Dispute Prediction Model Using System Dynamics in construction Projects

By

Syed Muhammad Tuaha Naqvi

(00000118327)

A synopsis submitted in partial fulfillment of the requirements for the degree of

Master of Science

In

Construction Engineering and Management

Department of Construction Engineering and Management
Post Graduate Wing.

School of Civil & Environmental Engineering (SCEE)

National University of Sciences and Technology

Islamabad, Pakistan (2019)

THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS thesis written by Mister Syed Muhammad Tuaha Naqvi (Registration No. 00000118327), of PG Wing - SCEE has been vetted by undersigned, found complete in all respects as per NUST Statutes / Regulations, is free of plagiarism, errors, and mistakes and is accepted as partial fulfillment for award of MS/MPhil degree. It is further certified that necessary amendments as pointed out by GEC members of the scholar have also been incorporated in the said thesis.

Signature: ____________________________

Name of Supervisor: **Dr. Khurrum Iqbal Ahmad Khan**

Date: ________________________________

Signature (HOD): ______________________

Date: ________________________________

Signature (Dean/Principal): ______________

Date: ________________________________

This is to certify that the

thesis titled

Dispute Prediction Model Using System dynamics In Construction Projects

submitted by

Syed Muhammad Tuaha Naqvi

has been accepted towards the partial fulfillment

of the requirements for the degree

of

Master of Science in Construction Engineering & Management

____

Dr. Khurram Iqbal Ahmad Khan

Assistant Professor, Head of Department (HOD)

Department of Construction Engineering and Management

Post Graduate Wing

School of Civil & Environmental Engineering

National University of Sciences & Technology, Islamabad

I dedicate this thesis to my family (especially my mother) and teachers who have supported me in this challenging journey.

ACKNOWLEDGEMENT

First and foremost, I would like to thank Allah Almighty Who always helped me throughout my life and to get through this research degree and thesis.

I would like to pay debt of gratitude to my supervisor Dr. Khurrum Iqbal Ahmad Khan (HoD, CE&M), Co-supervisor Dr. Sohail Anwar Malik and Dr. Muhammad Jamaluddin Thaheem for their profound guidance and encouragement, to complete this research work. I sincerely appreciate the valuable time, motivation and personal support accorded by them. I am also extremely grateful to the committee members, Dr. Ahsen Maqsoom and Dr. Abdur Rehman Nasir for their sincere guidance to complete this research work. I owe my special thanks to my batch mates of CEM-07 for their support throughout the course work and in the initial research work. I am very grateful to all the respondents for their valuable contribution to this research. And in the end I would like to pay my earnest and honest gratitude to my parents for their unconditional support, encouragement, prayers and patience.

Abstract

Strong understanding of project dispute causation and its prediction is very critical for the success of construction project and companies as well. This prediction will help in understanding and formulating the strategies against the potential problem beforehand. Studies in disputes factors were done before but they were all fragmented and no interdependencies between these factors was addressed/considered. To address this shortcoming of complex interdependencies between disputes factors a system dynamic (SD) model was developed which can also forecast their behavior over time. The proposed model integrates seventeen factors which have been identified through content analysis and verified by professional experts through survey. Disputes factors includes delay, cost, motivation, communication/sharing, differing interpretation, defects, rework/correction, suspension, experience/workmanship, strategic-uncertainty, claims, different valuations, disputes, disputes resolution, latent fast-tracking requests, Inadequate contract and tendering. The model mainly focuses during construction phase and is intended for use by three main parties. Model was test by different checks as proposed by (Qudrat-Ullah & Seong, 2010). The model was also used to simulates different scenarios which occurred during construction. The research advances the understanding and working of disputes factors during construction projects by creation of more holistic and interdependent model of disputes factors.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

Chapter 1

Introduction

1.1. Overview

Construction industry is one of the diverse and booming industry in the world. It contributes around one tenth toward the global GDP. It consumes staggeringly high fifty percent of the world resources and consumes (economywatch.com). According to economic Survey of Pakistan in its annually report for fiscal year 2016-17 published that the construction industry grew by 9.1 percent contributed 2.7 percent in the GDP of the country. Due to the improvement in the country's security situation and China-Pakistan Economic Corridor (CPEC) agreements, construction industry of the country is boosting. To get the maximum advantage from this industry, careful planning and understanding of all integrated activities of the construction project is inevitable.

Due to unique and multidisciplinary nature of constructions projects and involved parties, the complexity of the system is growing resulting in differences of opinion and escalate the conflicts which result in the rising disputes (Cakmak & Cakmak, 2014). Ever increasing complexity of construction and unstable economic situation incurred the need for strong/refine understanding of factors that leads to disputes if we want to reduce the dispute phenomena (P. Love, Davis, Ellis, & On Cheung, 2010). According to (Maqsoom, Charoenngam, Masood, & Awais, 2014) to keep cost and schedule of the project within limits demands sound understanding of the project along with strong engineering holding and judgement. *Due to the different liking and disliking of owners, contractors and consultant delays are inevitable resulting project to deviate from its original estimates*.

According to (S.-O. Cheung, Suen, & Lam, 2002) dispute is due to the involvement of disagreement. According to (Merriam-Webster, 1996) describe dispute is due to the insistence of contradicting views or claims or disagreement as to right.

According to(Carmichael, 2002) conflicts and disputes are co-related and when stakeholders /parties were unable to handle theirs conflicts first hand than the disputes arises. (S. O. Cheung & Yiu, 2007) describe disputes as common part of construction which utilizes the resources which otherwise would have been used in more sensible and productive manner. According to the (Fenn, 2007) conflicts and dispute can arise anytime during the project and not only deviate the project from the preplanned path but also increases its time, cost and performance, thus these two are very critical in any project success and should be identified and solved as soon as possible.

Impact of disputes on direct cost ranges from 0.5 to 5 percent of project cost. and on the other hand indirect cost resulting from loss of productivity, fatigue, worsen relationships and damaged reputation etc. incurred more damage to project and parties (P. Love et al., 2010). Due to high impact of dispute on the project performance, its sound understanding and formulation of dispute prevention process beforehand has become very importance for project success (Ilter, 2012). As of today, claims and disputes keep arising and construction industry struggle to solve them economically and equitably (Arditi & Pulket, 2005). (Shin, 2000) was of the viewpoint that during project operation, dispute handling should be part of project management, so that dispute which are very common on project will be solved promptly as they occur. Disputes are the prime reasons to worry in any construction work (Gibbons, 2007).

1.2. Problem Statement

In the past much, work has been focused on identifying the critical disputes causing factors based on perception of different involved parties. Hence despite of the much work has been done on construction disputes, it keeps on rising because the steps taken to mitigate one critical reason will lead to a scenario where other cause will becomes critical and resulting in further delay and disputes. Identification and quantification of relationship and effect of one factor on another were not widely discussed. (P. Love et al., 2010) pointed out the same need to identify causal relationship between dispute factors to better understand this phenomena. (Doloi, Sawhney, Iyer, & Rentala, 2012) pointed out the same gap for delay in construction projects as in term of identification of causal relationship between factors and predicting their effect on delay. Construction process itself is dynamic and complex in nature, therefore SD methodology is proposed which deals with complex systems.

1.3. Research Objectives

Following are the research objectives:

i. To identify and shortlist critical dispute causing factors in construction projects.
ii. To create a system thinking framework for dispute in construction, their constituent variables and interdependencies.
iii. To create a system dynamics model incorporating the disputes factors affecting the construction projects.
iv. To validate model using a case study.

1.4. Scope of the Study

The research scope is limited to traditional construction contracts only.

1.5. **Significance of the study**

The model obtained will help in understanding the critical construction disputes factors and interaction between these factors in work environment and their impact on the construction project, giving sound knowledge and understanding of the critical disputes factors, which than help in reducing the disputes during the construction projects.

1.6. **Relevance to Nation Need**

Pakistan being developing country cannot afford the wastage of resources which if sensibly used is vital for the country's development. Unfortunately, most of construction project goes out of the way, which result in the wastage of time, effort and money resulting in the poor performance of the country's economy, this study will help in understanding the construction disputes to minimize its impact.

1.7. **Thesis overview**

The thesis has been organized into five chapters.

Chapter 1 is about the introduction and gives insight to the research, problem statement, objectives and scope of the study.

Chapter 2 is about 'literature review' and disuses previous published worked regarding the research.

Chapter 3 is about 'Research Methodology' and explain how research has been carried out.

Chapter 4 is about "Result and Discussions" and covers data analysis.

Chapter 5 is about "Conclusion and Recommendations".

Chapter 2

LITERATURE REVIEW

2.1. Disputes in Construction

Disputes not only results in worsen relationships between stakeholders but also damages project performance by consuming extra cost and time are one of the main reasons for unplanned completion of project as anticipated in the beginning of the project. Dispute may arise at any stage of project (Hall, 2002). However sound knowledge and understanding behavior of disputes causing factors help in minimizing the effect of disputes on project success (Cakmak & Cakmak, 2014) as they then will be settled in time hence avoiding court.

According to (Dangrochiya, Rathod, & Sharma, 2015) timely resolution of conflict can save involved parties a lot of cost which otherwise if unsuccessful would sunk in lieu of litigation proceedings. Dynamism and uncertainties in the industry is increasing due to multidisciplinary nature of stakeholders and projects resulting in Increasing conflicts which if not timely caters turns into disputes (Cakmak & Cakmak, 2014).

