Responsible Design and Delivery of the Constructed Project
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INFLUENCE OF COLLABORATIVE BEHAVIOR ON CLAIM NEGOTIATION

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The high cost incurred by the resolution of conflicts is largely affected by the existing adversarial nature of the construction industry along with the use of non-efficient dispute resolution methods in construction projects. This paper studies opinion dynamics in the negotiation of construction disputes while trying to understand the behavior and extremism of each contractual party. The developed model uses an agent-based approach to show how each agent's attitude can influence the negotiation process when solving a dispute. It can also be used to highlight the importance of alternative dispute resolution (ADR) methods and the use of a mediator in helping parties initiate negotiation and decrease the number of negotiation cycles needed to converge. The results showed that negotiation is not only affected by the attitude and character of the agents involved but it is also influenced by the delivery method of the project and the level of intensity of each agent. It was found that when the project is delivered through an Integrated Project Delivery (IPD) method, parties are more flexible and cooperative and will reach agreement within few negotiation cycles.

Keywords: Dispute resolution, Opinion dynamics, Relative agreement, Project delivery, Litigation, Social sciences, Construction management.

1 INTRODUCTION

Complex construction projects often result in complex disputes between the different contractual parties which most of the time arise from poorly prepared contracts, inadequate planning and lack of communication. One of the main factors that lead to the success of a project is the way the different parties approach their disputes and conflicts. Unfortunately, with the existing adversarial nature of the industry along with the use of non-efficient dispute resolution methods, this objective is rarely achieved.

Due to the complex structure of contracting firms and construction projects in addition to different attitudes involved, conflicts and disputes occur regularly during the entire life cycle of largescale projects. If these disputes are not addressed quickly and in an effective manner, the collaborative mode of the participants might be affected which will create an adversarial environment in which progress of the project will be largely affected. With that being said, better methodologies must be found to solve construction conflicts and promote collaborative behaviors among parties.

Social sciences have played an important role in understanding the different types of relationships among people. Many papers in the literature have targeted the subject of opinion dynamics and interaction among different agents (Deffuant *et al.* 2002, Lorenz 2008, Meadows

and Cliff 2012, Stephan and Menassa 2014). However, very few studies discussed the impact of social behavior and opinion dynamics on the effectiveness of the construction negotiation process (Long Chen 2012, Yuan and Ma 2012, Azar and Menassa 2013).

This paper uses the principles of the Relative Agreement theory to simulate the negotiation process between the contractor and owner agents when trying to resolve a dispute. The developed model can largely contribute to the construction industry through the analysis of the impact of each party's attitude and behavior on the negotiation process. This model also helps understand the impact of a certain project delivery method on decreasing negotiation time and establishing better communication between parties. In addition, this model can also be used to demonstrate how using a certain alternative dispute method can play a huge role in decreasing negotiation time and efforts.

2 METHODOLOGY

2.1 Relative Agreement

The developed agent-based model is based on the relative agreement (RA) model, an extension of the Bounded Confidence (BC) model where random pair interactions occur among the agents to influence each other's opinions. The main difference between the RA and BC models is that the RA model takes into account the uncertainty in opinion dynamics. In the initial RA model defined by Deffuant *et al.* (2002), each agent is characterized by two variables: its opinion X_i and its uncertainty U_i, both being real numbers. The opinions are drawn from a uniform distribution ranging between [-1, 1] and the uncertainty ranges between [0, 2]. The process of changing opinions is a process of continuous opinion dynamics. Around each agent's opinion lies an area of confidence in which he regards all opinions in this region as relevant and all others as irrelevant.

An agent interaction is calculated by first calculating the relative agreement between agents *i* and *j* by taking the overlap between the two agents' bounds h_{ij}, given by Eq. (1) (Deffuant *et al.* 2002):

$$h_{ij} = \min(x_i + u_i, x_j + u_j) - \max(x_i - u_i, x_j - u_j) \tag{1}$$

Subtracting the size of the non-overlapping part, the total agreement between the two agents, Eq. (2):

$$h_{ij} - (2 * u_i - h_{ij}) = 2 * (h_{ij} - u_i) \tag{2}$$

After calculating the relative agreement between the two agents h_{ij}; if $h_{ij} > u_i$, *Xj* and *Uj* are updated as shown in Eq. (3) and Eq. (4):

$$X_j = x_j + \mu\left[\left(\frac{h_{ij}}{u_i} - 1\right)(x_i - x_j)\right] \tag{3}$$

$$U_j = u_j + \mu\left[\left(\frac{h_{ij}}{u_i} - 1\right)(u_i - u_j)\right] \tag{4}$$

Where μ is defined as a constant parameter responsible for controlling the speed of population convergence.

