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Identification and Assessment of Uncertainty Factors that Influence the Transaction Cost in Public Sector Construction Projects in Pakistan

Zaigham Ali [1,2,*], Fangwei Zhu [1,*] and Shahid Hussain [1]

[1] Faculty of Management and Economics, Dalian University of Technology, Dalian 116024, China; shahidkhoja@mail.dlut.edu.cn

[2] Department of Business management, Karakoram International University, Gilgit-Baltistan 15100, Pakistan

* Correspondence: zaigham.ali@kiu.edu.pk (Z.A.); zhufw@dlut.edu.cn (F.Z.)

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Abstract: Like other kinds of projects, construction projects are exposed to uncertainty, which plays a critical role in determining the transaction cost (TC). This study explores the uncertainty factors that are associated with construction projects that substantially influence the TC. To obtain the opinions of construction professionals, a survey questionnaire was developed after identifying 30 relevant causes of uncertainty from the literature. A survey of 216 professionals was conducted in Pakistan, and the relative importance index (RII) was used to prioritize the significant uncertainty factors that escalate the TC. Based on the responses from various construction professionals, this study determined that the most significant uncertainty factors that influence TC are: competitive tendering, incomplete design and specifications, late payments, conflict management, delayed possession of sites, force majeure, and work acceleration. This study also compared and analyzed the views of project managers and consultants and found that uncertainty from internal sources has a more significant influence on TC than that from external sources. The political and environmental groups do not contribute much escalating the TC. However, uncertainties that arise from the commercial, project site, and technical groups are more of an influence on TC. This research helps practitioners and professionals to adopt integrative systems in most uncertain situations proactively to find opportunities in volatile markets to reduce the impact of uncertainty on the total project cost.

Keywords: uncertainty; transaction cost; construction projects; risk; Pakistan

1. Introduction

Construction projects face various kinds of uncertainties. This is due to the numerous parties being involved in the process of project design, project contracting, and project execution. The major parties in any project comprise the owner, designer, contractor, supervisors, suppliers, and manufacturers [1]. These projects and their environment are dynamic and invariably encounter uncertainty, which influences project performance. Practitioners perceive uncertainty as a threat, which can take any form in a project [2]. One of the outcomes of uncertainty in Design-bid-build (DBB) construction projects is that the budget usually exceeds the scope of the project [3]. To understand this phenomenon, transaction cost economics (TCE) theory is applied in which uncertainty is a necessary assumption. TCE theory emphasizes that there is a cost to conduct a transaction through market [4,5]. The TCE theory claims that project managers in the contracting business not only bear the contract preparation cost, but also contract enforcement and monitoring cost, which is known as the transaction cost (TC) [5]. The main contention is that it is the uncertainty that is associated with human and environmental factors that cause project managers to incur a TC over and above production cost until

project completion [6]. The uncertainty during project delivery is implicitly used to explain the project failure justifying the schedule extension by iron-clad parameters, i.e., time, cost, and objective [1].

Atkinson et al. [1] argued that uncertainty is associated with all stages of a project's life cycle and may influence TC at any stage. To reduce uncertainty, the conventional uncertainty management approach that focuses more on project planning is believed to be insufficient unless the identification of contextual uncertainty through environmental scanning and analytical methods are not applied [2]. It is believed that knowledge accumulation and experience can transfer uncertainty into either risks or opportunities [2]. Instead of uncertainty necessarily having a negative connotation, it could potentially be an opportunity if the identification of information and acquisition of necessary skills to use it for better results [7]. However, Böhle et al. [8] studied new orientation to deal with uncertainty and found that planned and experienced base actions of managers were critical strategies to deal with uncertainties in projects. Thus, uncertainty should be revisited beyond the risk management discourse collecting experiences from the industry experts, which may equip them to find opportunities from uncertain situations.