2.2. Conflict and Dispute

Conflict and dispute are often homogenously used especially in the construction industry (Acharya, Dai Lee, & Man Im, 2006). These two are unequivocal, conflict occurs when there is difference of opinion which can be solved at site upon proper handling whereas unmanaged conflict give rise to dispute which need settlement through court (Fenn, Lowe, & Speck, 1997). (Collins,1995) define conflict in term of endorsement or defiance against something valuable. (J. Diekmann, Girard, & Abdul-Hadi, 1994) define disputes as “any contract question or controversy that must be settled beyond the jobsite management”.

2.3. **Causative Disputes factors**

The targeted journals in this study includes Journal of Management in Engineering (ASCE), International Journal of Project Management, International Journal of Advance Research in Engineering, Science & Management (IJARESM), International Research Journal of Engineering and Technology (IRJET), International Journal of Engineering Science & Research Technology (IJESRT), Business Sciences International Research Journal (IMRF), International Journal of Management & Organizational Studies (IJMOS).

Top five causes of disputes includes change order, poor contractor selection, poor work quality, delays in work and payments (Zubair, Gabriel, & Thaheem, 2017). A study by (Soni, Pandey, & Agrawal, 2017) concluded that lack of available information in design, delayed payment by owner, delay in work by contractor, ambiguous meaning in documents, financial failure of contractor are top factors causing conflicts and dispute in construction projects.

(Barman & Charoenngam, 2017) observed disputes, which are Contractual-misinterpretation, Escaping Contractual Commitments, Incompleteness of Information, poor Collaboration, Defects in construction, poor performance of contractor, nonpayment and suspension. (Hafez, Aziz, & Elgayar, 2016) in his study for time delay disputes found out that delays, design, project complexity, quality and workmanship, tender, site conditions, accelerations, differing goals, variations, co-ordination and value engineering are the main causes of disputes. Study indicates that change order, delay, site conditions, soil condition are critical elements to disputes(Semple, Hartman, & Jergeas, 1994). (Kumaraswamy, 1998) in an study concludes that ambiguity in contract, differing interpretation, risk allocating, change order, delay are among main causes of conflicts. (Zaneldin, 2006) in an study to enlist the frequency of different claims, found that contract vagueness related, change order related, delay related, extra work related, acceleration related and different site conditions related claims are the top claims in

UAE. In an study of arbitration cases in Indian (Iyer, Chaphalkar, & Joshi, 2008) observed that delayed in site access, payment, approval of drawing, work, and extra work are frequent causes of claims and disputes. (Hashem M. Mehany & Grigg, 2014) during study of highway and bridge construction claims in Colorado found out that differing site conditions, different interpretations, errors in design and specification, delays, variations are frequent basis of claims. (Barman & Charoenngam, 2017) in a study of 48 litigious cases filled in England and Wales identified delay, termination, performance, defect, negligence and payment are the core reasons in escalating disputes.

2.4. Significant Dispute Causing Factors

methodology as proposed by (Zubair et al., 2017) was followed. Initially, 54 published research papers between the years 1992-2018 were analyzed for the identification of dispute causing factors, out of which 16 papers were found most relevant. 78 factors were identified from the selected papers. After merging similar factors, 23 factors were left. Upon Keeping factors with at least 25% of citation, 16 disputes causing factors were left which were than used in model development.

Furthermore, ranking of the identified factors was done following two-part content analysis. In first part their frequency of importance and in second part their qualitative importance based on 3-point Likert scale was considered. Qualitative score and quantitative scores were than multiplied to get the literature score and then normalized for ranking, as shown table-1.

Table 1 Content Analysis

S. No.	Dispute causing factors	References	Literature score	Ranking

1	Excess change orders (variation in spec and design, oral orders, outside scope)	(Zubair et al., 2017), (Soni et al., 2017), (Singh, Chotai, Verma, RIZVI, & PAI, 2017), (Hafez et al., 2016), (Divakar & Kumar, 2015), (Dangrochiya et al., 2015), (Chaphalkar, Iyer, & Patil, 2015), (Hashem M. Mehany & Grigg, 2014), (Alnuaimi, Taha, Al Mohsin, & Al-Harthi, 2009), (Iyer et al., 2008), (Zaneldin, 2006), (Kumaraswamy, 1998), (J. E. Diekmann & Girard, 1995), (Semple et al., 1994), (O'Connor, Chmaytelli, & Hugo, 1993).	0.938	1
2	Delay (payment, decision, response, work, lawsuit, protest)	(Zubair et al., 2017), (Soni et al., 2017), (Singh et al., 2017), (Hafez et al., 2016), (Divakar & Kumar, 2015), (Dangrochiya et al., 2015), (Chaphalkar et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Alnuaimi et al., 2009), (Iyer et al., 2008), (Zaneldin, 2006), (Kumaraswamy, 1998), (J. E. Diekmann & Girard, 1995), (Semple et al., 1994), (O'Connor et al., 1993).	0.938	1

3	suspension/termination (due to restricted site access, act of God, weather, accidents, changed conditions, strike, subcontractor)	(Zubair et al., 2017), (Soni et al., 2017), (Singh et al., 2017), (Hafez et al., 2016), (Divakar & Kumar, 2015), (Chaphalkar et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Alnuaimi et al., 2009), (Iyer et al., 2008), (Zaneldin, 2006), (Kumaraswamy, 1998), (J. E. Diekmann & Girard, 1995), (Semple et al., 1994), (O'Connor et al., 1993).	0.875	2
4	Exaggerated Claims (Extension of time)	(Zubair et al., 2017), (Soni et al., 2017), (Divakar & Kumar, 2015), (Chaphalkar et al., 2015), (Alnuaimi et al., 2009), (Kumaraswamy, 1998).	0.375	11
5	Defect (design and specification, (bid) estimation, site investigation, work)	(Zubair et al., 2017), (Soni et al., 2017), (Singh et al., 2017), (Hafez et al., 2016), (Divakar & Kumar, 2015), (Dangrochiya et al., 2015), (Chaphalkar et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Alnuaimi et al., 2009), (Iyer et al., 2008), (Zaneldin, 2006), (Kumaraswamy, 1998), (J. E. Diekmann	0.875	2

		& Girard, 1995), (O'Connor et al., 1993).		
6	Insufficient / lack communication (between parties, adjust with scenario)	(Zubair et al., 2017), (Soni et al., 2017), (Singh et al., 2017), (Barman & Charoenngam, 2017), (Hafez et al., 2016), (Dangrochiya et al., 2015), (Alnuaimi et al., 2009), (Iyer et al., 2008), (Zaneldin, 2006), (Kumaraswamy, 1998), (J. E. Diekmann & Girard, 1995), (Semple et al., 1994).	0.750	4
7	double meaning/ ambiguity in documents, Unfavorable / inadequate contract clauses/ poor documentation/ unfair distribution and allocation of risk	(Zubair et al., 2017), (Soni et al., 2017), (Barman & Charoenngam, 2017), (Hafez et al., 2016), (Divakar & Kumar, 2015), (Dangrochiya et al., 2015), (Alnuaimi et al., 2009), (Zaneldin, 2006), (J. E. Diekmann & Girard, 1995), (O'Connor et al., 1993).	0.625	6

8	Poor contracting (selection, bidding, faulty negotiations))	(Zubair et al., 2017), (Soni et al., 2017), (Singh et al., 2017), (Divakar & Kumar, 2015), (Dangrochiya et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Alnuaimi et al., 2009), (Zaneldin, 2006), (Kumaraswamy, 1998), (J. E. Diekmann & Girard, 1995), , (O'Connor et al., 1993).	0.688	5
79	Cost	(Zubair et al., 2017), (Soni et al., 2017), (Divakar & Kumar, 2015), (Dangrochiya et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Alnuaimi et al., 2009), (J. E. Diekmann & Girard, 1995), (Semple et al., 1994).	0.500	7
10	Differing Valuation of contract	(Soni et al., 2017), (Barman & Charoenngam, 2017), (Divakar & Kumar, 2015), (Dangrochiya et al., 2015), (Chaphalkar et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Alnuaimi et al., 2009), (Iyer et al., 2008).	0.500	7

11	Inflation (in material and labor cost)	(Zubair et al., 2017), (Divakar & Kumar, 2015), (Chaphalkar et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Zaneldin, 2006), (Semple et al., 1994), (O'Connor et al., 1993).	0.438	9
12	workmanship (Inadequate experience, competence, poor performance by all parties, labor skill, poor planning)	(Zubair et al., 2017), (Soni et al., 2017), (Singh et al., 2017), (Iyer et al., 2008), (Alnuaimi et al., 2009), (J. E. Diekmann & Girard, 1995), (O'Connor et al., 1993).	0.438	9
13	Motivation	(Zubair et al., 2017), (Hafez et al., 2016), (Dangrochiya et al., 2015), (Iyer et al., 2008), (Zaneldin, 2006), (J. E. Diekmann & Girard, 1995).	0.375	11
14	strategic uncertainty (negative attitude of parties, Adversarial approach in	(Zubair et al., 2017), (Singh et al., 2017), (Barman & Charoenngam, 2017), (Zaneldin, 2006), (J. E. Diekmann & Girard, 1995), (O'Connor et al., 1993).	0.375	11

	handling conflicts, owner personality)			
15	Differing interpretation (plan or specification)	(Soni et al., 2017), (Divakar & Kumar, 2015), (Dangrochiya et al., 2015), (Chaphalkar et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Alnuaimi et al., 2009).	0.375	11
16	Rework (changed spec., misinterpretations, variation)	(Chaphalkar et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Iyer et al., 2008), (J. E. Diekmann & Girard, 1995), (O'Connor et al., 1993).	0.313	15
17	Disputes and strikes	(Zubair et al., 2017), (Hafez et al., 2016), (Chaphalkar et al., 2015), (Hashem M. Mehany & Grigg, 2014), (Zaneldin, 2006).	0.225	16

2.5. System Dynamics

In 1961 J Forrester developed System Dynamics (SD) to apprehend complexity and dynamics of nonlinear complex systems using stock and flows, internal feedback, information and delays (Dangerfield, Green, & Austin, 2010). SD creates more simple, comprehensive and practical “micro worlds” of complex real-world problem. A causal loop diagram of system is developed which than evolves into Stock and flow model for computer simulation. SD breaks complex real world power into logical sub systems (Khan, Flanagan, & Lu, 2015).

