RISK ANALYSIS AND DECISION MAKING IN CONSTRUCTION CLAIMS

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Claims in construction projects are inevitable and can result in costly litigation. Construction contract ambiguity, overtly restrictive terms, and unfairly allocated risks to one party increase the likelihood of disputes. The goal of this study is to introduce a decision making framework that evaluates claim processes. This paper outlines a comprehensive list of dispute triggers in construction projects. The causal relationship between these triggers are analyzed using Bayesian Belief Networks. The introduced diagrams becomes an input to a game theoretic approach which models parties' interactions in pretrial negotiations. Then the considerations for modeling construction claims in a game theory format are elaborated. This paper concludes that the integration of Bayesian Networks and Incomplete Information Games is an effective tool to analyze construction claims.

1. Introduction

This research shows how to analyze construction claims based on parties' information and subjective beliefs on dispute case. Section 2 introduces research objectives and the questions to be answered in this research. Section 3 is a literature review on construction conflicts and defines claims from both contractors' and owners' perspectives. Section 4 introduces various mathematical models applied to analyze construction claims, types of claims and reasoning are discussed. Section 5 provides the method used to create the main framework of analyzing individual project claims. The method explains how the current categorization can be modeled in a Bayesian Network format. Then it summarizes on game theoretic analysis of construction conflicts and elaborates on parameters to be considered in modeling a claim. The last section is the conclusion and future research opportunities potential contributions in this research.

2. Research Objective

The purpose of this study is to introduce a framework to analyze claims from economic viewpoint considering causation and reasoning as key elements for disputes. Identifying such elements requires recognizing the causal relationship between parameters that may be considered by dispute parties in their decision making. Then, the significance of such parameters in the decision making process should be measured in terms of probabilities. The product will become an input to a game theoretic bargaining model. A non-cooperative game approach can analyze each party's strategies that can lead to the most desired outcomes based on their beliefs and information on a case basis.

The result of this research will be helpful for the claim parties (contractors and owners) to select the best strategies in pretrial bargaining processes that can result in a fair amount for settlement. It will also help parties to understand the main considerations in pretrial negotiation or settlement. This paper responds to the following questions: What are the chains of causes for disputes or claims? What parameters should be considered in modeling a claim? How to incorporate these parameters into the decision making process?

3. Construction Conflicts

Construction contracts face enormous uncertainties resulting from imperfect contract documents. As a result, all contract parties are obligated to collaborate conscientiously to avoid conflicts. Any misunderstanding in such collaborations or misinterpretation of contract terms and conditions may advance conflict between parties and lead to disputes. The causes for such conflicts includes, but are not limited to, incomplete or defective plans and specifications, ambiguity in contracts, overly restrictive terms, and unfairly allocated risks to one party (Rubin, Fairweather, Guy, & Maevis, 1992). If a dispute is not resolved between the parties, the conflict will be elevated in a legal format such as a claim. A claim is defined as a demand asserted by one party on another party relating to services or products specified in the contract (Barnard, 2005).

A claim can be analyzed from different traits such as engineering, legal aspects, relationships, and project constraints. Still, approaches to the issue are fairly similar regardless of the mentioned viewing platforms. Common elements that become essential in claim considerations can be briefed as monetary values, responsible party for damages, causation and reasoning, and applicable laws and contract terms or conditions. Construction claims can be on any of the four main elements of the project: cost, time, quality, and safety. All of these elements eventually translate into a monetary compensation or time relief sought by the contractor.

Claims from different parties perspective

In construction, contracts project owners and contractors firms are typically the parties involved in claims. There are some instances that involve other agencies such as Architectural and Engineering (A/E) firms, but depending on the project type A/Es have a separate contract with either owner or contractor. As a result, given the type of contract claims against the A/E firm or any other agency can be analyzed identically to the ones between owners and contractors. In general, contractors may make a claim about changes to the work, project schedule, or work means and methods. On the other hand, owners may have concerns about contractor's failure to perform the work as specified in the contract, which includes performance (time), quality, and costs.

Contractors in construction projects face a multitude of risks. Examples of these risks are inflation, inclement weather, labor problems, material shortages, accidents, and unforeseen conditions. Such risks have monetary consequences that may hurt contractor's profitability. Contractors tend to be inveterate optimists, believing that the risk is either contractually imposed upon them, or will not occur to them; or even if the

risk occurs the contract clause will not be enforced (Rubin et al., 1992). This optimism behavior makes contractors to be risk takers and increase the chance of conflicts.

