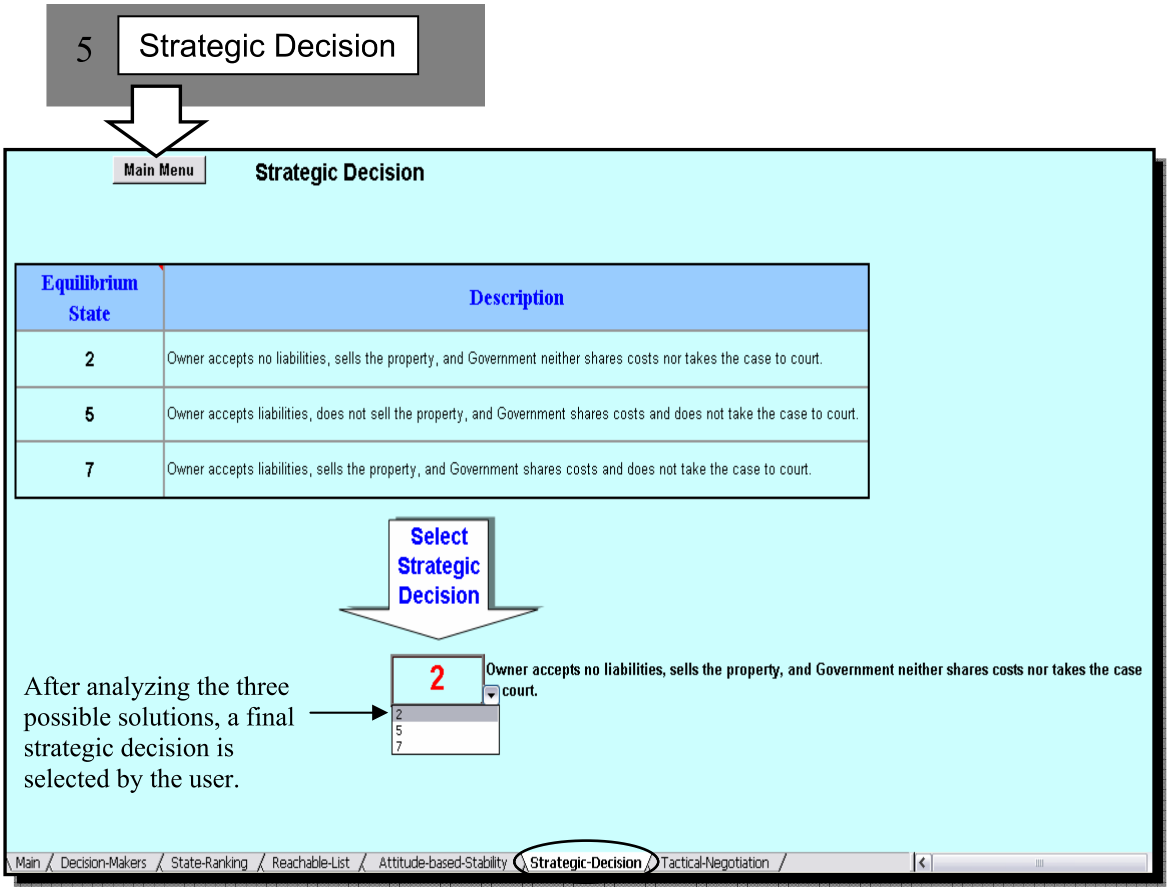
As shown in Figure 8.6, the user should first enter an appropriate type for the attitudes of the DMs toward themselves and one another using the attitude table and the drop-down boxes provided for each cell. Three types of attitude are defined in the boxes: positive, neutral, and negative. The user examines the DMs’ attitudes according to the conflict situation and then enters the appropriate attitude term into each cell in the attitude table. Once the attitude terms have been entered into the table, the program automatically carries out the stability analysis in a systematic format within a tableau, as shown in Figure 8.6 and according to the following sequential steps:

1. The program generates the DMs' state rankings using the state-ranking screen shown in Figure 8.4.
2. The program automatically determines the states underneath each state in the DM's state ranking using the DMs' reachable lists discussed in Subsection 8.3.3.
3. The program automatically determines the DMs' moves from each state in the DMs' state rankings to the states within the DMs' reachable lists, using the DMs' attitudes toward themselves and one another.
4. The program identifies the states within each DM's state ranking from which they have no move and marks them as NASH stable in the "DMs' stability" row shown in the stability analysis tableau.
5. The program automatically analyzes the stability of the remaining states involved in each DM's state rankings, and determines the stability type of the remaining states (e.g., RSEQ or U), according to the definition of RSEQ and U provided in Section 4.4.
6. The program identifies the states within both DMs' state rankings from which they have at least one type of stability. If a state in both DMs' state rankings is marked with RNASH or RSEQ, then the program marks the state as E in the "Equilibria (Final Results)" row shown in Figure 8.6.

As can be seen, the proposed prototype completely automates the attitude-based stability analysis. The user needs to enter only the appropriate attitudes of the DMs in the attitude table, and the program then quickly and accurately provides the user with a possible equilibrium state. As discussed in Chapter 4, it is very cumbersome to carry out an attitude-based stability analysis manually.

8.3.5. Step 5: Select a Strategic Decision

Once the attitude-based stability analysis has been carried out, the program provides the user with a list of equilibrium states that are generated in table format along with a description of each equilibrium state, as shown in Figure 8.7.



Equilibrium State	Description
2	Owner accepts no liabilities, sells the property, and Government neither shares costs nor takes the case to court.
5	Owner accepts liabilities, does not sell the property, and Government shares costs and does not take the case to court.
7	Owner accepts liabilities, sells the property, and Government shares costs and does not take the case to court.