SD is widely used in different area like population, ecological and economics systems, interacting strongly with each other. SD can be used to process system having two distinctive features one incorporating change over time in it and second is those incorporating feedback in it (Ogunlana, Li, & Sukhera, 2003).

SD approach has been used previously in several research studies relating to construction industry to access the performance of the construction projects (Nasirzadeh, Afshar, & Khanzadi, 2008). SD has not been used previously to develop the comprehensive model for disputes in construction project. As such the core contribution of this research is to develop the SD model catering the interrelationship between all literature identified 17 factors and impact between them.

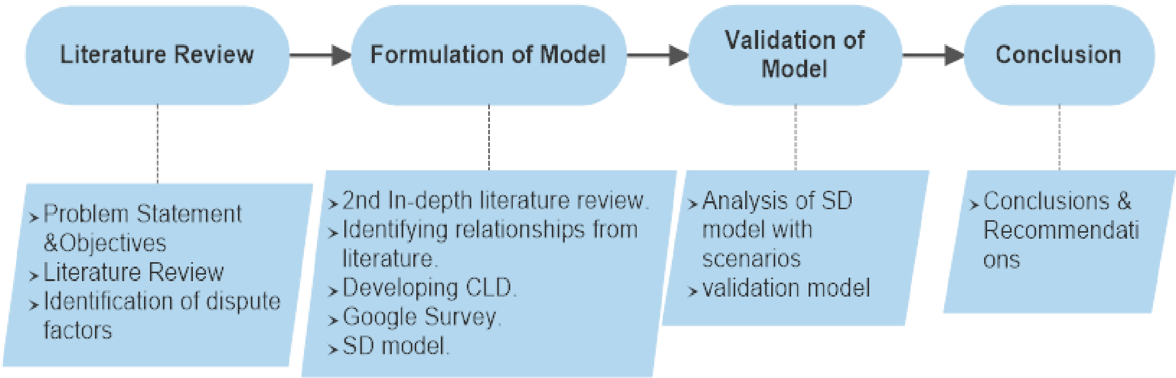
Chapter 3

REARCH METHODOLOGY

3.1. General Workflow

The main objective of this study is to develop system dynamic model for dispute prediction in construction project. Modified methodology as proposed by (Wang, Dulaimi, & Aguria, 2004) was used as shown in Figure -1

Figure 1 Research Methodology



3.2. Identifying Causal Relationship

To achieve the research objectives, second in-depth review of the literature was carried out to investigate the dependencies and influences among the identified factors causing disputes in construction project as followed by (Leon, Osman, Georgy, & Elsaid, 2017) to form the CLD. Additional factor i.e. “resolution cost” was included to make model more comprehensible (Rasul, Malik, Bakhtawar, & Thaheem, 2019) which was also validated through survey.

3.3. Data Collection and Analysis

CLD was developed using the secondary data collected from literature, to get the latest primary data, google survey was designed keeping in view the above-mentioned purpose.

Questionnaire consisting of three section was formulated using Google ™ Docs. In first section, respondent general information was collected. In second section information regarding the nature of relationship (i.e. directly proportional or inversely proportional) between two variables were collected, in third section respondent were asked to mark the impact of one variable on another on a Likert scale of 1-5 (1= least and 5=highest). In this study sample size of 96 was used as it satisfy the central limit theorem (Chan, Darko, Olanipekun, & Ameyaw, 2018) and also ensured the representation (Dillman, 2011). Local population was target in this survey having at least 01 year of experience in construction field.

3.4. **Model Development**

CLD which was developed than used to develop the stock and flow diagram using VENSIM®. Data from google survey was used to attain the quantitative score for model simulation. The focus of this research is to inspect the associative relationship between the dispute causing indices, formulation of conceptual model by embracing the CLD, and exploring the behavior through quantitative computer simulating using VENSIM®.

CLD is more of qualitative way and help in providing of dynamic situation, for in-depth quantitative analysis a stock and flow is developed from CLD (Prince Boateng, Chen, Ogunlana, & Ikediashi, 2013). Model development requires different related phases as proposed by (Sterman, 2000), the proposed model was developed by following that phases, such as formulation of causal loop diagram (CLD), transforming the CLD into stock and flow diagram, coin the qualitative and quantitate interconnection, revamp the schema and legitimize the model.

Chapter 4

Result and Discussion

4.1. Field Data

Professionals targeted in survey includes designer, contract administrator, Project Engineer, Construction managers, Project directors, Assistant managers, Planning engineers, architectures/Designer, university teachers. Highest numbers of respondents are Project engineers (18.6%) followed by Planning engineers (15.9%). Table 2 gives the insight of profile.

Table 2 Frequency Distribution of Responses

Profile		***Frequency***	***Percentage***
Total responses = 103			
Qualification	B.Tech/Diploma	1	0.9
	B.Sc/B.Engg	58	51.3
	M.Sc/M.Eng/M.Tech/P.G.Dip	49	43.3
	PhD/D.Eng	3	2.7
	Others	3	2.7
Organization type	Government	20	17.7
	Semi-Government	15	13.3

	Private	68	60.2
	NGOs	1	0.9
	University (Academia)	6	5.3
	Other	3	2.7
Field of experience	Buildings	55	48.7
	Roads and Bridges	30	26.5
	Tunnels	3	2.7
	Water Management	5	4.4
	Power Sector	6	5.2
	Metro Transit	6	5.3
	Airports and Railways	2	1.8
	Civil	2	1.8
	Others	10	9

	0 to 5 years	91	80.5
Job title	Project Manager	11	9.7
	Project Engineer	21	18.6
	Site Manager	11	9.7
	Planning Engineer	18	15.9
	Others	12	10.6
Experience	6 to 10 years	14	12.4
	11 to 15 years	4	3.5
	16 to 20 years	2	1.8
	21 years and above	2	1.8

Local population was targeted. Total 103 responses were received.

4.2. **Causal Loop Diagram**

Formulation of CLD helps in visualization of the interaction of involved variable in a system structure (Sterman, 2000). In CLD there are two types of polarities of variables with arrowhead in direction of effect. Polarities weather its positive (+) or negative (-) is represented on the arrowhead. The combined closed relationship among variables form a feedback loop (Sterman, 2000). The positive feedback loops are represented by an arrow with "+" sign, they are self-supporting, means they have high tendency for either quick ascending or descending effect on project performance. On the other hand, negative (or "balancing") reinforcement feedback loop is represented by an arrow with "-" sign, they counter any change in every cycle in a system. CLD was formed from the outcome of second in-depth synthesis of relevant published literature, development of the CLD itself is an iterative process where connection among variable were chronologically perceived through professional judgment. The CLD shown in figure 2 provide sound knowledge of system behavior and graphically depict the interdependencies of dispute causing factors in a system.

Figure 2 Causal loop diagram (CLD)

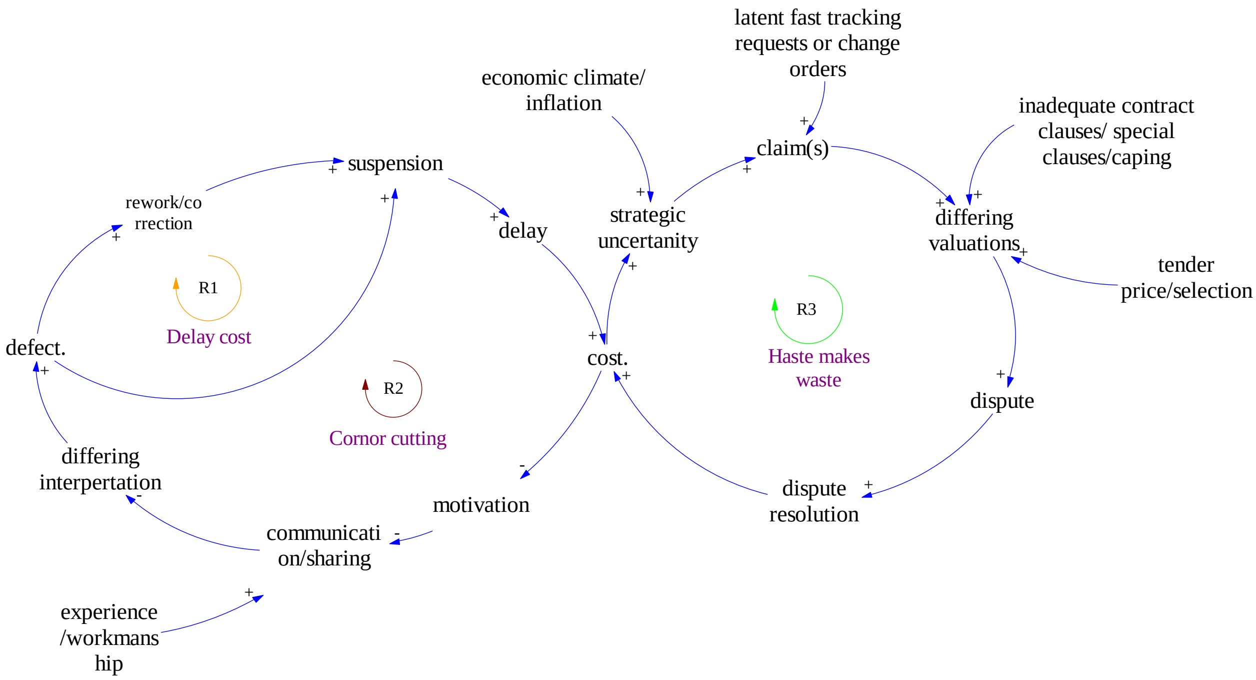


Table 3 Nature of Relationship

Impacting variable	*Impacted variable*	*Polarity (+/-)*	*Sources*
Delay	Cost	+	(P Boateng, Chen, & Ogunlana, 2012) , (Nasirzadeh et al., 2008)
Cost	Strategic uncertainty	+	(Zaneldin, 2006), (Iyer et al., 2008)
Cost	motivation	-	(Hwang, Thomas, Haas, & Caldas, 2009), (Nasirzadeh et al., 2008)
motivation	Communication/sharing	+	(Kermanshachi, Thakur, & Govan, 2018) , (Nasirzadeh et al., 2008)
Communication/sharing	Differing interpretation	-	(Ogunlana et al., 2003)

