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Investigation of Conflict Impacts on Engineering, Procurement, and Construction Schedule Performance

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Abstract: Most construction projects are subject to disagreements among the primary stakeholders (owners, engineers/designers, and contractors) which, if not addressed and resolved in a timely manner, become very time consuming and costly. Although these conflicts and disagreements have the potential to adversely affect project schedule performance and success, their undesired consequences rarely have been studied. Therefore, the aim of this study was to investigate the impact of the primary stakeholders' internal and external conflicts on engineering, procurement, and construction (EPC) schedule performance. To achieve this objective, potential conflict scenarios were initially defined. Then, data associated with 30 completed case studies of construction projects was collected and analyzed. Two-sample *t*-test statistical tests were utilized to assess the impact of various potential conflict scenarios on project schedule performance. Next, Cohen's d method was utilized to measure the weights associated with each of the identified scenarios. It was concluded from the results that *internal conflicts among contractors* and *external conflicts between designers and contractors* have a significant impact on schedule performance associated with the engineering, procurement, and construction phases. Additionally, the results revealed that conflicts within contractor entities seriously affect the design and procurement schedule performance. This study will assist project managers in effectively allocating resources, based on their impact on schedule performance throughout the project. The findings of this study will also provide guidance to project decision makers, helping them proactively plan how to effectively address disagreements at the early stages of their lifecycle.

1 INTRODUCTION

In every construction project, primary and secondary stakeholders at different levels and with different responsibilities must communicate with each other. While effective communication works as a lubricant for the project process and expedites steps and tasks, ineffective communication acts against the normal project flow and decreases the pace of a project (Kamalirad and Kermanshachi, 2018; Nipa et al. 2019). Ineffective communication may cause misunderstandings and lead to eventual conflicts among stakeholders. Therefore, conflicts are expected to arise when at least two of the participants in a project can not agree (Kamalirad et al. 2017).

Although stakeholders' conflicts can hinder the progress of civil and other engineering projects, and have a serious impact on EPC schedule performance, the phase-based impact of project conflicts on schedule performance rarely has been studied or analyzed. Therefore, the aim of this study was to investigate and analyze the conflict emergence and process in the lifetime of construction projects. The following sub-objectives were formulated to achieve these goals: (1) define all potential conflict scenarios that occur among primary stakeholders; (2) determine significant conflict scenarios that affect schedule performance; and (3) classify the conflict scenarios, based on the size of the resulting impact. Since this study analyzes and quantifies conflicts based on their impact on schedule performance, its findings can help to improve the quality of communication and project schedule performance. In other words, the outcome of this paper

will significantly help practitioners manage project conflicts by either controlling the extent of their impact or by preventing their occurrence.

2 LITERATURE REVIEW

The construction industry is a project-based industry, in which many individuals, teams, and organizations come together to build a project and disband once the project is finished (Dainty et al. 2006). Accordingly, Leung and Ricky Yee-Kwong (2003) explained that effective communication is one of the critical success factors for a construction project, and differences among project managers' perspectives produce conflict. Lee et al. (2017) claimed that as construction projects consist of various issues, environments, and stakeholder parties, they are inherently complex; the root causes of conflicts differ widely; and no uniform causes/ consequences exist. Ilies et al. (2011) defined conflict as a negative experience that is accompanied by aggressive and controversial behavior during the exchange of knowledge and information pertaining to different aspects and perspectives. De Wit et al. (2012) explained conflict as the process emerging from perceived incompatibilities or differences between team members and/or stakeholder parties. Takim (2009) believed that one of the important causes of conflict throughout the execution of a construction project is the differences in stakeholder positions. In 2016, Anicich et al. stated that conflicts in organizations are commonly perceived as relational friction, due to different aspects and perspectives, opinions, or personal grudges and dislike among team members. Through a comprehensive literature review, it was found that project conflicts and their associated impacts have been defined in a myriad of ways by researchers, and have evolved over the last decades, as depicted in Table 1.

