Multi-objective Decision Making Model for Construction Dispute Mediation

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Abstract

The construction industry is regarded as one of the most adversarial industries. Mediation as one of the alternative dispute resolution methods has gained acceptance in Hong Kong since its introduction in the 1980s. Mediation is a problem-solving process assisted by a neutral third-party, who tries to help the disputing parties in reaching an agreement. The study of mediation has focused on the identification of successful factors, disputants’ satisfaction, mediation outcomes and tactics. In recent social research, mediation is defined as ‘administration and enforcement of rules or social norms’ for disputants’ conformity. Very little is known, however, about relationship between people’s conformity to social norms for dispute resolution and their actual attitude. This paper reports a study that aims to bridge the gap, by examining what people should do in the mediation. Identifying efficient frontier is found to be the common goal in studies of negotiation analysis, game theory and decision making analysis. In this regard a multiple objective decision making system is employed to propose approximate efficiency frontier which can be used to engender an efficient and fair mediation agreement. The results obtained facilitated the investigation of the optimal solution and the trade-off process between parties.

Keywords: multi-objective decision making, ultimatum game, efficient frontier, construction mediation.
1. Introduction

Conflict and dispute regularly feature in construction industry. The use of alternative dispute resolution (ADR) has gained acceptance in Hong Kong since its introduction in the 1980s. Due to the flexible, cost-effective and non-threatening process, mediation is now an integral part of the dispute settlement provisions in many standard forms of construction contract in Hong Kong. Voluntary mediation has been introduced in the civil procedures rules of the High Court as part of the Civil Justice Reform that come into force on 2nd April 2009. Under the New Practice Direction 31, adverse cost order is used to discourage ‘refusal to mediate’ and ‘failing to attempt to mediate’ (Wall, 2009).

Mediation is negotiation involving two or more parties who are assisted by a neutral third-party, and trying to reach an agreed settlement (Kressel & Pruitt, 1989). Mediation is also a problem-solving and decision making process, where equality, participation, self-determination are involved as well as the interactive parties (Neale and Bazerman, 1992). In recently social and legal research, mediation is defined as ‘administration and enforcement of rules or social norms’ for disputants’ conformity (Fuller, 1971; Menkel-Meadow, 2001).

On the subject of mediation, there exists quite a lot of good descriptive literature on the identification of successful factors (Wall, 1993; Marieke, 1996), mediation outcomes and disputants satisfaction (Alberts et al, 2005; Yiu et al, 2006) and mediator tactics (Carnevale et al, 1989; Cheung and Yiu, 2007; Yiu and Cheung, 2007). Very little is known, however, about the relationship between people’s conformity to social norms for dispute resolution and their actual attitude. To bridge the gap, the study examines what people should do in the mediation.

Identifying efficient frontier is found to be the common goal in negotiation analysis, game theory and decision making analysis. Efficient frontier was introduced in economics, refined further in game theory with the development of solution for non zero-sum bargaining problem (Nash, 1950), then reworked in integrative negotiation research (e.g. Lax and Sebenius, 1986) and in decision making modelling (Teich 1994). In this study a multiple objective decision making system is employed to approximate the efficiency frontier and to simulate the normative behaviour on reaching a settlement with efficient and fair trade-off utility value.

2. Mediation styles and tactics

Mediation can be classified as transformative, facilitative and evaluative. This paper focuses on the first two styles. Compared with other two styles, facilitative mediation is relatively dominant, directive and settlement oriented. Facilitative mediation focuses on economic trade-off and generates mutually-acceptable agreements. Transformative mediation involves empowerment and recognition, which aims at transforming dysfunctional, destructive conflicts to become functional and productive. Generally this means fostering integrative over distributive agreement. Empowerment means empowering parties to define issues and to seek solutions on their own. It helps disputants to ‘experience a greater sense of self worth, security, self determination and autonomy’ (Bush and Folger, 1994, pp.87). Recognition means recognizing the other party’s needs and interests, and better
understanding the other party’s perspective. It exploits the opportunity for parties to acknowledge and respond to each other and enhances relationship. Fuller (1971)’s definition of mediation is confined to the interdependent relationship between the parties. For Fuller, transformative mediation releases the parties from the encumbrances of rules and nourishes or improves the tied-in relationship with mutual respect, trust and understanding. Mediator’s role is to select and implement tactics and strategies for positive intervention. The notion of a staged process came from early labour management research. The mediation styles and corresponding tactics are summarised in table 1. In conclusion, “Tied-in” relationship and “economic trade-off” are the two critical characteristics of mediation (Menkel-Meadow 2001, Ren 2003).