Experience	Communication/sharing	+	(Zaneldin, 2006), (Nasirzadeh et al., 2008)
Differing interpretation	Defect	+	Sammy et.al. 2011; (Barman & Charoenngam, 2017)
Defect	Rework	+	Sammy et.al. 2011(deduced); (Nasirzadeh et al., 2008), , (Nasirzadeh, Khanzadi, & Rezaie, 2014), (P. Love, Davis, London, & Jasper, 2008)
Defect	suspension	+	(Zaneldin, 2006), (Nasirzadeh et al., 2008),

Suspension	Delay	+	(Kaming, Olomolaiye, Holt, & Harris, 1997), (Nasirzadeh et al., 2014), (Nasirzadeh et al., 2008), (Chritamara, Ogunlana, & Bach, 2002)
Latent fast tracking	Claims	+	(P. Love et al., 2008)
Inflation	Strategic uncertainty	+	(P. Love et al., 2008)
Strategic uncertainty	Claims	+	(Zaneldin, 2006)
Claims	Differing valuation		(Barman & Charoenngam, 2017)
Inadequate contract	Differing valuation	+	(Barman & Charoenngam, 2017), (Zaneldin, 2006)
Differing valuation	Dispute	+	(Barman & Charoenngam, 2017)
Tender selection	Dispute		(Zaneldin, 2006)

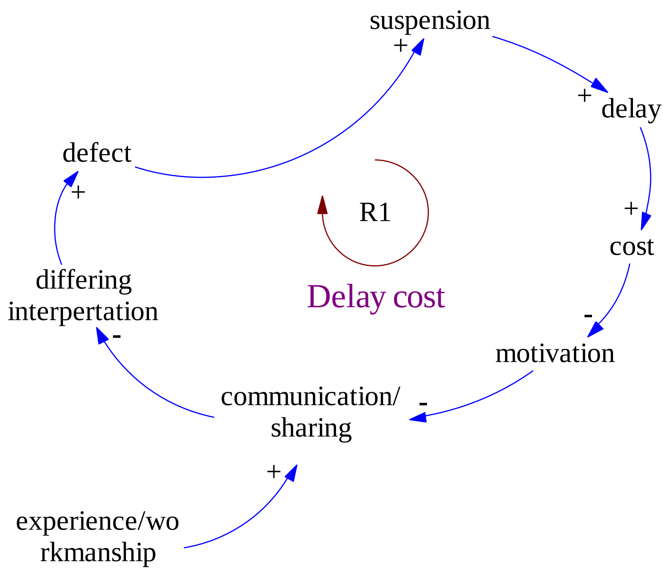
Dispute	Resolution	+	(P Boateng et al., 2012)
Resolution	Cost	+	(P Boateng et al., 2012)

The shown CLD illustrate three reinforcing loops: R1, R2 and R3. Table 3 shows the literature identified nature of relationship among dispute factors. There is no balancing loop as all the factors used in CLD are disputes causing factors in construction projects. Identified loops are discussed below.

4.2.1. Reinforcing loop R1 (delay cost)

Delay result in overrun in project time and cost (Owolabi et al., 2014). Delay can occur in sharing information, test reports, replying queries, design, payment or providing site access. On analyzing the disputes cases in a study 5 out of 18 cases were related to delay, unsuccessful in sharing information regarding design, agreement or contract among parties found out to be the core reason for delay as it results in different or overlapping commitments among parties leading to delay (Barman & Charoenngam, 2017). Delays which results in increased cost give rise to opportunistic and unfair behavior among parties against the liquidated damage clause in the agreement resulting in disagreement leading to dispute (Barman & Charoenngam, 2017).

Figure 3 Loop R1

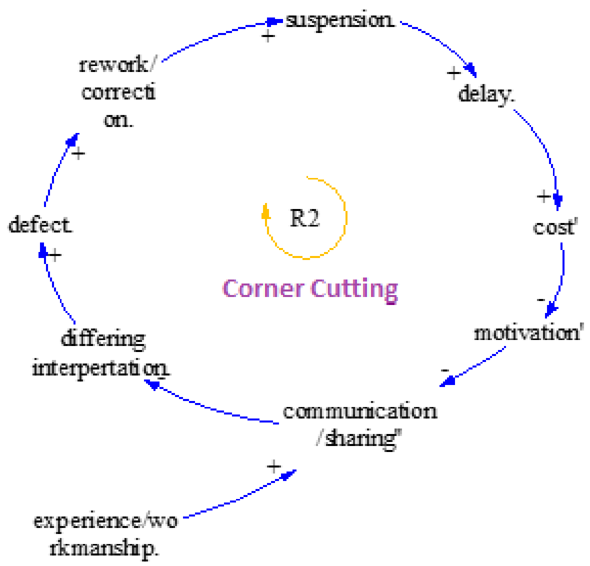


From figure 3, it is shown that delay result in increased cost. as cost increases motivation decreases and hence communication and sharing decreases. As communication and sharing decreases different interpretation increases as a result defect increases which result inn increase suspension, which than leads to delay, and so on.

4.2.2. Reinforcing loop R2 (Corner cutting)

Rework negatively influence the project performance and is considerable factor to cost and time overruns (P. E. Love, 2002). It not only effect the project performance but also demoralize the stake holders (P. E. Love, 2002). Rework arises whenever there is defect involved. Defect can occurs in design, material, specification and workmanship (Barman & Charoenngam, 2017). In a study found that 17 out 48 cases data set were involving defects and core reasons of dissent was over liability for the defect, unfair definition of capping clause, valuation claims ((Barman & Charoenngam, 2017); (Chaphalkar et al., 2015).

Figure 4 Loop R2



In most such cases It was observed that opportunistic behavior is shown in case where contract failed to clearly define the liability of the parties in defect claims.

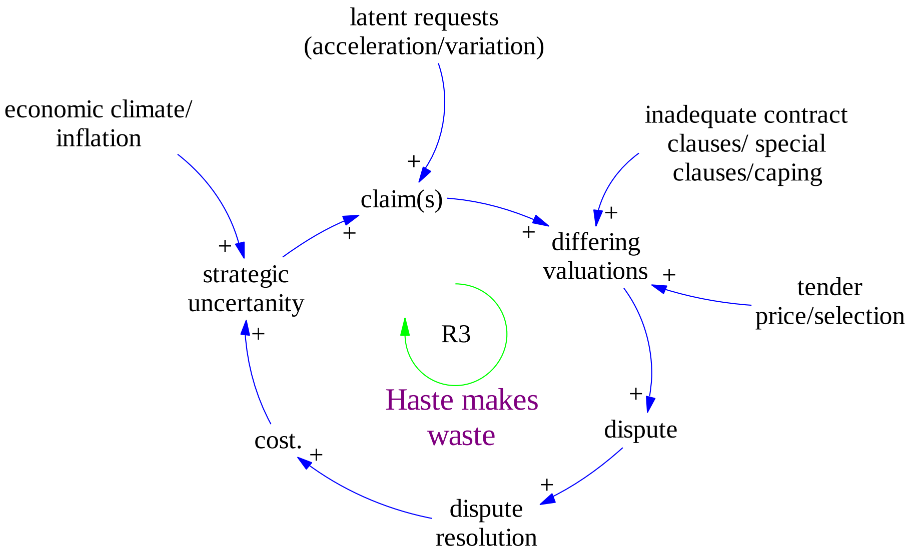
In figure 4, it is shown that delay result in increased cost. as cost increases motivation decreases and hence communication and sharing decreases. As communication and sharing decreases different interpretation increases as a result defect increases which result in increased rework, as rework increases suspension increases which than leads to delay, and cycle goes on.

During a study of 04 arbitration cases of a construction project in India (Singh et al., 2017) concluded that defect in contract regarding defining rates and in B.O.Q along with different interpretation leads to arbitration.

4.2.3. Reinforcing loop R3 (Haste makes waste)

(Manzoor Arain & Sui Pheng, 2005) shows that change orders (latent fast-tracking) results in increased overheads resulting in increased project cost and rework. Fast tracking aim for shorter construction duration but it often doesn't happened and result in increased uncertainty and cost (Fazio, Moselhi, Theberge, & Revay, 1988). Fast tracking adds in cost and time and low in quality work (Sun & Meng, 2009). Results of fast tracking induced defensive or opportunistic behavior in involved parties, where one party tries to exploit new situation in their advantage to cater their loss or maximize the profit as (Leon et al., 2017) found out that Increased cost effect the profit margins..