Table 1. Conflict Definitions and Main Findings in Literature

No	Authors (Year)	Conflict Definition
1	Robert Dubin (1957)	Conflict is an inevitable component of interactions between two parties.
2	Boulding (1962)	Conflict is a situation where the parties wish to occupy a potential future position that is not compatible with the wishes of the other parties, and the involved parties are aware of that incompatibility.
3	Louis R. Pondy (1967)	Conflict is an adversarial behavior due to either limited resources or stress, tension, hostility, and/or anxiety
4	Louis R. Pondy (1967)	Conflict must be considered as a dynamic process consisting of several disagreement episodes among individuals in an organization.
5	Amason et al. (1994)	Conflict forms when team members have different expectations regarding tasks.
6	Cheng et al. (2000)	Conflict refers to having incompatible goals and expectations.
7	Leung et al. (2002)	Conflict means not giving proper importance to the expertise of the contributors during decision making
8	Chen et al. (2005)	It's a ubiquitous phenomenon when two or more groups work together. When there is a difference in context that the groups propose, then conflict occurs
9	Dean Tjosvold (2006)	It can be agreed that conflict is a result of opposing interests while establishing divergent goals, but this definition hampers the constructive side of the conflict.
10	Ellen Lau. (2011)	Conflict is a relationship which contains trust and distrust at the same time.

Narayanan et al. (1999) noted that conflict is one of the occupational job stressors that is strongly connected to a reduction in project performance (Brockman's 2014; Habibi et al. 2019; Safapour et al. 2019). If conflict in a construction project is not controlled and managed appropriately, it can escalate, and result in unfavorable outcomes, such as schedule delays, cost overruns, and quality defects (Leung et al. 2005; Kermanshachi and Safapour 2019). Park and Jung (2015) claimed that in Korean construction projects,

conflicts have resulted in average delays of 3.6 years and cost increases of 290%. Several strategies, best practices, and collaborative delivery methods (e.g. Integrated Project Delivery) could be used to improve the quality of working relationships among construction participants and prevent the emergence of potential conflicts and disputes in the projects (Kermanshachi, 2010).

In summary, a conflict, in this paper, is defined as an inevitable and dynamic event that happens when there is disagreement among stakeholders. In an effort to decrease the cost of delays in engineering projects, this study focuses on the relationship between conflicts and the resulting effects on a project schedule.

3 RESEARCH METHODOLOGY

A five-step research methodology was developed and implemented to achieve the above-mentioned goals of this study. The process of this study's methodology and its steps are presented in Figure 1. In the first step, a comprehensive literature review was conducted to define the research objectives, and the various conflict scenarios were defined. Then, case study projects were collected through the data collection process.

Figure 1. Research Methodology Framework.

Preliminary data analyses were conducted in step 3. In the fourth step, according to the type of data, two-sample t-test tests were conducted as statistical data analyses to determine significant conflict scenarios in schedule performance. Finally, the results were obtained and discussed.

4 DEFINITION OF CONFLICT SCENARIOS

Stakeholders are expected to cooperate with each other and work towards common goals and shared benefits in every project. As primary stakeholders (owners, designers, and contractors) have a significant role in the ultimate outcome of a project, their interactions, specifically in a conflictual situation, have a vital impact on the project schedule performance (Amason et al., 1994; Habibi et al. 2018a and 2018b; Safapour et al. 2018). A conflict can also occur within a stakeholder entity (e.g., owners) or between two or more participating organizations (e.g., designers and contractors). Therefore, the potential and probable conflict scenarios within and between primary stakeholders are defined and visualized, as described in Figure 2.

A project involves teamwork because it requires a variety of individuals with different skills and areas of knowledge who are working toward the common goal of a successful project. The effective communication of the three major stakeholders can help ensure the success of the project (Safapour and Kermanshachi 2019). Conversely, any difficulties in their communication may lead to misunderstandings and may jeopardize the success of the project (Safapour et al. 2019). For the purpose of this study, we assumed that the three primary stakeholders had the same level of authority in controlling the disagreements, although, their conflicts in different phases and situations may have had different levels of impact on the project.