Table 1: Summary of Mediation Styles and Tactics

<table>
<thead>
<tr>
<th>Authors</th>
<th>Transformative: “Tied-in” Relationship</th>
<th>Facilitative: Economic Trade-off</th>
<th>Evaluative: Settlement, Conformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schneider Honeyman (2006)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Douglas (1962)</td>
<td></td>
<td>problem identification, alternate solution search, solution selection</td>
<td></td>
</tr>
<tr>
<td>Stevens (1963)</td>
<td>face saving</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zartman Berman (1982)</td>
<td>diagnosis (needs affirmation, review relationship)</td>
<td>formula (understanding, trade-off and joint solution)</td>
<td>details (making specification of the agreement)</td>
</tr>
<tr>
<td>Kolb (1983)</td>
<td>develop a dialogue, encourage direct communication and joint meetings</td>
<td>substantive issues and concessions</td>
<td></td>
</tr>
<tr>
<td>Druckman (1983)</td>
<td>agenda debate, search for principles</td>
<td>issue definition, concession exchange</td>
<td>implementing details</td>
</tr>
<tr>
<td>Folberg Taylor (1984)</td>
<td>creating trust and structure</td>
<td>fact-finding and isolation of issues; creation of options and alternatives, negotiation and decision-making</td>
<td>legal review and implementation</td>
</tr>
<tr>
<td>Fisher Ury (1991)</td>
<td>separate people from the problem, focus on interests, not positions, invent options for mutual gain and insist on using objective criteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moore (2003)</td>
<td>establishing relationship, guide mediation, collect background information, design plan, building trust and cooperation</td>
<td>defining issues and setting agenda, uncovering hidden interests, generate options</td>
<td>assessment of options, final bargaining, formal settlement</td>
</tr>
</tbody>
</table>
3. Ultimatum game

Based on the two characteristics, a two-party mediated game is developed to illustrate the mechanism of normalising people’s behaviour in generation of a mutually satisfactory agreement.

Mediation involves Party A, Party B and the third Party C (the mediator). Disputes are usually seen to be “real or apparent incompatibility of parties’ needs or interests”. Party A wants to maximize while Party B wants to minimize. Moreover, the parties in mediation are locked in a “bilateral monopoly” relationship. If any party disagrees with the mediation outcome, the mediation will fail and thus any party’s expected interest will be forfeited. Under this “tied-in” relation, an agreement can only be achieved if both parties consent to it, a situation similar to the ultimatum game.

Ultimatum game is often used in economic experiments in which two players interact to decide how to split a sum of money. Player 1 proposes how to divide the sum between the two players, and the Player 2 can either accept or reject this proposal. If the Player 2 rejects, neither player receives anything. If the player 2 accepts, the money is divided according to the proposal.

Theoretically, if Player 1 and Player 2 are rational, Player 2 should accept even the smallest positive offer, since the alternative is getting nothing. Theoretically Player 1 should offer only slightly more than zero to Player 2, and Player 2 should accept it as an improvement on its status quo. However Nowak et al (2000) pointed out that the majority of Player 1s offer are about 40-50% of the total sum, and about half of all Player 2s reject offers below 30%. Bazerman and Neale (1995) found that Player 1s generally offer 30-50% of the sum to Player 2, 20% reject the offer and over half reject those of less than 30%. Player 2 has the power of reject to punish Player 1 for unfairness of distribution, since the opportunity cost of loss is much less than Player 1.