2

Owner accepts no liabilities, sells the property, and Government neither shares costs nor takes the case court.

2
5
7

After analyzing the three possible solutions, a final strategic decision is selected by the user.

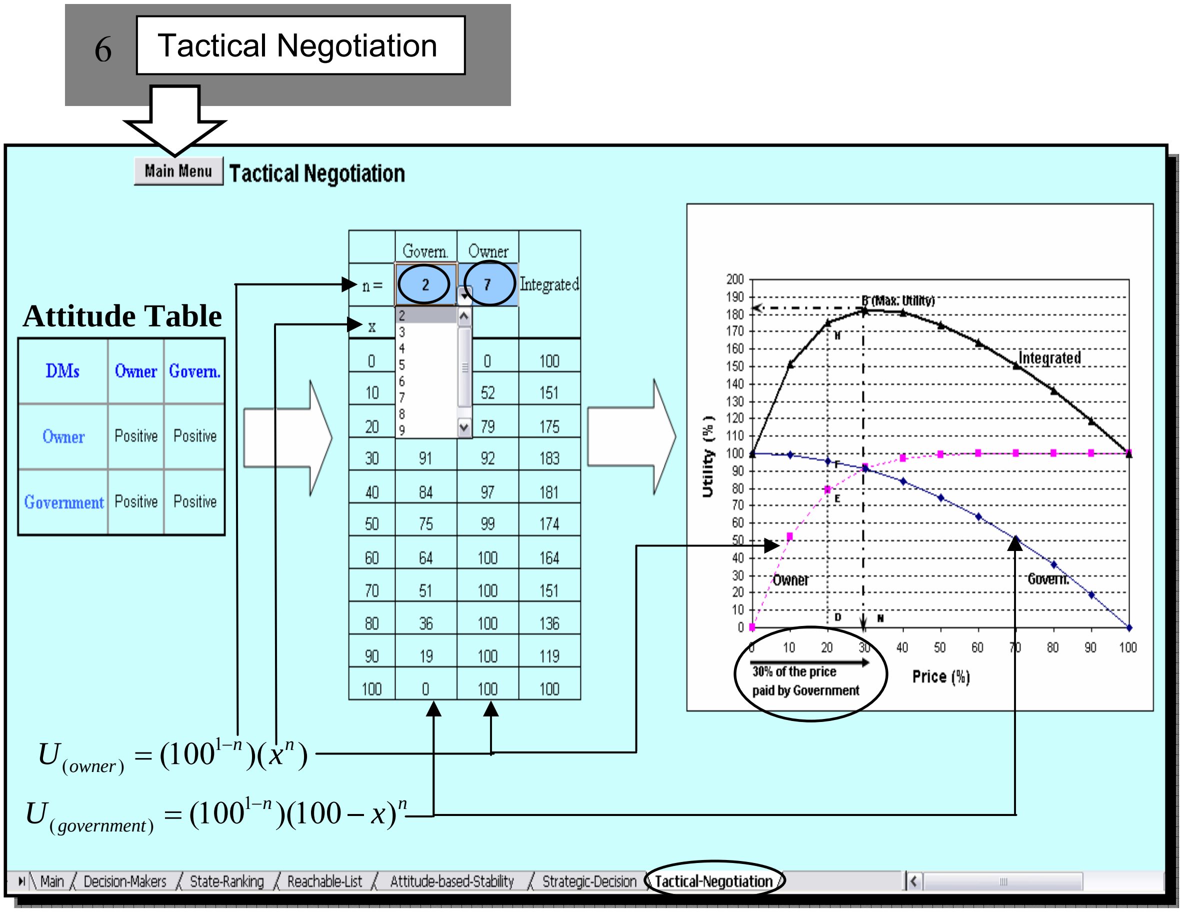
Figure 8.7: “Strategic Decision” Screen in the Proposed NDSS

Appropriate links have been defined between this worksheet and other worksheets in this program. For example, the equilibrium state cells on the left side of the table are linked to the cells in the equilibrium row shown in the stability analysis tableau in Figure 8.6. The user reviews and analyzes the resulting equilibrium states, or potential solutions for the conflict, and based on the current conflict situation, selects the most beneficial solution at the strategic level.

As discussed in Chapter 4, the most beneficial strategic decision for the present case study negotiation is equilibrium state 2, which was in fact agreed upon by the DMs. As shown in Figure 8.7, a drop-down box is provided so that the user can select the strategic decision; once the appropriate decision option is selected, the description of the decision appears to the right of the state selected. The state description helps the user identify the negotiation issues that will be negotiated at the tactical level, as discussed in the following section.

8.4. Tactical Negotiation Support

The agreed-upon strategic decision can be further negotiated at the tactical level in order to reach a mutual detailed resolution. The proposed NDSS includes a tactical negotiation component which has been designed based on the tactical negotiation methodology developed in Chapter 6. In the proposed methodology, a polynomial utility function is assigned to each DM, and through interaction of the DMs' utility functions, an integrated utility function is obtained and used to determine the settlement point, or the specific concession each DM should make in order to reach a mutual detailed resolution. The tactical negotiation screen is shown in Figure 8.8.