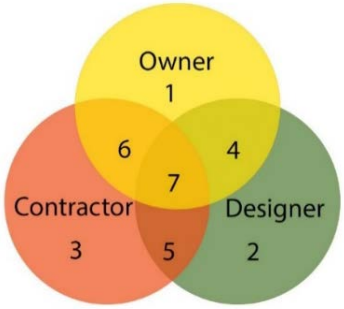
Potential Conflict Scenarios	Graphical Representation of Conflict Scenarios
Internal Conflicts	
Scenario 1: Conflict between Owners (O)	
Scenario 2: Conflict between Designers (D)	
Scenario 3: Conflict between Contractors (C)	
External Conflicts	
Scenario 4: Conflict between Owners & Designers (O&D)	
Scenario 5: Conflict between Contractors & Designers (C&D)	
Scenario 6: Conflict between Owners & Contractors (O&C)	
Scenario 7: Conflict between Owners, Contractors, & Designers (O&C&D)	

Figure 2. Various Scenarios for Conflicts.

5 DATA COLLECTION AND PRELIMINARY DATA ANALYSIS

Data related to communication quality/conflict was collected and analyzed for 30 completed construction project case studies. To eliminate any potential biases in the data collection process, projects were collected from all three primary stakeholders, and the collected data was divided into the following groups: those with minor conflicts between primary stakeholders, and those who encountered major disagreements and conflicts. Although conflict is inevitable, it imposes deconstructive impacts at higher levels. This process was performed once for each of the owners, designers, and contractors, as well as for communication between owners and designers; owners and contractors; designers and contractors; and owners, designers, and contractors. Table 2 presents information on three case studies and associated delays in the engineering, procurement, and construction phases. Conflict quality was evaluated by a seven-step Likert scale in an effort to discover the extent to which conflict can affect a project's schedule and cause delays. Phase-based delays are also presented in engineering, procurement, and construction.

Table 2. Case Studies Information

Case Study NO.	Conflict Scenarios							Phase-Based Delay		
	Internal Conflicts			External Conflicts						
	Owner	Designer	Contractor	Designer & Owner	Contractor & Owner	Contractor & Designer	Contractor & Designer & Owner	Engineering	Procurement	Construction
1	3	3	3	3	5	4	2	27%	45%	15%
2	4	3	3	1	1	1	2	100%	5%	73%
3	2	3	3	3	1	2	3	33%	20%	28%

Likert scale data was collected pertaining to how the relationship was adversarial. Table 3 presents one sample question and the value of associated numbers. This table refers to internal conflicts; however, other possible conflictual situations were also explored.

Table 3. Questionnaire Sample

How strong was the conflict within each participant group?							
Project Participants	***Conflict Types***						
	Weak Conflict			Moderate Conflict			Strong Conflict
	1	2	3	4	5	6	7
Owner (O)	☐	☐	☐	☐	☐	☐	☐
Designers (D)	☐	☐	☐	☐	☐	☐	☐
Contractors (C)	☐	☐	☐	☐	☐	☐	☐

Table 4 demonstrates the project type distribution of the collected data, as well as the average duration and estimated budget of each phase. The table shows that the average duration of the 30 case studies was 30 months, and the average budget was $366,030,240. Most of the collected data pertained to heavy industrial types.

Table 4. Project Characteristics in Data Collection

Distribution of Project Types	
Heavy Industrial	70.00%
Light Industrial	6.67%
Buildings	16.67%
Infrastructure	6.67%
Average Project Baseline Schedule	
Total Project Schedule	30 Months
Detailed Engineering/Design	9 Months
Procurement	11 Months
Construction	18 Months
Average Project Baseline Budget	
Total Project Cost	$366,030,240
Detailed Engineering/Design	$39,502,307
Procurement	$162,849,912
Construction	$163,382,009

6 STATISTICAL ANALYSIS

6.1 Effects of Conflict on Schedule Performance

Since success is qualitative and conceptual in nature, most researchers define project success by its cost and schedule performance. In this regard, Kermanshachi et al. (2016) established a benchmark of 10 percent or less cost in overruns and delays for a project to be considered successful. Thus, as conflict significantly affects one schedule performance component of success, which leads to ultimate poor cost management, this study focused on analyzing the impact of conflicts on project schedule performance. To determine and measure this relationship, the two-sample t-test was utilized to determine whether a significant difference existed between the mean value of phase-based schedule delays and primary stakeholders' conflict scenarios. The results are presented in Table 5.