In literature, studies used uncertainty and TC to justify the form of governance [9,10]. Some researchers have studied the level of uncertainty and contract complexity [10,11]. Other researchers described the possible relationship of uncertainty and opportunity [8,12]. Studies also explained the risk management in construction projects [13,14]. However, in the traditional methods of risk management, risk and uncertainty were not properly differentiated [12]. For instance, Kreiner [15] has considered both the concepts same with the justification that the project managers' have limited and localized rationality, which was supported by many authors [12,16]. Other studies also neglected uncertainty, i.e., treated uncertainty either risk or ignored [7,17]. Since in the new project management discipline risk and uncertainty were distinguished that uncertainty may lead to risk and opportunities [8,18,19]. Hence, this study takes the uncertainty as an opportunity rather than a risk.

This study aims to identify and assess the critical uncertainty factors that influence TC in construction projects. To address the research question, three objectives are formulated: first, to identify the essential sources of uncertainty that affect TC in construction projects. Second, to determine the relative importance of critical sources of uncertainty from the perspective of project managers and consultants. Third, to assess the essential factors of uncertainty that escalate TC in the construction industry.

Unfortunately, previous studies on construction projects have primarily ignored the investigation on the positive aspects (opportunities) of uncertainties that are associated with projects. In addition, previous studies have mostly been conducted in the developed countries of the West, thereby providing little empirical evidence about the costs of project related to uncertainties from a developing country perspective. Given the fact multi-billion dollars construction projects, under the umbrella of One Belt One Road Initiative, are in the way in the developing countries such as Pakistan. This study provides significant unique contributions to the body of knowledge that argues that uncertainties are not always a threat and can be sources of opportunities in managing projects. It also adds to the public sector construction industry of Pakistan, helping industry professionals to take opportunities from the uncertainties, which will enable them to be more proactive rather than reactive decision makers in overcoming TC escalation problems. Further, this research provides project planners with a basis for preparing realistic budgetary plans and will help project managers reduce cost overrun issues.

In this paper, we take our initial step by reviewing the relevant literature. In the second step, we elaborate upon the research method adopted for this study. The third step is the analysis and discussion of the results. The paper finally concludes with practical implications and recommendations.

2. Literature Review

2.1. Project Uncertainty and Risk

Although project management literature has discussed risk and uncertainty [1,2], a clear distinction has never been made [2]. In literature, they were distinguished in the field of economics and psychology [20]. Studies suggest that risks are known, and they can be assigned a numerical probability, while uncertainty is unknown and is hard to assign numerical probabilities. In other words, risks are known and can be given a fixed numerical value [2]. The risk management approach is also covered in the body of knowledge (BoK). However, uncertainty has been disregarded by the same BoK despite its differences from the risk [2]. Studies also suggested that quantitatively measuring risk is appropriate due to the availability of adequate information, whereas measuring uncertainty is challenging due to the unavailability of adequate information, making it hard to measure [21].

Along with a similar line, Xiang et al. [22] argued that incompleteness and asymmetry in available information trigger uncertainty among the parties involved in a project, which further increases risk. Therefore, risk is the consequence of uncertainty, which is an instructionist approach and only works if adequate information is available [21,23]. Conversely, Perminova et al. [2] contend that there is no clear differentiation of risk and uncertainty. Some authors believed that uncertainty management could be used as an alternative to risk management [24,25]. This ambiguity can be seen in the definitions. For instance, Project management institute (PMI) [26] defines risk as an uncertain event, which, if it occurs, will have either positive or negative influences on some or all project characteristics (cost, time, and objective). Uncertainty, in simple English, is the lack of certainty that derives from the variability of predefined costs, time, and objectives. It is about the ambiguity of the relevant project players, project data, and project structure [19].

Similarly, from the TCE perspective, uncertainty per se does not cause market failure (i.e., increase in TC) unless it is operationalized with human, environmental, and project factors [5,6,27]. Likewise, risk has always been considered to have a negative implication, whereas, in the absence of information about uncertainty, one cannot be sure whether it will lead to negative or positive outcomes. Therefore, a dual approach to handle these outcomes in projects is required [2]. One can infer from this distinction that risk and uncertainty are different from each other because the consequences of risk are always known to be negative and to negatively influence TC, whereas in the case of uncertainty, due to the lack of information, the consequences of uncertainty could be positive and negative [7], which can influence on cost performance.