Owners usually take the risk on time and budget and quality. There might be additional risks beyond these three constraints depending on the complexity of the project such as environmental or regulatory issues, or public protests. There are cases that owners claim for damages against the contractor for failure to fully perform the contract, failure to pay subcontractors, completion or repairs of defective work, late project completion or costs incurred by contractor's suspension. In most cases contractors are bonded, therefore owners usually seek after bond and surety companies for any substantial damages.

Construction Claim types

The construction claim is a process which begins with dispute between parties involved in the contract (Construction Industry Institude, 1990). The study conducted by Construction Industry Institute suggested that each party has a limited knowledge of claim process. The knowledge includes an interpretation of facts surrounding the dispute, the contract, and the applicable law. Parties' knowledge on the origins of disputes and types of claims may affect their evaluation and considerations in their decision making process.

Unresolved disputes by either contract parties climb up the dispute ladder to become a claim. Disputes and claims do not always rise because of a specific issue in the project or contract. For example competitive bidding scheme and tight economic situation have forced contractors to look further into alternative methods to recover profit after winning contracts. The alternatives may include negotiations, change orders, disputes, and claims. This phenomenon is often referred as Opportunistic Bidding.

Delay, directed change, constructive change, acceleration and constructive acceleration, differing site conditions, defective and deficient contract documents, Owner-furnished items, Impossibility of performance, Interference with performance, Defective Inspection/ misinterpretation of the contract, superior knowledge. misrepresentation, strikes, weather, suspension, default/nonpayment, termination, and warranty are amongst the most common types of claims (Barnard, 2005). Each claim for a project usually is a combination of various claim types mentioned above. This paper grouped claims into categories based on terms generally defined in a contract. Knowing these types helps contract parties to recognize the potential disputes early and prevent claims by providing adequate documentation or notification.

4. Statistical Analysis on Construction Conflicts

Yiu and Cheung use catastrophe-theory-based analysis on three variables of construction conflict, level of tension, and the amount of behavioral flexibility. (K. T. W. Yiu & Cheung, 2006). The same authors applied Moderated Multiple Regression (MMR) to the mentioned three variable system (T. W. Yiu & Cheung, 2007). This model identifies thresholds for flexible individuals that are willing to avoid/resolve

construction conflicts. Aibinu et al. develope structural equation modeling technique to demonstrate the influence of organizational justice on contractors' dispute tendencies and intensity of conflict. (Aibinu, Ling, & Ofori, 2011).

Cakmak used Analytical hierarchy process (AHP) to determine the relative importance of the main causes for construction disputes. (Cakmak & Cakmak, 2014). Zhang et al rank variable by questionnaires to identify a comprehensive list of claim transaction cost variables and their relative importance in the dispute process. (Lu, Zhang, & Pan, 2015). Yiu et al. applied fuzzy fault tree analysis (FFTA) approach to conceptualize the root causes of construction dispute negotiation failure. (T. W. Yiu, Cheung, & Lok, 2015). Jelodar et al. uses a three-stage approach to identify sources of dispute (Jelodar, Yiu, & Wilkinson, 2015). Nash Equilibrium on sequential offers using extensive form games (Ho & Liu, 2004). El-adaway uses multi-agent simulation models for construction dispute mitigation. The simulation effort resulted in a algorithmic framework to estimate the mean amount of the settlement based on specific situations (El-adaway, 2008).

Construction Industry Instituted (CII) has developed research to determine the relationship between project characteristics and the likelihood of contract disputes. This research resulted in a computerized model that identifies the Dispute Potential Index (DPI) of a project. DPI is a tool used to anticipate the likelihood of disputes in a construction at different stages of the project from initiation to closeout. A complementary study has been performed by Cheung et al. on the subject matter and diagnostic approaches to identify construction disputes. The result of this study is a comprehensive list of causes for construction disputes with their respective occurrence likelihood. The ranking of these causes has been determined by designing questionnaires to ask expert opinions on the causes. (Cheung & Pang, 2013). Love et al. developed a causal diagram with the factors that influence construction disputes. (Love, Davis, Cheung, & Irani, 2011).