Attitude Table

DMs	Owner	Govern.
Owner	Positive	Positive
Government	Positive	Positive

	Govern.	Owner	
n =	2	7	Integrated
x			
0		0	100
10		52	151
20		79	175
30	91	92	183
40	84	97	181
50	75	99	174
60	64	100	164
70	51	100	151
80	36	100	136
90	19	100	119
100	0	100	100

$$U_{(owner)} = (100^{1-n})(x^n)$$

$$U_{(government)} = (100^{1-n})(100-x)^n$$

Figure 8.8: Tactical Negotiation Screen in the Proposed NDSS

The agreed-upon strategic decision selected for the present case study, as shown in Figure 8.7, constitutes one issue for negotiation, which is the selling price of the owner’s property. The DMs involved in the present case study negotiation decide to cooperatively negotiate the issue and obtain the specific concessions each DM should make in order to reach a mutual resolution at the tactical level.

Based on the above negotiation situation and the DMs' positive attitude toward themselves and each other, the user enters a positive attitude in the four cells in the attitude table (Figure 8.8). Once the attitude table has been completed, the program automatically adjusts an appropriate range for the n value, the power of the polynomial utility function. Because the DMs have a positive attitude toward each other in this situation, the program selects the range [$1 < n \leq 10$], and the user enters appropriate n values for the DMs, using the drop-down boxes shown in Figure 8.8. Once the n values have been entered by the user, the program automatically carries out the following sequential steps:

1. The program generates an appropriate number of rows (11 rows in this case) for the middle table, as shown in Figure 8.8. The first column on the left represents the x value of the DMs' polynomial utility functions and constitutes a 10% concession that each DM can make in each step. The second, third, and fourth columns include the numerical values for the utility functions of the owner, the government, and the integrated function, respectively.
2. The program draws the DMs' utility function form in a coordinated system using the numerical values of the table generated in Step 1.
3. The program draws the integrated utility function form and specifies the maximum point on it.
4. The program graphically reflects the maximum point of the integrated utility function on the horizontal axis in order to show the exact concession each DM should make, as circled in Figure 8.8.

As can be seen, the proposed prototype utilizes the concept of utility theory and incorporates an easy-to-use graphical feature in order to determine the exact concessions needed at the tactical level of negotiation. For example, Figure 8.8 depicts a situation in which the user selects the n values of 2 and 7 for the owner and the government, respectively. The program then automatically carries out the remaining tactical negotiation process and determines that a 30% concession should be made by the government, and that a 70% (100% - 30%) concession should be made by the owner with respect to the cost of the selling price of the owner's property. It should be noted that the DMs' disagreement point, as defined in Chapter 6, has not been considered in the proposed NDSS.

8.5. Summary

This chapter describes the implementation of the negotiation methodology proposed in the previous chapters in a simplified negotiation decision support system. The proposed prototype offers a promising framework for turning the implicit experience gained by construction participants into the explicit expertise needed for resolving the increasingly complex disputes that occur in the construction industry. The design of the negotiation decision support system was developed as a method of allowing the proposed negotiation methodology to be conveniently applied to construction disputes. The scalability feature of the proposed prototype allows future expansion, such as the consideration of the weight and disagreement point for each issue and each DM, as well as the consideration of multiple decision makers and multiple negotiation issues. Moreover, sensitivity analysis at both the strategic and tactical levels of negotiation can be considered using the proposed sensitivity analysis described in the previous chapters.

CHAPTER 9: Conclusions

9.1. Introduction

This chapter presents a review of the contents of this thesis and provides a summary of the conclusions and research contributions. It also highlights recommendations and suggestions for future studies of the complex conflicts and disputes that occur in the construction industry.

9.2. Research Summary

The goal of this research was to present a systematic, logically consistent, and theoretically well-founded approach to the study of negotiation methodology for resolving complex disputes in construction. Accordingly, a negotiation framework was proposed in order to achieve the following objectives: 1) understand construction negotiation and the attitudes of the decision makers; 2) develop a negotiation methodology that considers the attitudes of the decision makers; and 3) design a negotiation decision support system.

To provide a good understanding of construction negotiation, a thorough analysis of the characteristics of construction negotiations was performed, as provided in Chapter 2, in order to identify the characteristics of negotiation, particularly those related to the area of brownfield negotiations.

To develop a suitable negotiation methodology, two complementary levels of negotiation have been considered, as described in Chapter 4: strategic and tactical. With respect to the strategic level, the Graph Model for Conflict Resolution (GMCR) was presented in Chapter 3. Chapter 4 described the adaptation of GMCR to include consideration of the attitudes of the decision makers with the goal of determining a potential strategic agreement that is the most beneficial decision given the competing interests of the decision makers involved. To that end, attitude was formally defined and represented within the paradigm of GMCR. Attitude-based stability concepts, such as Nash stability and Sequential stability were then defined, following which a variety of attitude scenarios were examined and their results analyzed in order to determine the most acceptable strategic decision.

The proposed negotiation methodology includes the in-depth tactical-level study of the chosen strategic decision using attitude-based utility functions to help the decision makers reach a mutually acceptable solution to the issues pending. As described in Chapter 6, an attitude-based utility function is therefore defined for each decision maker, according to the attitude of the decision maker. An integrated utility function is then determined and used to identify the most beneficial negotiated settlement with respect to each issue.