As demonstrated in Table 5, the statistical analyses were performed at both 90% and 95% confidence levels (P-value<0.05 and 0.05<P-value<0.1). As is indicated in Table 5, internal conflicts of designers and contractors can significantly impact a project's schedule performance and impose major delays. Conflicts between designers and contractors can be explained as disagreements between entities who play key roles in the engineering/design phase of projects, utilizing non-traditional delivery methods. The engineering phase is the point at which the project is officially initiated and engineers, designers, and contractors begin collaborating towards the same goal. As the stakeholders may not have previously worked together on a project, they may face some conflicts. The internal and external conflicts of designers and contractors in the engineering phase could involve the owner entity as well, and yield poor project schedule performance. Conflicts between owners, designers, and contractors have been identified as a significant contributor to project delays in the design phase; owners experience internal conflicts in this phase.

Table 5. Significant Conflict Scenarios in Schedule Performance

Conflict Scenarios	**Schedule Performance**		
	Engineering	Procurement	Construction
Conflict within Owners	0.88	0.014**	0.039**
Conflict within Designers	0.006**	0.39	0.075*
Conflict within Contractors	0.047**	0.061*	0.007**
Conflict between Owner & Designer	0.229	0.061*	0.95
Conflict between Owner & Contractor	0.576	0.092*	0.278
Conflict between Designer & Contractor	0.047**	0.061*	0.007**
Conflict between Owner & Designer & Contractor	0.035**	0.093*	0.724

Figure 3 depicts conflictual situations by numbers, and schedule performances are defined by the names of the phases. For example, number 1 represents how the owner's internal conflicts can influence schedule performance in the procurement and construction phases, and number 4 displays how an external conflict between owners and designers can affect schedule performance in the procurement phase. This figure envisions which scenario will happen between or among primary stakeholders.

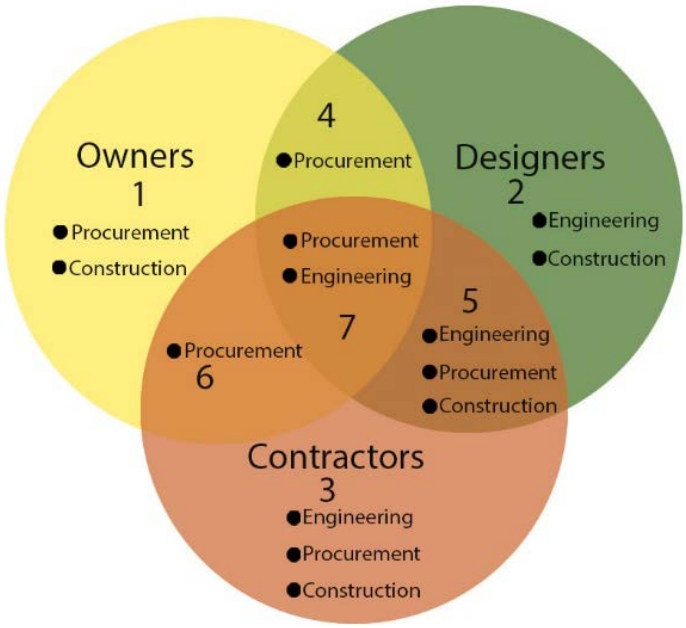


Figure 3. Conflict and Schedule Performance Overlaps in Different Project Phases.