Figure 5 Loop R3



Also decreased in profit margin result in poor quality work as contractor tries to compensate the loss from the low quality work and thus end in rework ((Alchimie, 2004) and (P. E. Love, Davis, Chevis, & Edwards, 2010)) and this cycle continues.

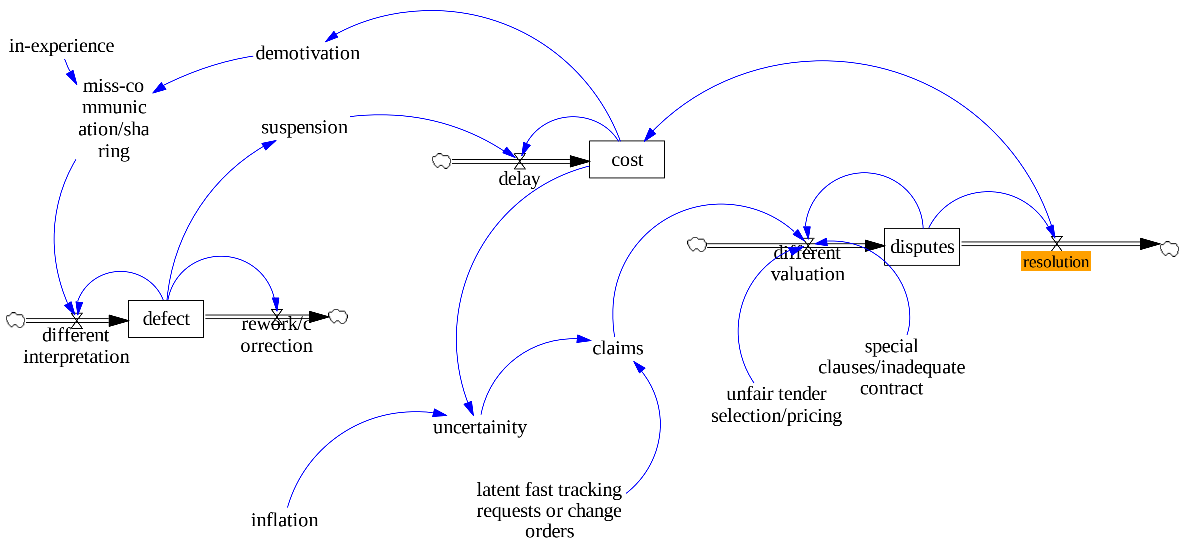
Ambiguity in contracts along with latent requests from owner results in uncertain behavior of parties and different valuations of claims which leads to arbitrations (Leon et al., 2017).

As disputes increases cost increases which than increases in strategic uncertainty and it than increases claims and the cycle goes on from figure 5, as latent request increases claims increases. With increase in claims different valuation increases which results in increased disputes. As disputes increases cost increases which than increases in strategic uncertainty and it than increases claims and the cycle goes on.

4.3. SD Model

Stock and flow uses the logic of causal loop diagrams in representing a system or problem, figure 6 shows the proposed SD model which captures the dynamics interrelationship of disputes variables in construction project (Leon et al., 2017). In the model "Inflation" act as exogenous variables whereas "defects", "cost" and "disputes" acts as stocks with "different interpretation", "rework", "delay", "different valuation" and "resolution" acts as rates with which increase and decrease in levels of stocks occurs. Result from the questionnaire were used to develop the different equations. A total 113 responses were collected with the demographic details as shown ealier.

Figure 6 System Dynamic Model (SD Model)



Normalized Mode values of the impact score obtained from survey was used in the model as it covered 25% of the data. Each CV was assigned an equation. The equation was the summation of the products of coefficient and variable of the CVs which were influencing that variable. As shown.

1. ***Different Interpretation*** *= (0.05* mis-communication + 0.05* defect) *100 ……………* ***Equation-1***

Similarly, functions for Rework, delay and different valuation were established as shown in equations 2, 3 and 4 respectively.

2. ***Rework*** *= (0.05*defects) *100 ………………………………………………………* ***Equation-2***
3. ***Delay*** *= (0.05* suspension + 0.05* cost) *100 ………………………………* ***Equation-3***
4. ***Different-valuation****= ((0.4 * claims) + (0.05* inadequate-contract) + (0.04 * unfair tender selection) + (0.05*disputes)) *100……………………………………………………………………………………* ***Equation-4***

4.4. Simulation Results and Discussion

The proposed model was simulated under different scenarios to better understand the dispute behavior in construction project, over the time period of 24 months.

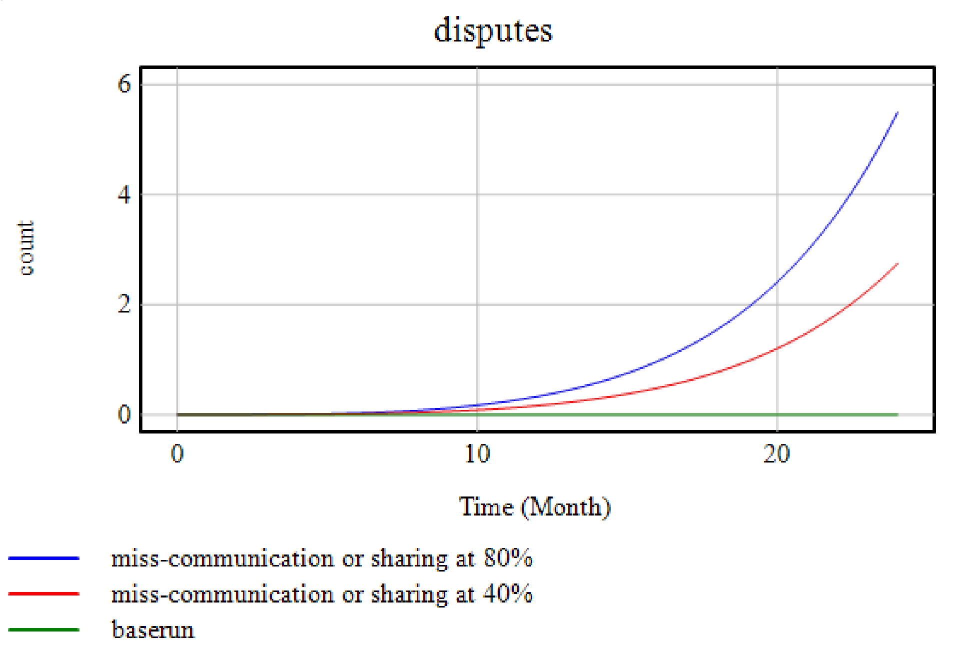
4.4.1. Scenario-1: Miss-communication or sharing

Under scenario-01, simulations for the effect of "miss-communication or sharing" on "disputes" in construction projects was done. Figure shows simulations at 40% and 80% of "mis-communication or sharing".

From below figure 7, logic is clearly conserved, as disputes start to occurs after some time of project into execution i.e 6 to 7 months into execution. Maximum value of 7 disputes is obtained when "mis-communication or sharing" is increased to 80%. The behavior of disputes is close to the case study presented in paper (Singh et al., 2017).

Many studies have pointed out that delay in communicating or sharing of important information related to other contract between parties, future endeavor and design give rise to ambiguities which results in defects and afterward leads to disputes due to disagreement or opportunistic behavior displayed by the involved parties ((Iyer et al., 2008), (Barman & Charoenngam, 2017) and (Singh et al., 2017)).

Figure 7 Scenario 01

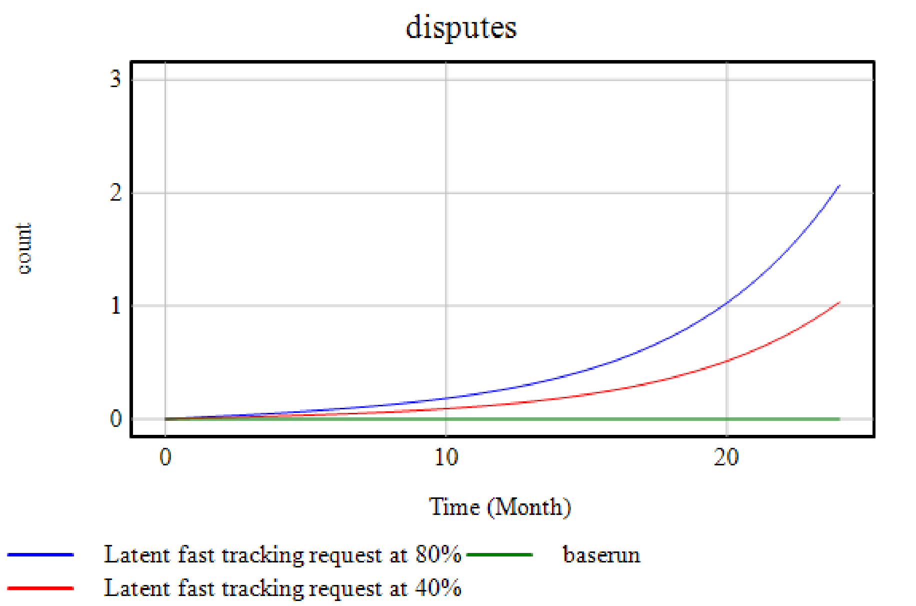


4.4.2. Scenario 2: Latent fast-tracking request or change orders

From figure 9, effect of "latent fast-tracking request or change orders" was simulated and we get maximum 2 numbers of disputes at 80% of the value. It was also logical to note that disputes occur after some time into project execution i.e 3 to 4 months.