To demonstrate the advantages of the proposed negotiation methodology, two construction case studies were used to explain the development of the proposed methodology. The first case study, a brownfield negotiation between two decision makers, was employed as presented and used in Chapters 4 and 6 in order to illustrate the development of the negotiation methodology that considers the attitudes of two decision makers. The second case study is a real-life brownfield negotiation case involving multiple decision makers which is discussed in Chapters 5 and 7 as a means of explaining the generalization of the negotiation methodology for multiple decision makers. For this case study, six attitude scenarios were identified and analyzed at the strategic level, as presented in Chapter 5, in order to determine the sets of possible strategic decisions. These sets were then analyzed and the most beneficial strategic decision selected. At the tactical level for the second case study, a generalized methodology for multiple decision makers was developed, as explained in Chapter 7, so that pending issues can be resolved using two approaches: one issue at a time, and two decision makers at a time. Using the latter approach, a mutual settlement for each issue was suggested for the decision makers involved in the case study. Chapter 7 also discusses the attitude-based sensitivity analysis which used the Monte Carlo simulation to evaluate the sensitivity of the outcomes of the negotiations to changes in the attitudes of the decision makers.

Once the negotiation methodology was developed and successfully applied to the case studies, a simplified negotiation decision support system was designed, as presented in Chapter 8. A prototype was developed that is capable of handling and solving the challenging conflicts and the complex disputes that occur in the construction industry.

The following are the main characteristics of the new negotiation methodology that make it an efficient approach for resolving challenging construction conflicts and disputes:

- It systematically combines the strategic and tactical levels of decision making and thereby offers complementary levels of decision making.
- It formally defines attitude and models it within the proposed negotiation methodology, thus providing a suitable approach for simulating the behavior of decision makers.
- It can consider multiple human factors, such as fear, anger, and hate, and can define them within the structure of the proposed negotiation framework.
- It permits the use of a wide range of numerical scales that can describe the quality of a solution at both levels.
- It can be used for resolving complex construction disputes that involve multiple decision makers and multiple conflicting issues.
- It has been developed based on the characteristics of the construction industry, such as its competitive-cooperative nature and its domain-specific knowledge.
- It takes into account the characteristics of construction negotiators, such as their positions and choices.

- It can be adapted to consider the characteristics of other types of disputes, such as family disputes.
- It employs the Graph Model technique by using attitude-based stability concepts such as RNASH and RSEQ to study the negotiators' actions and counteractions during negotiations.
- It consists of a supportive quantitative approach in addition to the qualitative approach used in GMCR in order to determine the strategic decision options.
- It employs the concept of utility theory in order to help the decision makers identify mutual agreement at the tactical level of negotiation.
- It uses the proposed attitude-based utility functions to enable decision makers to examine the impact of changes in their attitudes on the outcomes of the tactical negotiations.
- During the tactical negotiation process, it quantifies for each DM the weight and disagreement point for each issue under negotiation.
- It permits the decomposition of issues into sub-issues at the tactical level of negotiation.
- It incorporates a powerful sensitivity analysis to examine changes in the negotiation outcomes at both the strategic and tactical levels of negotiation.
- It has been developed and successfully applied to brownfield negotiation case studies involving multiple decision makers and multiple conflicting issues.

9.3. Research Contributions

This research contributes significantly to the provision of managerial tools that have the potential benefit of supporting construction negotiations by integrating the strategic and tactical perspectives of negotiation while considering the attitudes of the decision makers. The proposed attitude-based negotiation introduces a new systems engineering methodology that will help managers tackle a variety of real-world controversies, particularly in the construction industry.

With respect to the strategic level of negotiation, the expansion of GMCR to propose an attitude-based GMCR provides a flexible analytical tool that reflects how the attitudes of the decision makers may change the outcome of the negotiation. As well, the attitude-based solution concepts, defined within the paradigm of GMCR, provide operational tools for assessing whether unwanted consequences can result in a particular dispute because of improper attitudes. With respect to the tactical level of negotiation methodology, the attitude-based utility functions assist decision makers in ascertaining which attitudes are needed in order to guide the conflict to more preferable, or win/win, solutions for all of the decision makers concerned.

A negotiation decision support system is proposed in order to conveniently apply the developed negotiation methodology to actual disputes. The proposed negotiation decision support system has significant advantages with respect to speed, accuracy, practicality, flexibility, reliability, and versatility. Moreover, the proposed prototype offers a promising system for turning the implicit experience gained by construction participants into the explicit expertise needed for resolving the increasingly complex disputes that occur in the construction industry.

The research is expected to help improve negotiation methodologies for resolving challenging construction disputes and thereby save significant amounts of time and costs. The new methodology is also expected to help construction decision makers both in the public and private sectors make more appropriate decisions that will establish reliable engineering decision-making systems and ensure the sustainable operation of constructed assets. The model developed in this research is expected to provide the following important contributions:

1. The research is a step toward a better understanding of dispute resolution and the negotiation process in the construction industry.
2. The developed model constitutes a more comprehensive negotiation approach in which the strategic and tactical levels of negotiation are complementarily combined.
3. The proposed negotiation methodology has a unique ability to take into consideration the attitudes of the decision makers at both the strategic and tactical levels of negotiation.
4. The proposed negotiation methodology has been conveniently implemented into a simplified negotiation decision support system, which can provide

decision makers with significant advantages, such as automated negotiation modeling, easy-to-use features, and more accurate results.

5. The developed methodology is expected to help in the re-engineering of traditional construction negotiation processes. In other words, the useful concepts presented in non-engineering sciences such as psychology and sociology, can be used for developing negotiation support tools that provide more beneficial outcomes.
6. The relationships among attitude-based stability concepts, such as RNASH and RSEQ have been investigated, and relevant propositions have been formally defined.
7. The attitude-based model proposed in this research provides a unique opportunity to study the influence of other psychological factors, such as fear and hate, on the outcomes of negotiation.
8. The research helps to foster a positive environment in which construction professionals and practitioners can negotiate and therefore reduce the destructive consequences of complicated disputes.
9. The research provides a major expansion of GMCR by combining attitudes within the paradigm of GMCR which furnishes a flexible analytical tool which reflects how the DMs' attitudes may change the strategic negotiation outcomes.