There are several criteria for judging distributive fairness, which are equality, need and equity. Equality principle is based on a simple calculation shows Player 2 should only reject offers that are less than 1/n of the total sum, where n is the number of individuals in the game. This solution has many limits, such as the integer problem. Need principle is “those who need more of a benefit should get more than those who need it less” (Welsh 2006). According to that, the utility is employed in the bargaining situation to measure the value of the non-homogeneous issues. Equity principle is about the distribution of benefits to people’s relative contribution, which means each person’s outcomes are proportional to his or her inputs. Raiffa (2002) proposed a measurement of this “proportion”, which equals to (outcome value-reservation value)/ (maximum value-reservation value). Egalitarian solution is proposed because it is proved that Player 2 is not only motivated by self-interest but also “a strong aversion to being disadvantaged themselves” (Nowak et al 2000, Welsh 2006). It seems that the aversion to being disadvantaged (or “envy principle”) affected the animal species as well. Brosnan and de Waal (2003) reported that high percentages of capuchin monkeys rejected the opportunity to trade rocks for cucumber slices when they saw other monkeys receiving grapes, either in exchange for their rocks or without being required to exchange anything. In this sense egalitarian solution (maxi-min) aims to balance the difference between two parties. In this paper, the distributive fairness is evaluated by the combination of equity solution and egalitarian solution (maxi-min).
Raiffa (1985) and Lax & Sebenius (1986) pointed out that a lot of disputes settled with "the value left on the table". Disputants focus on creating gains to be shared, but never realize "this small pie" can be enlarged. *Nash Equilibrium* is the famous principle for solving "efficiency" in non zero-sum two-person bargaining game, which is to maximize the product of the two parties' utilities when the status quo point is normalized to be zero. Another evaluation called *Utilitarian solution* is to maximize the sum of the two parties' utilities (Thompson 1990, Raiffa 2002).

In these aspects, fairness and efficiency are the key criteria for an optimal mediation agreement which can be measured by *maxi-min equity solution* and *Nash equilibrium, utilitarian solution* respectively. Welsh (2006) concluded the negotiators' dilemma either offering too much or rejecting those of economic sense. Nash (1950) proposed the efficient frontier as solutions for collaborative bargaining. In economics, "frontier" is where alternative is worse than what they could achieve through agreement with the other party. In this regard, efficient frontier is the solution path for trade-off bargaining to achieve mutual agreement in mediation (Figure 1).

![Figure 1: Mutual Agreement (Thompson, 1990)](image)

4. *Multiple objective decision making model*

Based on the conception of the Ultimatum Game, a multiple objective decision making model is proposed to approximate the efficiency frontier. Multi-objective decision making (MODM) accompanied with multi-attribute utility theory (MAUT) and multi-criteria decision making (MCDM) has been widely applied to generate options and identify potential agreements in dispute resolution (Kersten 1997). The approximation of efficient frontier can be traced back to RAMONA system (Teich 1991, 1995), as a constraint proposal method, which is to choose reference points from the line connecting the decision makers' global optima. Kuula (1998) pointed out the limitation of RAMONA, which would be departed from optimal way when program step size was too long. Another method is by sliding the reference point along an auxiliary constraint plane (Etamo et al 1999, pp.1702). Followed with the constraint proposal methods, Keeney and Raiffa (1993, 2002) proposed another method to explore the efficient frontier, which is identification of some points on the efficient frontier by using an auxiliary line. By modifying the slope of auxiliary line, the points which are tangent to the efficient frontier can be determined. Goal programming is the most popular
method for generating optimal agreement, which is based on negotiators' feasible proposals and the specific decision making criteria. Here is the model:

Denote $i$ as negotiator $i = 1, 2$;  
Denote $j$ as issue $j = 1 \ldots J$;  
Denote $z$ as bargaining range of each issue $z = 1 \ldots Z$;  
Denote $x_{ijz}$ as input data for contractor and client  
Denote $w_j$ as $i$'s weight on issue $j$ where $\sum_j w_j = 1$, for $i = 1, 2$;  
Denote $M_{ijz}$ as relative utility value for each reference choice $M_{ijz} = w_j x_{ijz}$;  
Denote $F_i$ as feasible maximum value $i = 1, 2$;  
Denote $\mu_{ijz}$ as an integer variable, where $\sum_z \mu_{ijz} = 1$, $0 \leq \mu_{ijz} \leq 1$, on issue $j$  
Assume the weight $M_{1,ijz}$ by 1 and $M_{2,ijz}$ by $\lambda$, the auxiliary line can be defined as:

$$M_{1,ijz} + \lambda M_{2,ijz}$$

Where $\lambda = \frac{|M_{1,ijz} - M_{1,(j+1)}|}{|M_{1,ijz} - M_{2,(j+1)}|} (i = 1) \quad (s + 1) \in [1,Z]$;

s.t. $\max(M_{1,ijz} + \lambda M_{2,ijz}) \times \mu_{ijz}$, we can get a vector $[M_{1,ijz}, M_{2,ijz}, j = 1 \ldots J$, for every $\lambda$,  
$\therefore$ The utility value of efficient point on the frontier $[\sum_j M_{1,ijz}, \sum_j M_{2,ijz}]$ in terms of $\lambda$  
The optimal agreement is generated based on the three criteria:

Utilitarian solution: $\max \sum_i \sum_j M_{ijz} \times \mu_{ijz}$  
Nash Equilibrium: $\max \prod_i \sum_j M_{ijz} \times \mu_{ijz}$  
Maxi-min equity solution: $\max \{ \min_j \frac{\sum M_{ijz} - R_i}{F_i - R_i} \}$

To demonstrate the proposal approach and generate the results, a hypothesis data case is used here from the paper Construction Negotiation Online (Cheung et al 2004). This is a two-party, two-issue case. “This construction dispute begins with the date of completion, which was 1 Jan 2001 in the contract. But due to the delay of sub-contractor and late Architect Instruction, the completion date shifted from 1 Jan 2001 to 1 Mar 2001. The Issues are Extension of Time (EOT), which Main Contractor argued for 60 days but Architect only granted 40 days, Acceleration Cost (AccCost) which was estimated as $30,000 by Project Manager, as well as Lost and Expenses (L/E).” From their work, the issues, bargaining range and two parties’ input data are listed in table 2, and the reservation value for contractor and client is 20 and 30 respectively. Figure 2 shows 144 possible solutions (6*6*4).
Table 2: Input Data for Contractor and Client $M_{ij}$

<table>
<thead>
<tr>
<th>Issue</th>
<th>EOT</th>
<th>EOT</th>
<th>EOT</th>
<th>EOT</th>
<th>EOT</th>
<th>EOT</th>
<th>EOT</th>
<th>L/E</th>
<th>L/E</th>
<th>L/E</th>
<th>L/E</th>
<th>L/E</th>
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<tbody>
<tr>
<td>Level</td>
<td>35</td>
<td>36</td>
<td>37</td>
<td>38</td>
<td>39</td>
<td>40</td>
<td>6000</td>
<td>6100</td>
<td>6200</td>
<td>6300</td>
<td>6400</td>
<td>6500</td>
</tr>
<tr>
<td>Contractor</td>
<td>0</td>
<td>25</td>
<td>40</td>
<td>50</td>
<td>58</td>
<td>60</td>
<td>0</td>
<td>10</td>
<td>18</td>
<td>24</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>Client</td>
<td>30</td>
<td>28</td>
<td>24</td>
<td>18</td>
<td>10</td>
<td>0</td>
<td>40</td>
<td>38</td>
<td>33</td>
<td>25</td>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Issue</th>
<th>AccCost</th>
<th>AccCost</th>
<th>AccCost</th>
<th>AccCost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>10000</td>
<td>11000</td>
<td>12000</td>
<td>13000</td>
</tr>
<tr>
<td>Contractor</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Client</td>
<td>30</td>
<td>25</td>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 2: 144 Possible Solutions

Figure 3: Efficiency Frontier

The points that are satisfied with the auxiliary condition $M_{1ij} + \lambda M_{2ij}$ are listed in Table 3, and by moving the auxiliary line, all the efficient points can be found which constitute the efficient frontier (Figure 3). To determine the both parties’ feasible maximum value $F_i$, here the nonlinear efficiency frontier is approximated as linear segments. Thus the feasible maximum value $F_i$ can be simply estimated as 96 and 98.4 ($(25-0)/(100-98)=(25-20)/(x-98)$).

In Table 3 the optimal solutions can be generated according to 3 criteria. From Utilitarian solution and Nash Equilibrium, the point F and G are the maximum choice, which are highlighted in figure 3. To achieve Maxi-min equity solution, the smaller values between the two parties are selected to mark bold, and the maximum value among them is the optimal solution such as point E.

In Table 3, it can be found that Maxi-min equity solution is an effective way for measuring and balancing the difference between parties. It also shows the power change within the parties, and usually the optimal solution takes place at these points, such as point F. Moreover, it is found that when the solutions are efficient (point F and G), usually they also have advantage in the fairness distribution.
### Table 3: Set of Points on the Efficient Frontier