2.2 Extremism and Moderation

Agents are considered extreme in their opinion when they are more confident and less willing to make compromises and negotiate, thus their uncertainty is lower. In fact, most people who have extreme opinions tend to be less convinced. On the other hand, people who have moderate initial opinions are considered more flexible and more willing to collaborate and negotiate with the other party. Therefore, moderate parties have a higher variability or uncertainty when they interact with the other agent (Meadows and Cliff 2012).

2.3 Project Delivery Methods

In each construction project, the contractual relationships between the owner, architect/engineer (A/E), contractor and management services are defined by a certain project delivery method. Recent project delivery methods (PDM) focus on establishing a structure of collaboration and cooperative behavior while eliminating the adversarial nature of traditional methods. The four typical project delivery methods shown in Table 1 are chosen to reflect the implications of each method on negotiations in the construction industry.

Table 1. Most frequent Project Delivery Methods.

Delivery Method	Implication
Design-Bid-Build (DBB)	Promotes extreme behaviors and lack of cooperation between the agents. When a traditional DM is chosen for a project, the gap between each agent's opinions on time extension or money compensation is relatively high and the variability range of each agent is narrow or almost zero which dictates extreme behaviors.
Construction Management at-Risk (CM at-Risk)	The agents are flexible and demonstrate moderate behavior where they are willing to negotiate and interact. Therefore, the gap between each agent's opinions is much smaller than the case of the DBB and the variability of each agent's opinion has a wider range expressing a willingness to cooperate.
Design-Build (DB)	The communication between agents and collaboration is enhanced through an early involvement of both parties which leads to a moderate type of agents involved.
Integrated Project Delivery (IPD)	The IPD method allows agents to cooperate from the very beginning and agree on potential causes of conflicts. This project delivery method marks the peak of collaboration and willingness to resolve disputes. The gap between the agents' opinions is very small and their opinions' variability ranges are very wide.

3 EXPERIMENTAL MODEL

3.1 Model Initialization

When the model is launched, the user will need to make few selections on the simulation window. First, the user needs to choose the project delivery method. The choice of the PDM will influence three different parameters and variables:

- The time convergence factor: This parameter indicates the speed of convergence between the agents based on the level of communication between them. Higher values of μ will speed up the negotiation between the agents and help them reach an agreement at a faster rate.
- Owner's opinion: The owner's opinion and the gap between his opinion and that of the contractor are largely influenced by the PDM. The owner's opinion is drawn from a uniform distribution with different boundaries that are in function of the contractor's opinion. The higher the level of communication and interaction between the agents, the smaller the gap between the agents' opinions.
- Agents' variability: The variability is an indication of the agent's attitude: character, negotiation preference and approach to problem solving. When the project delivery method provides an opportunity for the agents to better interact and exchange their opinions in an open setting, their variability will increase and they will be more open to hear the other agent's opinion.

After selecting the project delivery method, the user will have to select the dispute scenario. Several claim scenarios were drawn from AIA claim classification and mainly fall under two categories: excusable and/or compensable. According to AIA clause 8.3, circumstances beyond the contractor's control can result in an excusable delay, justifying an extension of the contract time. Excusable delays may be further classified as compensable or non-compensable. If the delay is deemed compensable the party will be entitled to additional compensation for the costs of delay, as well as additional time for contract performance. However, it is possible for a delay to be compensable without extending the contract time. Seven different dispute scenarios were used for the current version of the model. However, this list can be further extended to include other relevant scenarios. When the user selects the dispute scenario, the agent-based model generates the following:

- Classification of claim: If a claim classifies as excusable, agents will be negotiating time extension in terms of days. On the other hand, if a claim classifies as compensable, agents will negotiate money compensation, in US $.
- Severity level: Each agent whether it is the owner or the contractor has a high or low severity level that expresses his attitude towards a specific dispute scenario. If the dispute is caused by the owner, the severity level of the contractor will be high since he is directly affected by the actions of the owner while the severity level of the latter is low since he is the one causing the dispute. In cases where none of the parties are directly responsible for the dispute, for example during unexpected weather conditions, both agents' severity level is low. Having a high or low severity level will also affect the gap between the agents' opinions.