In addition to the above contributions, the research provides the decision makers involved in brownfield disputes with an innovative negotiation framework that can take into consideration the psychological factors involved in brownfield negotiations. The proposed negotiation model may therefore assist participants in brownfield disputes to resolve growing number of increasingly challenging brownfield disputes around the globe in both developed and developing countries. Finally, although the focus has been on negotiation support for resolving construction disputes, the proposed system can be easily adapted to other types of disputes, such as those related to families or other industries, such as manufacturing or real estate.

9.4. Recommendations for Future Research

In spite of the inherent ability of the proposed negotiation framework to resolve complex construction disputes, like many other methods of modeling negotiation, it has limitations. A number of improvements which therefore would be beneficial include the following suggestions for future research:

- Study the cost of delays due to construction disputes, and consider the effect of time and costs on the length of construction negotiation.
- Conduct investigation that includes a variety of construction disputes, and analyze practical approaches for resolving complex disputes.
- Expand the three attitude types (i.e., positive, neutral, negative) to include the wider range of attitude types that lie within the types defined for this research.
- Investigate the influence of other psychological factors (e.g., fear, hate, and anger) on the outcomes of construction negotiations.

- Consider the situation at the tactical level of negotiation in which all decision makers intend to negotiate all conflicting issues simultaneously.
- Study the interrelationships of the proposed attitude-based solution concepts such as RNASH, RSMR, RGMR, and RSEQ.
- Expand the design of the negotiation decision support system to consider each DM's disagreement point with respect to each negotiation issue.
- Create an Internet (web-based) application from the current system to enable multiple users to use and benefit from the system simultaneously.
- Study the characteristics of negotiation and negotiators in other industries and implement the developed negotiation model for resolving disputes in other areas such as manufacturing, information technology, and environmental management.

The results of conducting more comprehensive stability analyses would undoubtedly lead to significant insight into the brownfield case studies and also provide an enhanced methodology for incorporating the attitudes of the decision makers into an interactive decision-making process.

It is believed that the model developed in this research will make the decision process clear, transparent, and easy to track for all decision makers. In addition, the decision makers involved in complex negotiations will be provided with more sustainable solutions to their disputes. These advantages will likely help construction participants make better decisions about resolving complex disputes. Uninformed or faulty decision making can thus be significantly reduced, thereby saving significant amounts of costs and resources, minimizing delays, and maximizing cooperation and productivity in the construction industry.

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APPENDIX A
Computer Program for Removing Infeasible Attitude Cases