6.2 Measuring Conflict Effect Sizes by Cohen's d Method

Cohen's *d* is an effect size used to indicate the standardized difference between two means. It can be used, for example, to accompany the reporting of *t*-test and analysis of variance (ANOVA) results. Cohen's *d* can be calculated as the difference between the means, divided by the pooled standard deviation (SD). The t value from the two-sample t-test was used to find the effect size, using Cohen's d method, and evaluate the schedule performance of each of the conflict scenarios by applying the following equation:

$$d = \frac{2\mathrm{t}}{\sqrt{\mathrm{df}}}$$

where *t* is the value from two-sample t-test descriptive results. In Cohen's d method, d is computed by the value of the *t*-test of the differences between the two groups. In the equation to the left, "*df*" is the calculated degree of freedom obtained from the two-sample t-test.

Orwin (1983) recommended that variables with effect sizes of 0.2 or less should be considered as having a small impact, 0.5 or less (down to 0.2) should be recognized as having a medium impact, and 0.8 or more should be categorized as having a large impact. Based on these classifications, the numerical effect size values of conflict scenarios were placed into their corresponding categories, which are shown in Table 6.

Table 6. Conflict Scenarios Effect Sizes on Schedule Performance in Different Phases

Conflict Scenarios	**Engineering Schedule Performance**	**Category**	**Procurement Schedule Performance**	**Category**	**Construction Schedule Performance**	**Category**
Conflict of Owners	-	-	1.051	L	1.18	L
Conflict of Designers	0.797	L	-	-	1.571	L
Conflict of Contractors	2.582	L	1.589	L	0.919	L
Conflict between Owner & Designer	-	-	1.202	L	-	
Conflict between Owner & Contractor	-	-	1.024	L	-	
Conflict between Designer & Contractor	0.496	S	1.202	L	0.780	M
Conflict between Owner, Designer, & Contractor	1.002	L	0.792	M	-	-

Short terms defined as S: Small, M: Medium and L: Large

Analysis of the effect sizes of conflict scenarios indicates that as the maturity level of the project increases, the impacts of internal and external conflicts on project schedule performance gradually decrease. The measure used for quantifying conflict for this study was schedule performance, and Table 6 illustrates comparables of conflict distribution in different project phases. If the conflict affects the performance schedule and is considered as conflict power, the most effective conflict can be assumed as the most powerful scenario in which various entities are competing with each other.

Table 6 indicates that conflicts among contractors have considerable effect sizes on schedule performance in both the engineering phase (2.582) and procurement phase (1.589). It was perceived that through the design phase of a construction project, the contractor entity needs to collect information and knowledge about the project such as climate, weather, and soil conditions, all of which impact the design and procurement phases, and be willing to comply with any actions required to execute the project. These types of challenges and issues affect the quality of internal communications among the stakeholders, and conflicts can occur. As a result, conflicts among the contractor entities seriously affect schedule performance in the design phase.

As presented in Table 6, conflicts within the designer entity had the highest effect size (1.571) for schedule performance of the construction phase. As each of the designer staff has unique experience, knowledge,

and skills related to construction projects, the process of reaching an agreement can be challenging and time consuming, the quality of internal communications among the mentioned stakeholders is affected, and conflicts might occur, negatively affecting the schedule performance of the construction phase.

7 CONCLUSION

Conflict can be defined as progressive miscommunication or a communication disorder. In other words, it occurs because of ineffective communication. Accordingly, the intent of this paper was to study the impact of internal and external conflicts among primary stakeholders on EPC schedule performance. It was concluded from the results that *internal conflict within contractor entities* and *external conflicts between designers and contractors* have a significant impact on schedule performance in the engineering, procurement, and construction phases. The results revealed that conflicts within the contractor entity have the greatest impact, and seriously affect engineering and procurement schedule performance. Additionally, the outcomes of this study demonstrate that the construction phase schedule performance is substantially affected by conflicts within the designer entity. This paper will help project managers design a proactive plan for allocating resources at the right time to mitigate the consequences of external and internal conflicts among primary stakeholders.

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