The increased in cost lower the profit and induced the opportunistic behavior in the parties leading to different interpretations of work or orders and hence leads to disputes ((Iyer et al., 2008) and (Singh et al., 2017).

Figure 8 Scenario 02

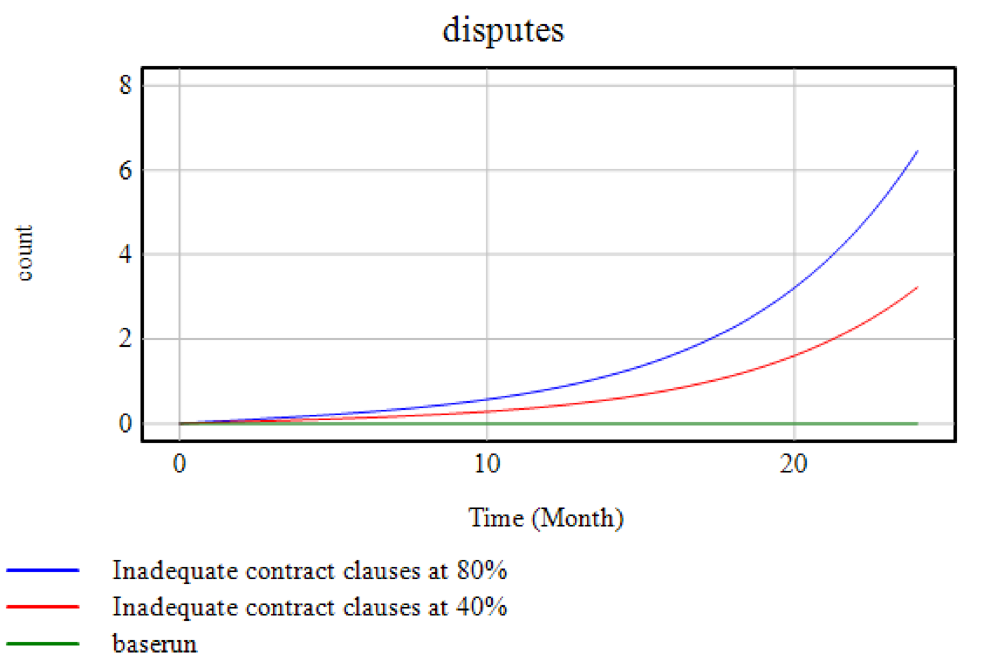


4.4.3. Scenario 3: Inadequate contract clauses

Simulation result at 40% and 80% values of "Inadequate contract clauses" for "disputes" behavior in construction project is shown in figure 9.

Ambiguous or inadequate clauses of contract form the basis of disputes. During construction, situations arises where there is need to determine the liability for the loss or need for adjustment (or calculation) of payment due to the change orders or latent requests from the owner needs to be done, in such scenario if contract is ambiguous or had special clauses in it than it will cause the different interpretations and different-valuations along with opportunistic behavior leads to disputes ((Barman & Charoenngam, 2017) and (Singh et al., 2017)).

Figure 9 Scenario 03



4.5. **Model Validation**

The model soundness depends on for which it is intended (Sterman, 2000). Many modelers made efforts to cornerstone the prior published data not considering the at hand assumptions, sensitivity of results and model boundary. Model testing should be able to unveil error so that intended user can improve it and use it for critical decisions making (Sterman, 2000). Plausibility and vindication of model is difficult because all models are simplified form of real world (Sterman, 2000).

The paramount purpose of the model in discussion is to quantify construction disputes. Proposed underline test verifies the structural validity of SD model (Qudrat-Ullah & Seong, 2010).

4.5.1. Boundary-adequacy test

This test serves three purposes as listed by (Sterman, 2000); first, if the response of the model change significantly if boundary assumptions are relaxed. Second, whether all the important concepts in the model are endogenous. Third, if policy recommendation changes when model boundary is extended.

After closely observing the variables in our SD model, all variables are vital as all are identified and verified through literature and survey respectively. All variables are endogenous except one which is “inflation”.

4.5.2. Structure verification test

This step of validation is of immense significance and the aim is to check whether the model structure is consistent with relevant descriptive knowledge used in the model. The developed CLD depends on variables identified from the literature and then field professionals provided with the influencing interrelations amongst all variables. Therefore, the model structure is logical and closely represents the actual system in the industry. This is in line with the methodology followed by (Qudrat-Ullah & Seong, 2010).

4.5.3. Parameter verification

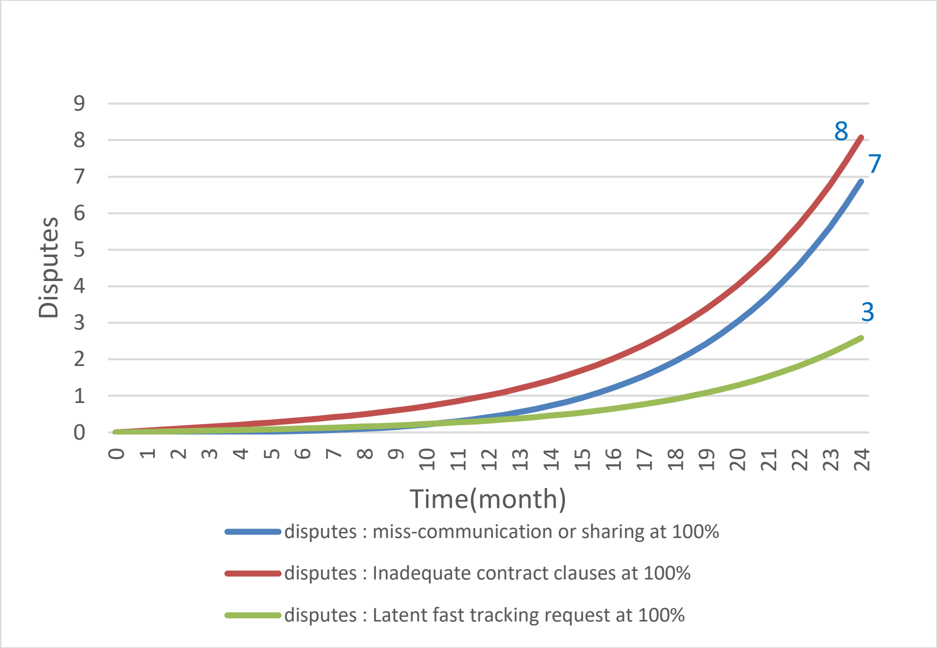
The mathematical functions developed to link the variables are based on responses from field experts that ensure empirical and theoretical foundations. Further, the developed simulation scenarios confirm that the model exhibits result which are relatable to previous studies (Han, Lee, & Peña-Mora, 2011).

4.5.4. Extreme condition test

The purpose of this test is to check if each equation makes sense when extreme values are used as input and if meaningful results are achieved at extreme condition without simulation failure or error (Sterman, 2000). Simulation scenarios developed in the above section explains that even

when the values for constants are increased to 90%, still the results are meaningful, they still do if they are given initial value of 100%. Shown in figure 10.

Figure 10 Model behaviour under extreme conditions



4.5.5. Model behavior verification test.

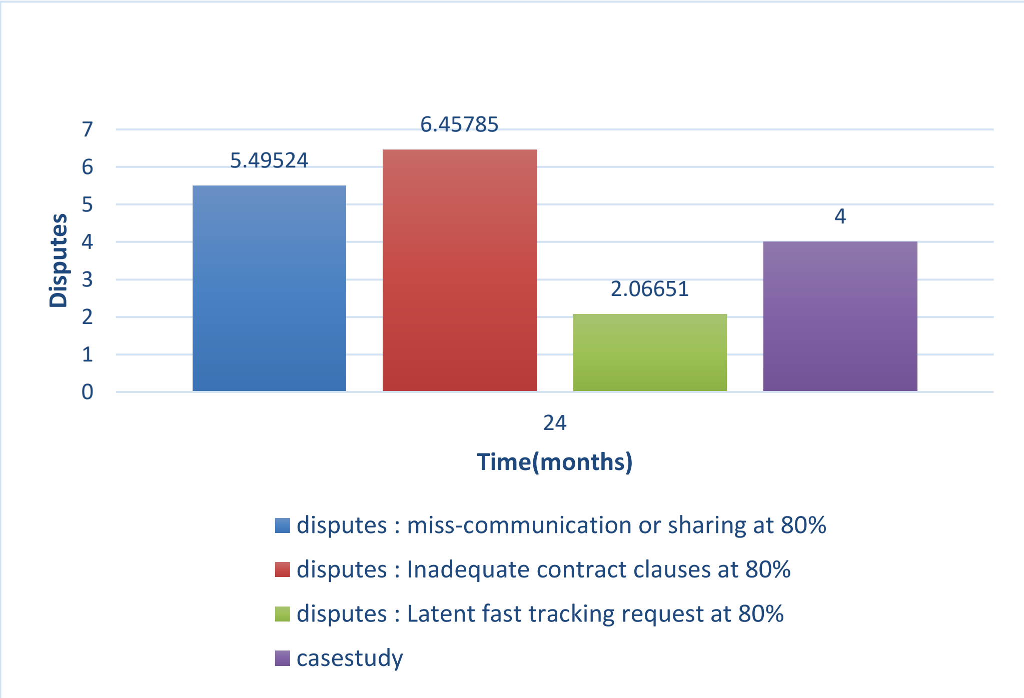
Apart from the four structural verification tests, the model behavior verification test is employed

to compare the simulation results with actual data. Since primary data is not available due to privacy concerns we have used secondary data in the form of a case study from literature to observe the model behavior in dispute prediction, when we put maximum values against the above mentioned scenarios our model generates the disputes between 2 to 9 as shown in figure 10, this trend is close to our selected case study as it experienced 04 disputes cases (Singh et al., 2017). The current model stands valid to address the defined objectives of this study.