It should be noted that the results of the following programming codes, written in java, are summarized in Tables 5.6, 5.7, and 5.8, presented in Chapter 5.

```
*********************************************************************************************
// Computer Program for Generating Various Attitude Cases and
// Removing Infeasible Attitude Cases
import java.util.Scanner;
import java.io.*;

public class AttitudeGenerator1
{   //instance variables
    private int numOfDemakers;
          private int numofAttudes;
          private int[][] attitudeArray;
          private int arrayDimention;
   public AttitudeGenerator1(int howManyDm, int howManyAtts)//Constructor
     {
       numOfDemakers=howManyDm;
       numofAttudes=howManyAtts;
       arrayDimention=((int)Math.pow(howManyAtts, howManyDm*howManyDm));
       attitudeArray= new int[arrayDimention][howManyDm*howManyDm+1];
       int [] attitudeType= new int [3];
             attitudeType[0]=+1;  //positive attitude
             attitudeType[1]= 0;  //neutral attitude
             attitudeType[2]=-1;  //negative attitude
             int index=-1;
       int count=1;
       for (int ii=0; ii<numOfDemakers*numOfDemakers; ii++)    //initialize
attitudeArray
       {
             count=numofAttudes*count;
             int position=arrayDimention/count;
             for (int i=0; i<arrayDimention; i++)
             {
                       if (i % position ==0)
                         {
                                 index++;
                         }
```

```
                         attitudeArray[i][ii]=attitudeType[index];
                         if ((index+1)==3 && ((i+1)%position==0) )
                           {
                                    index=-1;
                           }
              }
       }
     }
  public void printAttitudeArray( int perLinePrint)// print attitudeArray in a text file
named attitude.txt
            {

              PrintWriter outputStream =null;
               try
                  {
                    outputStream = new PrintWriter(new
FileOutputStream("attitude.txt"));
                  }
               catch(FileNotFoundException e)
                  {
                    System.out.println("Error opening the file attitude.txt.");
                    System.exit(0);
                  }
    int rpt=this.arrayDimention/perLinePrint;
    for (int iii=0; iii<rpt; iii++)
      {
       int ctr=0;
        for (int i=0; i<this.numOfDemakers;i++)
          {
            int temp=i*this.numOfDemakers;
              for (int j=iii*perLinePrint; j<iii*perLinePrint+perLinePrint; j++)
                        {
                          ctr=temp;
                                 for (int ii=0; ii<this.numOfDemakers;ii++)
                                   {
                                            outputStream.print(this.attitudeArray[j][ctr]);
                                             int repeat=CalSpace(this.attitudeArray[j][ctr], 3);
                                                for (int k=0; k<repeat; k++)
                                                 {
                                                       outputStream.print(" ");
                                                 }
                                                ctr++;
                                               if ((ii+1) % this.numOfDemakers ==0 )
                                                 {
                                                            outputStream.print("|");
                                                 }
```

```
                            }
                        }
            outputStream.println();

          }
    for (int i=0; i<(this.numOfDemakers*3+1)*perLinePrint; i++)
      {
              outputStream.print("-");
      }
    outputStream.println();
  }
  int ctr=0;
     for (int i=0; i<this.numOfDemakers;i++)
       {
          int temp=i*this.numOfDemakers;
            for (int j=rpt*perLinePrint; j<this.arrayDimention; j++)
                     {
                       ctr=temp;
                            for (int ii=0; ii<this.numOfDemakers;ii++)
                              {
                                          outputStream.print(this.attitudeArray[j][ctr]);
                                          int repeat=CalSpace(this.attitudeArray[j][ctr], 3);
                                            for (int k=0; k<repeat; k++)
                                              {
                                                outputStream.print(" ");
                                              }
                                            ctr++;
                                            if ((ii+1) % this.numOfDemakers ==0 )
                                              {
                                                      outputStream.print("|");
                                              }
                              }
                     }
         outputStream.println();
     }
  outputStream.close();
 }
 public void printInLine() //print attitudeArray in a line-base in a text file named
attitudePrintedInLine.txt
 {
           PrintWriter outputStream =null;;
             try
               {
                 outputStream = new PrintWriter(new
FileOutputStream("attitudePrintedInLine.txt"));
               }
```

```
            catch(FileNotFoundException e)
              {
                System.out.println("Error opening the file attitudePrintedInLine.txt.");
                System.exit(0);
              }
    for (int i=0; i<this.arrayDimention;i++)
      {
              for (int j=0; j<(numOfDemakers*numOfDemakers); j++)
                {
                      if (j % numOfDemakers==0 && j!=0 )
                       {
                               outputStream.print(" | ");
                       }
                      int  rpt=CalSpace(attitudeArray[i][j],3);
                       for (int ii=0; ii<rpt; ii++)
                              {
                                outputStream.print(" ");
                              }
                     outputStream.print(attitudeArray[i][j]);
                }
           outputStream.println();
   }
  outputStream.close();
  }
  private static int CalSpace(int var, int base)//number of spaces needed to be left
while printing
  {
    int space=base-Integer.toString(var).length();
    return space;
  }
  public void CalculationOfInfeasibilities() // recording infeasible cases in a text file
named infeasibles.txt
  {
           PrintWriter outputStream =null;
            try
              {
                outputStream = new PrintWriter(new
FileOutputStream("infeasibles.txt"));
              }
            catch(FileNotFoundException e)
              {
                System.out.println("Error opening the file infeasibles.txt.");
                System.exit(0);
              }
           int [] position=new int [this.numOfDemakers];
           int pos=0;
```

```
            for (int i=0; i<this.numOfDemakers; i++)
             {
                     position[i]=pos;
                     pos=pos+this.numOfDemakers+1;
             }
             int counter12=0;
             int counter13=0;
             int counter23=0;
             int counter123=0;
             int counter1=0;
             int counter2=0;
             int counter3=0;
             int Counter1=0;
             int Counter2=0;
             int Counter12=0;
           int [][] temp1=new int [this.arrayDimention/this.numofAttudes][4];
     int [][] temp2=new int [this.arrayDimention/this.numofAttudes][4];
     int [][] temp3=new int [this.arrayDimention/this.numofAttudes][4];
   for (int i=0; i<this.arrayDimention; i++)
   {
            if (this.numOfDemakers==2)
            {
                      if                    (this.attitudeArray[i][position[0]]==-1                    &&
this.attitudeArray[i][position[1]]!=-1 )
                       {
                                for (int ii=0; ii<4;ii++)
                                {
                                        temp1[Counter1][ii]=this.attitudeArray[i][ii];
                                }
                                Counter1++;
                       }
                      if                    (this.attitudeArray[i][position[1]]==-1                    &&
this.attitudeArray[i][position[0]]!=-1 )
                       {
                               for (int ii=0; ii<4;ii++)
                                {
                                        temp2[Counter2][ii]=this.attitudeArray[i][ii];
                                }
                              Counter2++;
                       }
                      if                    (this.attitudeArray[i][position[1]]==-1                    &&
this.attitudeArray[i][position[0]]==-1 )
                       {
                              for (  int ii=0; ii<4; ii++)
                                {
                                        temp3[Counter12][ii]=this.attitudeArray[i][ii];
```

```
                        }
                        Counter12++;
                }

        }
        if (this.numOfDemakers==3)
        {
                if                  (this.attitudeArray[i][position[0]]==-1                &&
this.attitudeArray[i][position[1]]!=-1 && this.attitudeArray[i][position[2]]!=-1 )
                {
                        counter1++;
                }
                        if              (this.attitudeArray[i][position[1]]==-1             &&
this.attitudeArray[i][position[0]]!=-1 && this.attitudeArray[i][position[2]]!=-1 )
                {
                        counter2++;
                }
                if                  (this.attitudeArray[i][position[2]]==-1                &&
this.attitudeArray[i][position[1]]!=-1 && this.attitudeArray[i][position[0]]!=-1 )
                {
                        counter3++;
                }

                if                  (this.attitudeArray[i][position[0]]==-1                &&
this.attitudeArray[i][position[1]]==-1 && this.attitudeArray[i][position[2]]!=-1 )
                {
                        counter12++;
                }
                if                  (this.attitudeArray[i][position[0]]==-1                &&