The user then needs to input the amount of days or money sought by the contractor agent in the simulation window. Several values were tested for both time and money to come up with results and test the logic behind the model. Values can also be chosen based on case studies of actual disputes that have occurred, to compare with actual data (Marzouk and Moamen 2009).

3.2 Negotiation Cycle

Each agent's opinion is drawn from a uniform distribution with varying boundaries. These boundaries depend on two main factors: the severity level of each agent and the project delivery method. The logic behind choosing each factor is related to the gap between the agents' opinions.

In fact, the more open and cooperative the agents are, the smaller the gap is. The agents' attitude is largely influenced by the nature of relation between them. These factors were found through trial and error analysis.

3.3 Convergence Check

After each negotiation cycle, the model checks for convergence. The latter is defined as the difference in agents' opinions that should not exceed 5%. When the owner's opinion falls within 5% of that of the contractor, the convergence and agreement between parties is reached. This specific difference in opinions was sought to be adequate after conducting a sensitivity analysis.

4 EXPERIMENTAL RESULTS AND DISCUSSION

The results obtained confirm the logic behind negotiations among cooperative and extreme parties. It was found that when the project delivery method is a Design Bid Build, parties tend to have a high gap between their opinions with low variability and thus they do not overlap in their opinions. Therefore, no negotiation cycle is initiated, and they will need further assistance in the form of an ADR method to initiate negotiation. As for the IPD delivery method, parties are more flexible and cooperative and that is confirmed through their close opinions and relatively high variabilities (AIA 2008). The parties will reach agreement within few negotiation cycles. In fact, in the case of excusable claims, results show that it takes one negotiation cycle to converge while it might take two negotiation cycles in the case of compensable claims to reach agreement. This can be explained by the fact that agents express higher severity levels, typically the contractor, especially when it comes to monetary compensation. Therefore, the gap between the agents' opinions will be bigger and thus it will take them more time to settle. As for other project delivery methods such as a CM at risk or a Design Build project, parties will sometimes converge but it will take them more negotiation cycles, typically four to five, than when having an IPD method.

The analysis of the results obtained also show how an extreme agent can bring a moderate agent to converge towards his opinion. In fact, when the variability of one agent is extremely low, the other agent's opinions are updated to minimize the gap. The results show that when the owner for example expresses very little variability in his opinion, it is the contractor that changes his opinion and tries to make the settlement. The latter proves the theory behind extremism and uncooperative behavior where the agent showing an extreme behavior is less willing to cooperate and negotiate with the other agent (Zhang *et al.* 2016). It is also interesting to note how the convergence time factor can influence the number of negotiation rounds that the agents go through before reaching settlement. In fact, when the project is delivered through a Design Bid Build type of contract, the speed of negotiations is much slower given the large gap in agents' opinions and the lack of communication between parties. For a Design Build project, agents will have to go through more negotiation rounds than the case where the agents negotiate under an IPD type of project. The latter is explained by the fact that for a design build, the time of convergence is expressed by a factor of 0.4 while for an IPD project, the time of convergence of 0.5 is higher and thus will bring the agents to converge at a much faster rate.

5 CONCLUSION

The presented agent-based model is a simulation of negotiations between contractual parties in construction projects. The results obtained show how the behavior and attitude of a party can largely affect the negotiation process and outcome. Not only is negotiation affected by the

attitude and character of the agents involved but it is also influenced by the delivery method of the project and the level of intensity of the agent. Therefore, a successful negotiation requires a combination of factors: the flexibility brought by the delivery method such as the case of an IPD method, a low severity level expressed by the parties and a willingness to negotiate and cooperate expressed through non-extreme behaviors. Future work will address how having an ADR method in the case of negotiation failure encourages ongoing and timely dispute resolution and prevents from leaving disputes pending till the end of the project. The presence of these key elements will guarantee the attainment of a settlement within few negotiation cycles and will leave all parties satisfied.

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