4.5.6. Validation through case study

Case study was taken from the published paper (Singh et al., 2017), case-study is an Indian highway construction project of the duration of 30 month. During the project 04 disputes cases were filed to AT (Arbitral Tribunal) for adjudication. Comparison of model output (for different scenarios) at 80% of the values was shown in figure 11. It is clear from the figure that our model gives the outcome (behavior) is very close to the real system.

Figure 11 Comparison with case study



Chapter 5

Conclusion and Recommendation

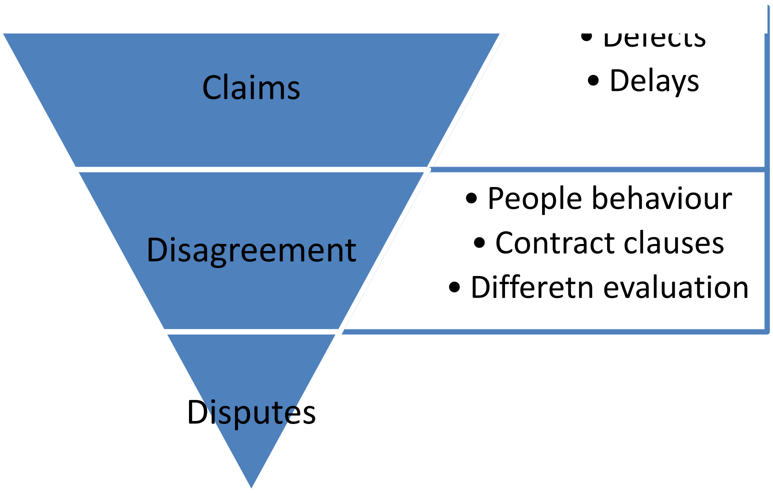
5.1. Conclusion

The proposed SD model reflects a complex interacting system where three loops provide an insight into mechanisms that generates disputes during construction project. Construction defects, rework, delays, miscommunication, different interpretations, cost overrun, latent fast-tracking requests, inadequate contract clauses and opportunistic behavior are the most critical dispute causing factors in various loops. Loops do not behave as independent cycles, but they interact with each other to transfer impact. After the identifying the top influential dispute factors and establishing the interconnections between their constituent variables, a system dynamics model was developed which was simulated under three different scenarios. The results show that dispute start arising after 07-08 month after the project into execution and after 20th months into execution, the disputes trend changes abruptly. Also, the model was validated with a case study which confirm the authenticity of the model. This complex interaction as illustrated in SD model negates linear assessment of disputes in construction projects as usually practiced by involved parties

5.2. Recommendation

The construction industry in developing countries is still struggling with disputes. The developed model help provides a more logical and quantifiable way to perceive disputes for improved project management practice in emerging economies and increasing project success rate. In figure 12 developed dispute propagation in a construction project is shown

Figure 12 Dispute propagation in projects



In good construction projects “No Injury” policy is practice for HSE environment. Similarly, during construction similar policy “No dispute” should be incorporated for achieving successful projects. Following points are proposed for toward exercising “no dispute” policy. With respect to dispute avoidance and resolution, the basic maxim which is frequently expressed is, that ‘prevention is better than cure’.

5.2.1. Early Involvement of Stake holders (ESH)

In a traditional form of contract designers produce a detailed design that is sent out to tender for a suitable contractor. This method may not always lead to the optimum end-product in terms of design, buildability (constructability) and commissioning. Issues raised at the construction stage will often result in significant delays and associated costs while designs are review accordingly and thus increase the potential for disputation. One should try for early involvement of the involved parties in contract especially contractor as soon as possible to minimize the miscommunication and different interpretations.

5.2.2. 'Partnering' for Improved Working Relationship

creating a non-adversarial culture between the various stakeholders is very import to project success. 'partnering is a process for improving relationships among those involved on a construction project to the benefit of all' (Wales, 1995). Partnering attempts to establish working relationships among stakeholders through a mutually developed formal strategy of commitment and communication. 'It attempts to create an environment where trust and teamwork prevent disputes to everyone's benefit and facilitate the completion of a successful project' (Stevens, 1993).

Previous studies and proposed model strongly pointed out that defects (whether it is in work, material, design or process etc.) leads to cost and time overrun thus stimulate the strategic uncertainty (opportunistic behavior) between the parties, as everyone tries to get maximum out of the situation hence leading the situation toward disagreement and to dispute. Hence good working environment is the need for the project success.

5.2.3. Adopting the Concept of Lean Construction

Every person involved in the lean construction project, from the constructors, architects, designers to the savvy owners, is taken into consideration for ensuring that the construction project is of high quality, delivered faster, and less costly. However it is also now widely recognized that lean construction and lean production cannot be achieved by an individual organization and that it is supported by a systematic and structured approach to the management of inter-firm relationships; that is the supply chain (London, 2004).

From literature review and SD model it is observed that delay (whether in of payment, site access, design, reports and approvals or in reply) is also among critical factors to disputes. Hence 'lean construction practices' proved to be vital in overcoming this problem.

5.2.4. Risk Allocation and Contract Drafting

Proper contract is the key to successful project completion. During studying of arbitration cases from published research it was noticed that most cases were due to the faulty or ambiguous allocation of risks in the contact (Barman & Charoenngam, 2017). Also, special or ambiguous clauses in contract were also the main cause of arbitration due to the differing evaluation by the dispute parties. One should clearly read and remove all ambiguities before signing the contract.

5.2.5. Documentation and Record

Documentation of every instruction or change order is very important. Many of the dispute cases were due to the 'oral change orders' by the owner etc. Therefore, documentation and record must be maintained.

Final words, all the proposed approaches have a recurring theme of creating an environment which encourages good communications and good relationships between the project stakeholders which in turn should have the effect of avoiding or minimizing the impact of disputes.

5.3. Limitations

It is recognized that construction projects contain several disputes causing factors, whereas the SD model is only based upon top 18 dispute factors which reduce the coverage of model. However, it must be acknowledged that many variables in dynamic systems would form thousands of loops which will make the model complex to understand. Also, numerous meaningless and repetitive loops carrying low impact compromise the integrity of the model. Therefore, the most critical factors were selected.

However, qualitative or quantitative models on their own do not provide operational support and specific advice to project manager. Instead, they facilitate decision making process by increasing the perception of interdependencies and behavior of complex systems. The model must be used in collaboration with case-based or expert systems to provide comprehensive predictive advice to project team.

Future Research: (Doloi et al., 2012) pointed out the same gap for delay in construction projects as in term of identification causal relationship factors and predicting their delay

Reference

Acharya, N. K., Dai Lee, Y., & Man Im, H. (2006). Conflicting factors in construction projects: Korean perspective. *Engineering, Construction and Architectural Management, 13*(6), 543-566.

Alchimie, P. (2004). Target outturn cost: Demonstrating and ensuring value for money.

Alnuaimi, A. S., Taha, R. A., Al Mohsin, M., & Al-Harthi, A. S. (2009). Causes, effects, benefits, and remedies of change orders on public construction projects in Oman. *Journal of construction engineering and management, 136*(5), 615-622.

Arditi, D., & Pulket, T. (2005). Predicting the outcome of construction litigation using boosted decision trees. *Journal of Computing in Civil Engineering, 19*(4), 387-393.

Barman, A., & Charoenngam, C. (2017). Decisional Uncertainties in Construction Projects as a Cause of Disputes and Their Formal Legal Interpretation by the Courts: Review of Legal Cases in the United Kingdom. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 9*(3), 04517011.

Boateng, P., Chen, Z., & Ogunlana, S. (2012). A conceptual system dynamic model to describe the impacts of critical weather conditions in megaproject construction. *Journal of Construction Project Management and Innovation, 2*(1), 208-224.

Boateng, P., Chen, Z., Ogunlana, S., & Ikediashi, D. (2013). A system dynamics approach to risks description in megaprojects development. *Organization, technology & management in construction: an international journal, 4*(Special Issue), 0-0.

Cakmak, E., & Cakmak, P. I. (2014). An analysis of causes of disputes in the construction industry using analytical network process. *Procedia-Social and Behavioral Sciences, 109*, 183-187.

Carmichael, D. G. (2002). *Disputes and international projects*: CRC Press.

Chan, A. P. C., Darko, A., Olanipekun, A. O., & Ameyaw, E. E. (2018). Critical barriers to green building technologies adoption in developing countries: The case of Ghana. *Journal of cleaner production, 172*, 1067-1079.

Chaphalkar, N., Iyer, K., & Patil, S. K. (2015). Prediction of outcome of construction dispute claims using multilayer perceptron neural network model. *International Journal of Project Management, 33*(8), 1827-1835.

Cheung, S.-O., Suen, H. C., & Lam, T.-I. (2002). Fundamentals of alternative dispute resolution processes in construction. *Journal of construction engineering and management, 128*(5), 409-417.

Cheung, S. O., & Yiu, K. T. (2007). A study of construction mediator tactics—Part I: Taxonomies of dispute sources, mediator tactics and mediation outcomes. *Building and environment, 42*(2), 752-761.