Keeping in mind the above discussion, we believe that distinction exists between risk and uncertainty, and, therefore, this study focuses primarily on uncertainty. The definition of uncertainty in the literature is highly fragmented. This study followed Cleden [28], who defined uncertainty as an intangible aspect that is unknown or unknowable, but the consequences of which might affect one or more project goals. Project performance is measured by time, cost, and objectives that are influenced by uncertainties associated with project design and logistics, project estimates and basis of estimates, objectives, and priorities, and the nature of the relationship between the contracting parties [19]. Which can positively or negatively influence project performance [2]. Therefore, identifying the critical sources of uncertainty to control its influence on the TC is necessary.

2.2. Project Uncertainty and Transaction Cost

Atkinson et al. [1] argued that uncertainties in construction projects are primarily the result of the diverse groups that are involved in the process of project design, project contracting, and project execution. The project environment leads to uncertainty in making rational choices, even for alternative options [1]. There are various uncertainties that are associated with projects, for instance, uncertainties with estimates (lack of estimation, specification, knowledge, etc.), uncertainties with the contracting parties (work quality and reliability of work, performance, motivation, etc.), and uncertainties with the project cycle (failure to make a comprehensive design and implementation), which ultimately influence

the project cost performance [1]. However, in general, construction projects are exposed to external and internal sources of uncertainties about the transaction environment that affect the contracting parties' ability to comprehensively incorporate contingencies in the contract, which consequently influence project outcome [29–31]. These uncertainties are likely to increase the pre- and post-contract TC [31]. It is argued that TC comprises the direct cost, indirect cost, and opportunity cost in any project execution [32].

The sources of uncertainties external (EXT) to the transaction environment that cause unexpected delays are legal, social, economic, and technological [2,33,34]. For instance, project delays due to strikes, law and order situations, and extreme weather conditions may cause demands for rate revisions from project sites [29]. Similarly, political uncertainty in a country increases the cost of doing business because of frequent delays that cause various unexpected work revisions [35]. Jennifer et al. [36] discussed various internal and external sources that increase the cost of the projects. For instance, construction complexities, scope change, scope creep, and poor estimation are related to uncertainty sources that are internal to the organization. On the other hand, external sources include market conditions, unforeseen events, and unforeseen conditions. A project manager responds to the changing external environment by identifying potential opportunities and threats so that prompt decisions can be made to overcome their influence [2]. Thus, uncertainties in the project environment lead to renegotiations [37]. This enhances chances for trading partners to receive benefits regarding numerous claims, unbalanced bidding, and additional work, which could cause an antagonistic relationship between contracting parties, ultimately ending up in disputes and claims [30].

Similarly, the literature has identified various sources of uncertainties internal (INT) to the transaction environment, such as information systems, project location, corporate culture, and project finance [2,33,34]. Winch [38] argued that competitive tendering itself creates uncertainty due to the incompleteness of the project design and errors and omissions for specifying accurate costs, which create the difference between estimated and actual costs in projects. Similarly, uncertainty arises due to impractical tender estimation. This changes the post-contract project scope, which likely increases costs to the organization [39]. For instance, the study of Chan [40] on the identification of contractors' cost claims for drainage work found that 577 cost claims were granted. On these allowed claims, 76 were related to problems in the documentation, 108 were for direct payments, and the remainder were related to the execution of work. In addition, uncertainty causes owners to sustain additional costs in both the pre-contract and post-contract phases of the project cycle because of incomplete information, the lengthy process for contract negotiation and documentation, and the deployment of additional staff for the enforcement of the contract and its administration [30]. Thus, the sources of uncertainties, both internal and external to the transaction environment, cause direct or indirect TC escalation, and the owner bears this cost over and above the production cost, which eventually increases the total project cost. Therefore, the identification and detailed analysis of critical uncertainty factors that cause TC escalation are required.