this.attitudeArray[i][position[2]]==-1 && this.attitudeArray[i][position[1]]!=-1 )
                {
                        counter13++;
                }
                if                  (this.attitudeArray[i][position[1]]==-1                &&
this.attitudeArray[i][position[2]]==-1 && this.attitudeArray[i][position[0]]!=-1 )
                {
                        counter23++;
                }
                if                  (this.attitudeArray[i][position[0]]==-1                &&
this.attitudeArray[i][position[1]]==-1 && this.attitudeArray[i][position[2]]==-1 )
                {
                        counter123++;
                }
        }
 }
  if (this.numOfDemakers==2)
```

```
   {
   outputStream.println("DM1 negative and DM2 only neural and positive ==>
"+Counter1+" Infeasible Cases  ");
   int perLinePrint=10;
   int rpt=Counter1/perLinePrint;
    for (int iii=0; iii<rpt; iii++)
     {
       int ctr=0;
         for (int i=0; i<this.numOfDemakers;i++)
           {
             int temp=i*this.numOfDemakers;
               for (int j=iii*perLinePrint; j<iii*perLinePrint+perLinePrint; j++)
                        {
                          ctr=temp;
                                   for (int ii=0; ii<this.numOfDemakers;ii++)
                                     {
                                              outputStream.print(temp1[j][ctr]);
                                              int repeat=CalSpace(temp1[j][ctr], 3);
                                                for (int k=0; k<repeat; k++)
                                                 {
                                                          outputStream.print(" ");
                                                 }
                                                ctr++;
                                                if ((ii+1) % this.numOfDemakers ==0 )
                                                 {
                                                           outputStream.print("|");
                                                  }
                                      }
                       }
        outputStream.println();
          }
        for (int i=0; i<(this.numOfDemakers*3+1)*perLinePrint; i++)
         {
                  outputStream.print("-");
         }
        outputStream.println();
   }
    int ctr=0;
    for (int i=0; i<this.numOfDemakers;i++)
     {
       int temp=i*this.numOfDemakers;
         for (int j=rpt*perLinePrint; j<Counter1; j++)
                 {
                   ctr=temp;
                            for (int ii=0; ii<this.numOfDemakers;ii++)
                              {
```

```
                              outputStream.print(temp1[j][ctr]);
                              int repeat=CalSpace(temp1[j][ctr], 3);
                                 for (int k=0; k<repeat; k++)
                                   {
                                           outputStream.print(" ");
                                   }
                              ctr++;
                              if ((ii+1) % this.numOfDemakers ==0 )
                                {
                                       outputStream.print("|");
                                }
                         }
                 }
   outputStream.println();
   }
   outputStream.println();
   outputStream.println("DM2 negative and DM1 only neural and positive ==>
"+Counter2+"  Infeasible Cases  ");
    int rpt1=Counter1/perLinePrint;
    for (int iii=0; iii<rpt1; iii++)
      {
        int ctr1=0;
         for (int i=0; i<this.numOfDemakers;i++)
          {
           int temp=i*this.numOfDemakers;
             for (int j=iii*perLinePrint; j<iii*perLinePrint+perLinePrint; j++)
                    {
                      ctr1=temp;
                            for (int ii=0; ii<this.numOfDemakers;ii++)
                              {
                                     outputStream.print(temp2[j][ctr1]);
                                     int repeat=CalSpace(temp2[j][ctr1], 3);
                                     for (int k=0; k<repeat; k++)
                                      {
                                           outputStream.print(" ");
                                      }
                                     ctr1++;
                                    if ((ii+1) % this.numOfDemakers ==0 )
                                      {
                                            outputStream.print("|");
                                      }
                              }
                    }
       outputStream.println();
       }
     for (int i=0; i<(this.numOfDemakers*3+1)*perLinePrint; i++)
```

```
      {
               outputStream.print("-");
      }
       outputStream.println();
   }
    int ctr2=0;
    for (int i=0; i<this.numOfDemakers;i++)
     {
       int temp=i*this.numOfDemakers;
       for (int j=rpt*perLinePrint; j<Counter2; j++)
                {
                 ctr2=temp;
                          for (int ii=0; ii<this.numOfDemakers;ii++)
                             {
                                      outputStream.print(temp2[j][ctr2]);
                                      int repeat=CalSpace(temp2[j][ctr2], 3);
                                      for (int k=0; k<repeat; k++)
                                        {
                                                  outputStream.print(" ");
                                        }
                                   ctr2++;
                                      if ((ii+1) % this.numOfDemakers ==0 )
                                        {
                                                  outputStream.print("|");
                                        }
                             }
               }
     outputStream.println();
   }
   outputStream.println();
   outputStream.println("DM1 and DM2 simultaneously negative ==>
"+Counter12+" Infeasible Cases  ");
   int rpt3=Counter12/perLinePrint;
   for (int iii=0; iii<rpt3; iii++)
     {
       int ctr3=0;
         for (int i=0; i<this.numOfDemakers;i++)
           {
             int temp=i*this.numOfDemakers;
             for (int j=iii*perLinePrint; j<iii*perLinePrint+perLinePrint; j++)
                        {
                          ctr3=temp;
                                  for (int ii=0; ii<this.numOfDemakers;ii++)
                                    {
                                              outputStream.print(temp3[j][ctr3]);
                                              int repeat=CalSpace(temp3[j][ctr3], 3);
```

```
                                    for (int k=0; k<repeat; k++)
                                         {
                                             outputStream.print(" ");
                                         }
                                     ctr3++;
                                        if ((ii+1) % this.numOfDemakers ==0 )
                                          {
                                             outputStream.print("|");
                                          }
                              }
                    }
  outputStream.println();
 }
  for (int i=0; i<(this.numOfDemakers*3+1)*perLinePrint; i++)
    {
           outputStream.print("-");
    }
  outputStream.println();
}
 int ctr4=0;
 for (int i=0; i<this.numOfDemakers;i++)
    {
      int temp=i*this.numOfDemakers;
        for (int j=rpt3*perLinePrint; j<Counter12; j++)
               {
                  ctr4=temp;
                       for (int ii=0; ii<this.numOfDemakers;ii++)
                         {
                                outputStream.print(temp3[j][ctr4]);
                             int repeat=CalSpace(temp3[j][ctr4], 3);
                               for (int k=0; k<repeat; k++)
                                 {
                                  outputStream.print(" ");
                                 }
                               ctr4++;
                               if ((ii+1) % this.numOfDemakers ==0 )
                               {
                                      outputStream.print("|");
                               }
                         }
               }
 outputStream.println();
 }
 outputStream.close();
}
 if (this.numOfDemakers==3)
```

```
   {
          outputStream.println("DM1 negative, DM2 and DM3 only neutral and
positive=> infeasible cases: "+"   "+counter1);
          outputStream.println("DM2 negative, DM1 and DM3 only neutral and
positive=> infeasible cases: "+"   "+counter2);
          outputStream.println("DM3 negative, DM1 and DM2 only neutral and
positive=> infeasible cases: "+"   "+counter3);
          outputStream.println("DM1 and DM2 simoulateously negative, DM3 only
neutarl and positive=> infeasible cases:  "+"   "+counter12);
          outputStream.println("DM1 1 and DM3 simoulateously negativ, DM2 only
neutarl and positive=> infeasible cases: "+"   "+counter13);

          outputStream.println("DM2 and DM3 simoulateously negative, DM1 only
neutarl and positive=> infeasible cases:    "+"   "+counter23);
          outputStream.println("DM1, DM2, and DM3 simoulateously negative=>
infeasible cases:    "+"   "+counter123);
          outputStream.print("Total number of infeasible attitude case for three
DMs negotioations: ");
          int
sumOfInfeasibilities=Counter12+counter12+counter13+counter23+counter123+c
ounter1+counter2+counter3;
          outputStream.println(sumOfInfeasibilities);
          outputStream.println("Total feasible cases = Total cases - Total
infeasible cases ==> "+(this.arrayDimention-sumOfInfeasibilities));
     outputStream.close();
   }
  }
         public static void main(String[] args)
          {
           Scanner myScanner = new Scanner(System.in);
           System.out.println("Enter the number of decision makers:");
           int numOfDms=myScanner.nextInt();
           System.out.println(" Enter the number of attudes that they can have:");
           int numOfAttus=myScanner.nextInt();
           AttitudeGenerator1      app = new AttitudeGenerator1(numOfDms,
numOfAttus);
           app.printAttitudeArray(10);// 10 attitude case display
           app.CalculationOfInfeasibilities();// obtain the number of infeasible
attitude case
           app.printlnLine();
          }
}
```