Chritamara, S., Ogunlana, S. O., & Bach, N. (2002). System dynamics modeling of design and build construction projects. *Construction Innovation, 2*(4), 269-295.

Dangerfield, B., Green, S., & Austin, S. (2010). Understanding construction competitiveness: the contribution of system dynamics. *Construction Innovation, 10*(4), 408-420.

Dangrochiya, N., Rathod, H., & Sharma, N. (2015). A REVIEW ON CAUSES OF DISPUTES IN CONSTRUCTION INDUSTRY. *IJARESM, 1*(4). Retrieved from http://www.ijaresm.net/volume-1Issue-4.aspx

Diekmann, J., Girard, M., & Abdul-Hadi, N. (1994). Disputes potential index: a study into the predictability of contract disputes, Construction Industry Institute, Source Document 101 [09] Dispute Causation In Construction Projects, Manvendra Sinha 1, Dr. *AS Wayal, 2*.

Diekmann, J. E., & Girard, M. J. (1995). Are contract disputes predictable? *Journal of construction engineering and management, 121*(4), 355-363.

Dillman, D. A. (2011). *Mail and Internet surveys: The tailored design method--2007 Update with new Internet, visual, and mixed-mode guide*: John Wiley & Sons.

Divakar, D. K., & Kumar, S. S. (2015). Study on Sources of Disputes in Construction Projects, to Incorporate

Suitable Clauses in Contract for Dispute Resolutions. *International Research Journal of Engineering and Technology (IRJET), 02* (01), 5. Retrieved from https://www.irjet.net/archives/V2/i1/Irjet-v2i182.pdf

Doloi, H., Sawhney, A., Iyer, K., & Rentala, S. (2012). Analysing factors affecting delays in Indian construction projects. *International Journal of Project Management, 30*(4), 479-489.

Fazio, P., Moselhi, O., Theberge, P., & Revay, S. (1988). Design impact of construction fast-track. *Construction Management and Economics, 6*(3), 195-208.

Fenn, P. (2007). Predicting construction disputes: an aetiological approach. *Proceedings of the Institution of Civil Engineers-Management, Procurement and Law, 160*(2), 69-73.

Fenn, P., Lowe, D., & Speck, C. (1997). Conflict and dispute in construction. *Construction Management & Economics, 15*(6), 513-518.

Gibbons, M. (2007). A review of employment dispute resolution in Great Britain. *London: DTI*.

Hafez, S. M., Aziz, R. F., & Elgayar, M. B. (2016). TIME DELAY DISPUTES IN CONSTRUCTION INDUSTRY AND PREDICTION

MODEL. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY TIME DELAY DISPUTES IN CONSTRUCTION INDUSTRY AND PREDICTION MODEL, 5*(8). doi:10.5281/zenodo.59951

Hall, J. (2002). Ineffective communication: Common causes of construction disputes. *Alliance's advisory council legal notes, 13*(2).

Han, S., Lee, S., & Peña-Mora, F. (2011). Identification and quantification of non-value-adding effort from errors and changes in design and construction projects. *Journal of construction engineering and management, 138*(1), 98-109.

Hashem M. Mehany, M. S., & Grigg, N. (2014). Causes of road and bridge construction claims: Analysis of Colorado department of transportation projects. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, 7*(2), 04514006.

Hwang, B.-G., Thomas, S. R., Haas, C. T., & Caldas, C. H. (2009). Measuring the impact of rework on construction cost performance. *Journal of construction engineering and management, 135*(3), 187-198.

Ilter, D. (2012). Identification of the relations between dispute factors and dispute categories in construction projects. *International Journal of Law in the Built Environment, 4*(1), 45-59.

Iyer, K., Chaphalkar, N., & Joshi, G. (2008). Understanding time delay disputes in construction contracts. *International Journal of Project Management, 26*(2), 174-184.

Kaming, P. F., Olomolaiye, P. O., Holt, G. D., & Harris, F. C. (1997). Factors influencing construction time and cost overruns on high-rise projects in Indonesia. *Construction Management & Economics, 15*(1), 83-94.

Kermanshachi, S., Thakur, R., & Govan, P. (2018). *Discovering the Impact of Late Change Orders and Rework on Labor Productivity: A Water Treatment Case Study Analysis Using System Dynamics Modeling.* Paper presented at the Proceedings of Construction Research Congress.

Khan, K. I. A., Flanagan, R., & Lu, S.-L. (2015). Managing the complexity of information flow for construction small and medium-sized enterprises (CSMEs) using system dynamics and collaborative technologies.

Kumaraswamy, M. M. (1998). Consequences of construction conflict: A Hong Kong perspective. *Journal of Management in Engineering, 14*(3), 66-74.

Leon, H., Osman, H., Georgy, M., & Elsaid, M. (2017). System dynamics approach for forecasting performance of construction projects. *Journal of Management in Engineering, 34*(1), 04017049.

London, K. (2004). *Construction supply chain procurement modelling.*

Love, P., Davis, P., Ellis, J., & On Cheung, S. (2010). Dispute causation: identification of pathogenic influences in construction. *Engineering, Construction and Architectural Management, 17*(4), 404-423.

Love, P., Davis, P., London, K., & Jasper, T. (2008). *Causal modelling of construction disputes.* Paper presented at the Proceedings of the 24th Annual Conference of ARCOM (Association of Researchers in Construction Management).

Love, P. E. (2002). Auditing the indirect consequences of rework in construction: a case based approach. *Managerial auditing journal, 17*(3), 138-146.

Love, P. E., Davis, P. R., Chevis, R., & Edwards, D. J. (2010). Risk/reward compensation model for civil engineering infrastructure alliance projects. *Journal of construction engineering and management, 137*(2), 127-136.

Manzoor Arain, F., & Sui Pheng, L. (2005). The potential effects of variation orders on institutional building projects. *Facilities, 23*(11/12), 496-510.

Maqsoom, A., Charoenngam, C., Masood, R., & Awais, M. (2014). Foreign market entry considerations of emerging economy firms: An example of Pakistani contractors. *Procedia Engineering, 77*, 222-228.

Merriam-Webster, I. (1996). *Merriam-Webster's Dictionary of Law*: Merriam-Webster.

Nasirzadeh, F., Afshar, A., & Khanzadi, M. (2008). System dynamics approach for construction risk analysis. *international journal of civil engineering, 6*(2), 120-131.

Nasirzadeh, F., Khanzadi, M., & Rezaie, M. (2014). Dynamic modeling of the quantitative risk allocation in construction projects. *International Journal of Project Management, 32*(3), 442-451.

O'Connor, J. T., Chmaytelli, A., & Hugo, F. (1993). Analysis of highway project construction claims. *Journal of performance of constructed facilities, 7*(3), 170-180.

Ogunlana, S. O., Li, H., & Sukhera, F. A. (2003). System dynamics approach to exploring performance enhancement in a construction organization. *Journal of construction engineering and management, 129*(5), 528-536.

Owolabi, J., Amusan, L., Oloke, C. O., Olusanya, O., Tunji-Olayeni, P., Dele, O., . . . Omuh, I. (2014). Causes and effect of delay on project construction delivery time. *International Journal of Education and Research, 2*(4), 197-208.

Qudrat-Ullah, H., & Seong, B. S. (2010). How to do structural validity of a system dynamics type simulation model: The case of an energy policy model. *Energy policy, 38*(5), 2216-2224.

Rasul, N., Malik, M. S. A., Bakhtawar, B., & Thaheem, M. J. (2019). Risk assessment of fast-track projects: a systems-based approach. *International Journal of Construction Management*, 1-16.

Semple, C., Hartman, F. T., & Jergeas, G. (1994). Construction claims and disputes: causes and cost/time overruns. *Journal of construction engineering and management, 120*(4), 785-795.

Shin, K.-C. (2000). *Identification of Critical Dispute Characteristics(CDCs) during construction project operations.* School of Civil and Environmental Engineering, Georgia Institute of Technology.

Singh, T. A., Chotai, D., Verma, P., RIZVI, A., & PAI, S. K. (2017). STUDY ON CONTRACTUAL CLAIMS AND STAKEHOLDER'S DISPUTE LEADING TO

ARBITRATION IN CONSTRUCTION INDUSTRY. *Business Sciences International Research Journal, Vol 5*(Issue 1). doi:ISSN 2321 - 3191

Soni, S., Pandey, M., & Agrawal, S. (2017). EVALUATION OF FACTORS CAUSING CONFLICTS & DISPUTE IN CONSTRUCTION PROJECTS BY AHP & IMPI METHOD.

Sterman, J. D. J. D. (2000). *Business dynamics: systems thinking and modeling for a complex world*.

Stevens, D. (1993). Partnering and value management. *The Australian Institute of Quantity Surveyors Journal*, *The Building Economist*, 5-7.

Sun, M., & Meng, X. (2009). Taxonomy for change causes and effects in construction projects. *International Journal of Project Management, 27*(6), 560-572.

Wales, N. S. (1995). Department of Public Works and Services. *Sydney: Government of New South Wales: Capital Project Procurement Manual*.

Wang, S. Q., Dulaimi, M. F., & Aguria, M. Y. (2004). Risk management framework for construction projects in developing countries. *Construction Management and Economics, 22*(3), 237-252.

Zaneldin, E. K. (2006). Construction claims in United Arab Emirates: Types, causes, and frequency. *International Journal of Project Management, 24*(5), 453-459.

Zubair, M. U., Gabriel, H. F., & Thaheem, M. J. (2017). Comparison between Causes of Disputes in the Published Literature and the Construction Industry of Pakistan. *Studies, 6*(1).