2.3. Identifications and Classification of Uncertainty Factors

According to the TCE theory, the TC is the result of uncertainty due to the interplay among different sets of human, environmental, and project factors [6,27]. In this study, the factors that influence TC are extracted from the literature. These factors are broadly categorized into those internal and external to the transaction environment that can influence project performance [2,33,34]. Both the internal and external sources are critical for uncertainties that affect TC [30]. To make the study understandable, the work breakdown structure (WBS) pattern is followed [13,14], which distributes the major uncertainty sources into two categories, such as internal and external.

The internal and external sources of uncertainty factors require further classification. The uncertainty is arising from internal sources, such as technical, commercial, and project site, whereas uncertainties arising from external sources are classified as environmental, political, and socioeconomic [30,33,41]. Technical uncertainty occurs when the project may not be performed

on the required technical grounds, such as unclear work scope, late payments, incentive payments, delayed possession of site, contractor selection, impractical tender estimation, inadequate investigation, late issue of design and specifications, incomplete design and specifications, and failure to investigate contractor bidding behavior. Similarly, commercial uncertainty arises due to legal and contractual formalities. This group carries factors such as fair risk allocation, project complexity, rate escalation clauses, competitive tendering, relationship of contracting parties, coordination cost, and others. Uncertainty from the project site includes those uncertainties that occur on a project site during construction, such as conflict management, work acceleration, disputes over claim evaluation, trust deficit, and relationship with a subcontractor. Conversely, uncertainty arising from external sources are political, socioeconomic, and environmental [30,33,41]. Uncertainty from environmental sources arises when the physical environment adversely influences the TC, for instance, differing site conditions, labor strike, and inclement weather conditions. Uncertainty from socioeconomic sources occurs due to social and economic issues, and the only factor in this group is corrupt practices prevailing in the public sector offices. Political uncertainty arises due to expropriation and regulatory changes. In this study, this includes factors such as regulation changes, political uncertainty, and force majeure [2,33,34].

However, Atkinson et al. [1] claimed that uncertainty can be seen in all stages of the project life cycle and can cause both pre-contract and post-contract TC increases. Most importantly, incomplete project documentation and various unrealistic project estimations and predictions increase the TC to the owner at the post-contract phase of the project. Studies have proven that TC is expected to be lower in the pre-contract phase and higher at the post-contract stage [42,43]. The higher uncertainty in project operations causes a higher TC, because a higher level of uncertainty allows an opportunistic trading partner to jack up its bid, undertake extra work, and demand various claims, which escalates post-contract TC. Another study confirmed that project procurement preparation directly influences TC [30]. Effective communication between the contracting parties allows for better cooperation, which decreases the uncertainties related to the roles and responsibilities of the contracting parties, thus reducing the TC [44]. Therefore, this study aims to explore the critical, significant uncertainty factors that influence the TC in construction projects.

3. Research Methodology

This study was conducted to identify and assess the uncertainty factors that influence TC in public sector construction projects. The research methodology was performed in three major steps. The first step was the identification of preliminary variables from the literature. The second step was to conduct a pilot study to ensure the content validity of the questionnaire. The third step focused on the questionnaire survey to obtain respondents' perceptions of the uncertainty factors that escalate the TC, as shown in Figure 1.

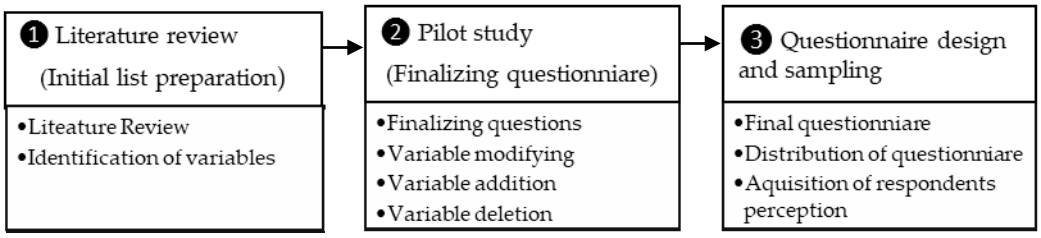


Figure 1. Data collection process.