Omoto et al (2002) analyzed the dispute resolution processes as a two-sided bargaining model with arbitration as an outside option (Omoto, Konayashi, & Onishi, 2002). Ho and Liu propose a game theoretic based model to study people behavior in different types of claims. This model is based on Subgame-Perfect Barough et al applied game theory approaches including Prisoner's Dilemma and Chicken Game to analyze construction conflicts. (Barough, Shoubi, & Skardi, 2012).

5. Method

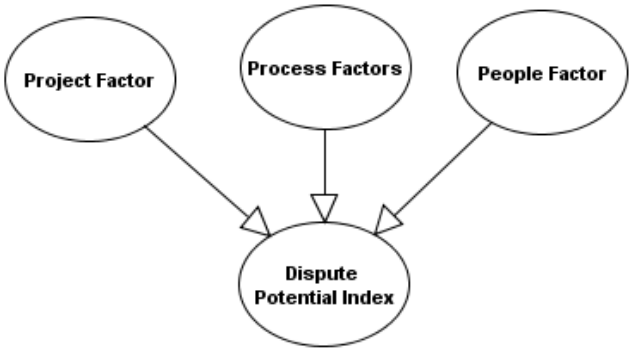
Defining Interdependencies between causes of claims

A comprehensive list of claim causes are gathered from previous studies such as CII and Cheung's researches. Then, causes are categorized into project variables that are correlated to dispute vulnerability. The variables that impact contract disputes are divided into three main groups: People, Process and Project. Issues involving People affect organizational relationships, roles and responsibilities, and individual's expectations. Process issues include all project management activities throughout the

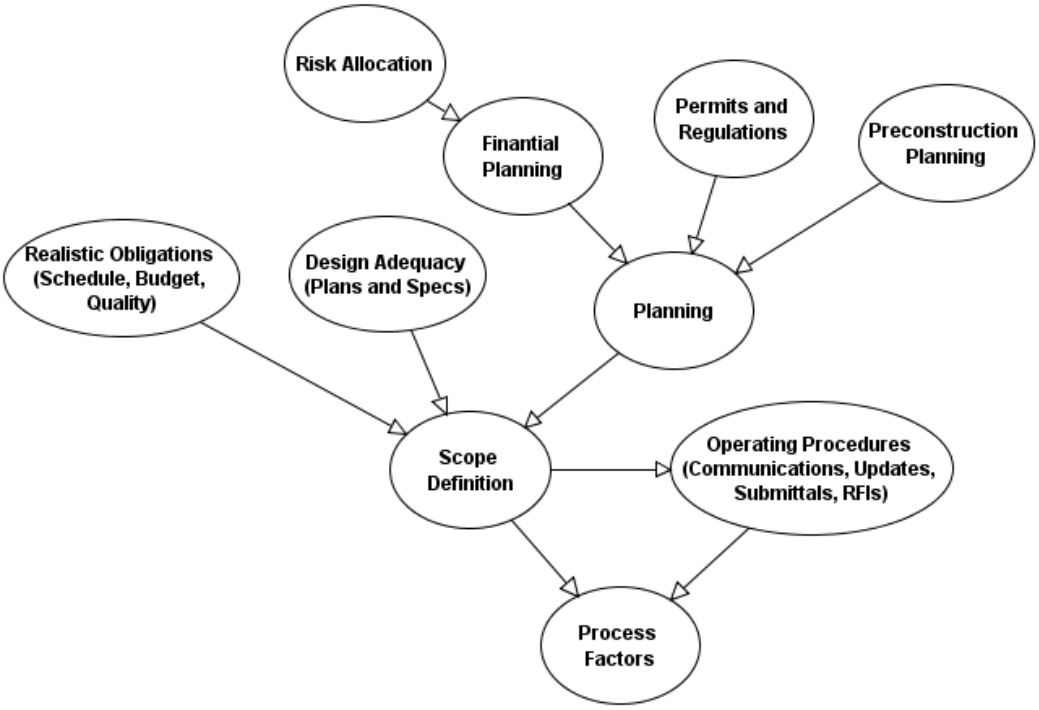
project lifecycle. Examples of such processes may include contractual language, risk allocation, scope definition, communication, and dispute resolution. Project characteristics define technical issues with the nature of the project such as complexity, environmental limitations, and unidentified project risk (Diekmann & Girard, 1994) .