Numerical Results for 3-DM Negotiation:

DM1 negative, DM2 & DM3 only neutral & positive => infeasible cases: 2916

DM2 negative, DM1 & DM3 only neutral & positive => infeasible cases: 2916

DM3 negative, DM1 & DM2 only neutral & positive => infeasible cases: 2916

DM1 & DM2 negative, DM3 only neutral & positive => infeasible cases: 1458

DM1 & DM3 negative, DM2 only neutral & positive => infeasible cases: 1458

DM2 & DM3 negative, DM1 only neutral & positive => infeasible cases: 1458

DM1, DM2, & DM3 simultaneously negative => infeasible cases: 729

Total number of infeasible attitude cases: 13851

Total number of feasible cases = Total cases - Total infeasible cases: 5832

Numerical Results for 2-DM Negotiation

```
DM1 negative & DM2 only neutral and positive attitudes==>Infeasible Cases: 18
-1 1  |-1 1  |-1 1  |-1 1  |-1 1  |-1 1  |-1 0  |-1 0  |-1 0  |-1 0  |
1  1  |1  0  |0  1  |0  0  |-1 1  |-1 0  |1  1  |1  0  |0  1  |0  0  |
----------------------------------------------------------------------
-1 0  |-1 0  |-1 -1 |-1 -1 |-1 -1 |-1 -1 |-1 -1 |-1 -1 |
-1 1  |-1 0  |1  1  |1  0  |0  1  |0  0  |-1 1  |-1 0  |

DM2 negative & DM1 only neural and positive attitudes ==> Infeasible Cases: 18
1  1  |1  1  |1  1  |1  0  |1  0  |1  0  |1  -1 |1  -1 |1  -1 |0  1  |
1  -1 |0  -1 |-1 -1 |1  -1 |0  -1 |-1 -1 |1  -1 |0  -1 |-1 -1 |1  -1 |
----------------------------------------------------------------------
0  1  |0  1  |0  0  |0  0  |0  0  |0  -1 |0  -1 |0  -1 |
0  -1 |-1 -1 |1  -1 |0  -1 |-1 -1 |1  -1 |0  -1 |-1 -1 |

DM1 & DM2 simultaneously negative attitude =========> Infeasible Cases: 9
-1 1  |-1 1  |-1 1  |-1 0  |-1 0  |-1 0  |-1 -1 |-1 -1 |-1 -1 |
1  -1 |0  -1 |-1 -1 |1  -1 |0  -1 |-1 -1 |1  -1 |0  -1 |-1 -1 |
```

Total number of infeasible attitude cases: 45

****