<table>
<thead>
<tr>
<th>EOT</th>
<th>L/E</th>
<th>AccCost</th>
<th>Contractor Utility</th>
<th>Client Utility</th>
<th>Utilitarian solution</th>
<th>Nash Equilibrium</th>
<th>Maxi-min equity solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>36</td>
<td>6000</td>
<td>10000</td>
<td>20</td>
<td>98.4</td>
<td>118.4</td>
<td>1968</td>
</tr>
<tr>
<td>B</td>
<td>36</td>
<td>6100</td>
<td>10000</td>
<td>35</td>
<td>96</td>
<td>131</td>
<td>3360</td>
</tr>
<tr>
<td>C</td>
<td>37</td>
<td>6100</td>
<td>10000</td>
<td>50</td>
<td>92</td>
<td>142</td>
<td>4600</td>
</tr>
<tr>
<td>D</td>
<td>38</td>
<td>6100</td>
<td>10000</td>
<td>60</td>
<td>86</td>
<td>146</td>
<td>5160</td>
</tr>
<tr>
<td>E</td>
<td>38</td>
<td>6200</td>
<td>10000</td>
<td>68</td>
<td>81</td>
<td>149</td>
<td>5508</td>
</tr>
<tr>
<td>F</td>
<td>38</td>
<td>6200</td>
<td><strong>11000</strong></td>
<td>73</td>
<td>76</td>
<td>149</td>
<td>5548</td>
</tr>
<tr>
<td>G</td>
<td>39</td>
<td>6200</td>
<td>10000</td>
<td>76</td>
<td>73</td>
<td><strong>149</strong></td>
<td><strong>5548</strong></td>
</tr>
<tr>
<td>H</td>
<td>39</td>
<td>6200</td>
<td><strong>11000</strong></td>
<td>81</td>
<td>68</td>
<td><strong>149</strong></td>
<td>5508</td>
</tr>
<tr>
<td>I</td>
<td>39</td>
<td>6300</td>
<td><strong>11000</strong></td>
<td>87</td>
<td>60</td>
<td>147</td>
<td>5220</td>
</tr>
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<td>J</td>
<td>39</td>
<td>6400</td>
<td><strong>11000</strong></td>
<td>91</td>
<td>50</td>
<td>141</td>
<td>4550</td>
</tr>
<tr>
<td>K</td>
<td>39</td>
<td>6400</td>
<td>12000</td>
<td>94</td>
<td>40</td>
<td>134</td>
<td>3760</td>
</tr>
<tr>
<td>L</td>
<td>40</td>
<td>6400</td>
<td>12000</td>
<td>96</td>
<td>30</td>
<td>126</td>
<td>2880</td>
</tr>
</tbody>
</table>

Utilitarian solution = \(\text{Max.} (\text{Contractor Utility} + \text{Client Utility})\);  
Nash Equilibrium = \(\text{Max.} (\text{Contractor Utility} \times \text{Client Utility})\);  
Maxi-min equity solution = \(\text{Max.} (\text{min}((\text{Contractor Utility}-20)/(96-20), (\text{Client Utility}-30)/(98.4-20)))\).

The multi-objective decision making system is not only facilitated as generation of optimal solution, but also a mediator, who helps people to do effective trade-offs during the mediation bargaining scenarios and thus normalize disputants’ behaviour for dispute resolution. In this approach, the mediation proposed to begin with the most preferred points. In this case, client begins with point A and contractor with point L respectively. If both parties follow the mediator’s suggested solution path (shown in Figure 3), they could coincide with point F in an easy way. In the every bargaining scenario, the mediator would choose a direction so that the loss can be the minimum for one party and benefit maximum for the other party. For example from A to B, the contractor loosed the budget from 6000 to 6100, only with 2.4 utility in loss, but the contractor increase by 15 utility from that. Meanwhile, the mediator also persuaded the contractor to cut down EOT arguments, which can realize his benefits from client and also improve client’s position in mediation. In this way moving along the efficient frontier, both parties could choose their most preferred points for improvement till convergence.
5. Future research

This paper is discussing what people should do in mediation, and as a preparation for examining the relationship between the behaviour outcome and risk preference. Since the utility value/function of the model largely depends on the people’s risk preference which involving risk aversion (loss aversion), risk lover, risk neutral, or combination of the above.

6. Conclusion

In recent social research, mediation is defined as ‘administration and enforcement of rules or social norms’ for disputants' conformity. While previous researches on construction mediation focused on identification of successful factors, disputants’ satisfaction, mediation outcomes and tactics, very little about relationship between people’s conformity to social norms for dispute resolution and their actual attitude. To bridge the gap, this study is focused on what people should do at the mediation. Multiple objective decision making model is simulated as the mediator in helping negotiators to achieve a mutual satisfactory mediation settlement with efficiency and fairness. This paper facilitated as an experiment on examining the interrelationship between the outcomes and people’s preferences in the second part of the research.

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