Bayesian Network is a type of statistical model that represents a set of random variables and their conditional dependencies. Below is the graphic model for conditional dependencies between the causes of claims in a Bayesian Network (BN) format. There are two sets of Bayesian Networks created for owner and the contractor. The intent of the BN model is to calculate party's subjective belief on the probability of being held liable at the court. In addition, each party may calculate beliefs of their opponent on the opponent's estimates on prevailing the case. These subjective beliefs will be used in the Game theory model discussed in the next section for parties' decision making.

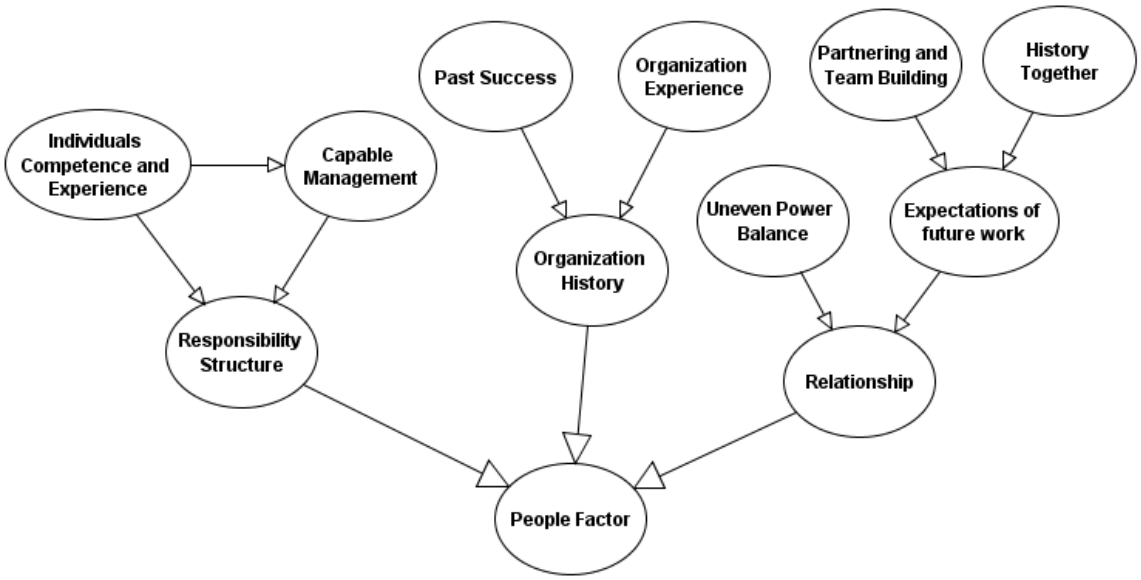
Main causes for claims



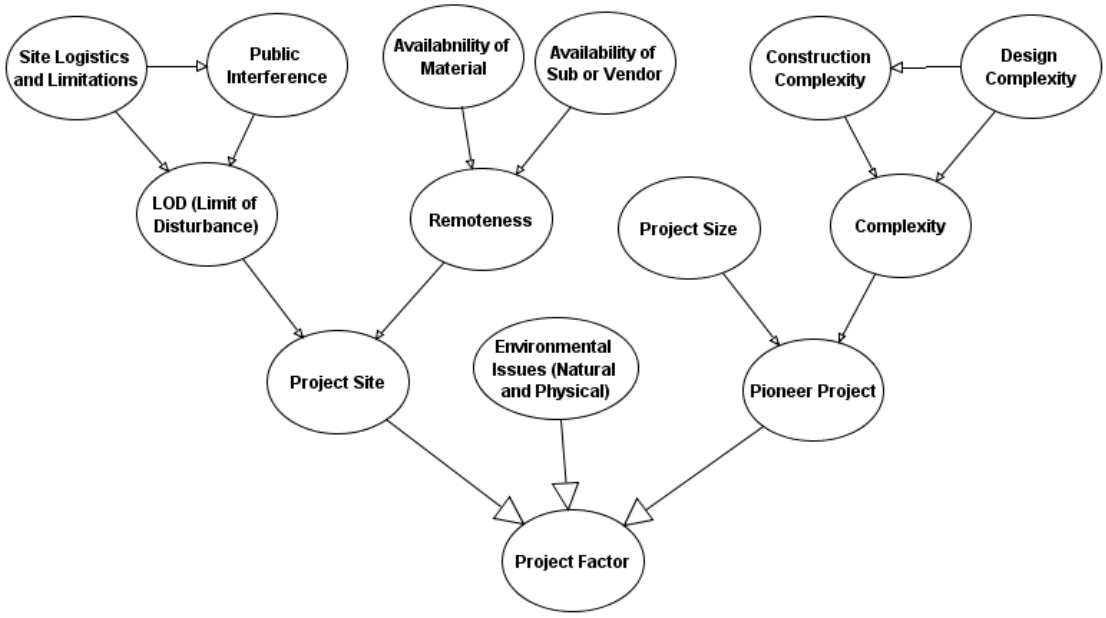
Process factor



People factor



Project Factor



Game theory Application in Negotiations

Decision theory is a mathematical tool used to identify the values, uncertainties and other issues relevant in a given decision, its rationality, and the resulting optimal decision for a single agent. Game theory, on the other hand, is a tool to analyze interactive decision making for multiple agents (also called players). In game theory each agent has a set of available actions where each action taken by any agent may affect the outcome of other agents. Game theory can model the behaviors of agents and

provides best strategies leading to the best possible outcomes. This interactivity between agents is the major difference between classic decision theory and game theory models (Maschler, Solan, & Zamir, 2013).

Pretrial settlement bargaining involves interaction between the claim parties, contractors and owners. Therefore, game theory is a great tool to analyze these negotiations. This type of game is often analyzed by non-cooperative games where each agent wants to maximize its own payoff given their available options.

There has been tremendous progress on litigation decision models, where theoretical models developed mostly based on pure economic outcomes. There are various models used for such analysis that were briefly discussed in the literature review. Although, the economic outcomes are considered to be a key driver to the disputes, there are other parameters that might play a crucial role in litigation decision making. The following section is the breakdown of all important parameters in the subject matter.

Game Theoretic Analysis of Construction Claims

There are multiple variables in the analysis of claims. I found it appropriate to define all these variables to clarify different ways that settlement games can be modeled. The following discusses different types of techniques used to analyze settlement games and introduces the main variables and parameters involved in such games.

Players

The primary players of construction claims (litigants) are General Contractors (Plaintiffs) and Project Owners (Defendants). Other players that are considered in sophisticated models include judge or jury, attorneys, experts, and other contracting agents (i.e. A/E firms, Sub-contractors, Consultants, Commissioning Agents, etc.).

Actions and Strategies

Action is Parties' (players) choice on the available options at each stage of the game. For example Contractor's action can be submitting a proposal, filing for claim, or asking for settlement amount. On the other hand, Owner's actions are accepting the proposal or offer, rejecting, or sending counterproposals. Some models allow multiple rounds of actions or proposals and some other only consider the final action (take-it-or-leave-it offers).

Depending on the rules of the game there are limited allowable actions at each decision opportunity of players. Moreover, actions chosen at one point may limit future actions or transfer private information to the opponent. The set of actions each player takes during the game is called player's strategy. Players choose their strategy considering both outcomes of their own actions and their opponent's action.

Outcomes and Payoffs

The result of the strategies played by parties is the outcome. There are a broad range of outcomes, from the contractor not pursuing the claim and no amount transfer between the parties, or the judge ruling an amount to be transferred from owner to contractor.

The numerical value of the outcome associated to each party is called the payoff. In the literature, payoffs are modeled as either dollar amounts or utility functions. Using the utility function in the calculations allow us to model risk preference of the parties. In other words, by using utility function a party can be considered risk averse or risk taker.

Timing

The sequence of play and duration of the claim are the two topics of interest of the timing parameter. The early settlement models are developed mostly based on general theoretical models of bargaining processes. These models are called axiomatic, which were initiated by Nash (1950). After developments and improvements of these models, a strategic approach was suggested to capture more details of the settlement negotiations.

In the strategic approach, parameters, such as sequential versus simultaneous offers, play an essential role in the analysis. In the sequential model, each party may offer and wait for the other player's response. In simultaneous offers, actions from either party cannot be observed by their opponents, or it may not have influence on the opponent's decision for game strategy.

Another way that time can affect the settlement analysis is the duration of the claim. Disputes and claims in reality have a finite length of time. In other words, there is always a termination to the claim either by court date, settlement, dripping the case, or even by a statute of limitations (not filing the suit in a timely fashion). As a result, there are different analyses in the literature that consider multiple phases for pretrial negotiation.

Information

The information that contractors and owners have at each stage of the project can vary due to obtaining it from different sources, perceiving the current situation differently, or receiving updates on the subject matter. Information can be either on the facts of the case, opponent's estimation and beliefs, Judges' verdict, or type of the players.

If players are exactly sure about a judge's verdict in a given case being reviewed in the trial, the game is called *perfect information*. In reality none of the players can exactly predict the verdict, which is called *imperfect information*. In such games if the information is shared knowledge between contractor and owner the analysis of the game is *Symmetric*. In cases that each party obtains private information game is

considered to be *Asymmetric.* Asymmetric games can be one sided (only one party has private information) or two sided.

Prediction

The main purpose of settlement models is to make a prediction about the outcome of bargaining. In the recent literature, the notion of equilibrium has been used for modeling. Most of the simplified models and earlier works in the literature used the notion of cooperative game theory, where the solution to the game should be efficient (no money is wasted in the process). Nash Bargaining Solution (NBS) is an example of axiomatic solution that applies to cooperative games. However, claims and disputes are non-cooperative conflict between the parties, and it is reasonable to analyze them with the notion of non-cooperative games. In the strategic format of non-cooperative games, players predict the payoffs conditional to the opponent's belief.

When there is uncertainty about the information, as in incomplete information games, typically each player may consider their opponents' knowledge in addition to their own knowledge on a situation; they also may consider their opponent's knowledge about their own knowledge, and so on. This notion is defined as hierarchies of beliefs in context of incomplete information games.

In this context, the Bayesian approach has been recognized as the most widely accepted statistical decision making approach for games with incomplete information (Maschler et al., 2013). In this method, players have probability distribution over parameters that are unknown to them. Actions taken by each player are based on their beliefs defined in that distribution. Players also have beliefs about each other's probability distribution, which updates their prior belief on the subject matter. As a result, an infinite number of hierarchies of beliefs form between players. The challenge of the theory is to incorporate these hierarchies of beliefs into a model.

6. Conclusion

The two main variables in claims are liabilities and damages. Liabilities often depends on the specifics of the case and contract. In other words, the probability of owner being held liable in the court is defined by project characterization. The proposed Bayesian Belief Network is an effective tool to measure the liability element. On the other hand, damages is defined by parties' behavior in the dispute process. In other words, initial proposal for the original dispute amount, settlement offers and any responses such as acceptance, rejection, or counteroffers are indicators of the damages incurred. The true amount of damages and liabilities are to be determined by the court in the discovery and decision processes; however, parties' belief on the liabilities and damages defines their expectations amounts to be paid to either settle or pursue the case in the court.

Each party may have private information about the liabilities and damages of a specific claim. The information difference causes different beliefs on parties' estimate on these two parameters. Larger belief gaps often causes parties go to the court rather than the settlement process. The information can be acquired at any point in the dispute process.

As a result the belief gap created prior to the dispute may vary over time during the dispute by acquiring additional information. Bayesian game theory is an effective tool to model such interaction between the claim parties.

Contractor and owners may not have a common prior belief over the probability of prevailing at trial and the amount of damages. The asymmetry in initial beliefs may be due to differences in each party's perception of the information they have or optimistic opinion of their lawyer on obtaining favorable verdict. These assumptions increase the probability of failing to reach an agreement in the settlement process. During the bargaining process either or both parties may learn new information revealed from discovery process or their own investigation. The new information becomes a basis for parties to update their beliefs on the amount of damages and prevailing at trial. The updated probability is calculated in the proposed Bayesian Network by defining scenarios within the model in the form of subjective beliefs. The beliefs of party on its own case and beliefs on the opponents case becomes an input to the proposed game theoretic approach. The game theory approach is being used to analyze parties' threshold in acceptable settlement ranges and to define best strategies to avoid claims and maximize outcomes given the available information.

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