This survey research began with preparing a preliminary list of factors. The study was initiated to review the literature to find the uncertainty factors that influence TC in construction projects. The first round of literature review enabled us to identify 28 factors. These factors were primarily distributed into internal and external sources of uncertainty based on their origins. These sources were further categorized; for instance, internal uncertainty was further classified as technical, commercial,

and project site sources, while the external uncertainty was categorized into environmental, political, and socioeconomic sources.

The second step of study was to test the hypothesis. The prepared list was given to professionals and academicians in an interview to ensure that all the stated questions conveyed our intended meaning and to avoid misunderstandings. In total, 14 experts were called, among whom eight were practitioners, and six were academics from different public sector construction related industries and higher education institutions. We made sure before inviting the professionals that they had ample knowledge of the issues and that they frequently addressed such problems in their respective areas. During the interviews, the participants were provided with the list of factors identified from the literature. They were given freedom to add to or subtract from the factors in the provided list and also ensured that additional factors would not emerge. After extensive deliberation, the interviewees made the following addition to the proposed framework: "corrupt practices" and "rate escalation clauses" were considered to be critical for uncertainty and potentially escalating TC. The professionals and academics helped us to prepare the final list for the questionnaire, which comprised 30 factors. The final list was used to develop the survey questionnaire as shown in Table 1.

Table 1. The Summary of Uncertainty Factors that Escalate Transaction Cost.

S. No	Factors	References
1	Differing site conditions	[45]
2	Labor strike	[46]
3	Inclement weather conditions	[14]
4	Fair risk allocation	[14]
5	Coordination cost	[47,48]
6	Project environment uncertainty	[29]
7	Competitive tendering	[49]
8	Project environment complexity	[47,49]
9	Strong relationship seldom achieved	[50]
10	Owner negligence	[51]
11	Rate escalation clauses	(Establish through interviews)
12	Dispute on claim evaluation	[29]
13	Trust deficit	[47]
14	Conflict management	[52]
15	Contractor-subcontractor relationship	[53]
16	Work acceleration	[52]
17	Impractical tender estimation	[54]
18	Late payments	[39]
19	Unclear project scope	[14]
20	Contractor's characteristics	[55]
21	Incentive payments	[50]
22	Delay possession of sites	[32]
23	Failure to investigate contractor's bidding	[56]
24	Incomplete design and specifications	[57]
25	Late issue of design and drawings	[32]
26	Inadequate investigation	[58]
27	Change of regulations	[59]
28	Force majeure	[29]
29	Political uncertainty	[60]
30	Corrupt Practices	(Establish through interviews)

The last step was to structure the final survey questionnaire and to devise a mechanism by which to elicit responses from the respondents. The survey questionnaire was divided into two sections. The first section was designed to collect demographic information from the respondents. The second section was planned to measure the respondents' degree of agreement on each uncertainty factor. Thus, a five-item Likert scale was used in the questionnaire. The five-item Likert scale contained the following responses: 1 = strongly disagree; 2 = agree; 3 = neither agree nor disagree; 4 = agree; and, 5 = strongly

disagree. The respondents had to choose any item on the Likert scale according to their importance level. The questionnaire distribution mechanism started with profiling the respondents. Data collection began by first identifying the population and sample size for different regions. The sample was limited to respondents from public sector organizations. Thus, the initial information gathering started by browsing websites and using personal sources to identify relevant organizations. The selection of respondents was made based on their experience with large and small projects in the construction industry. The authors then finalized the organization list to collect the data. The selection of the respondents was made using simple random sampling method. The questionnaires were explained to the respondents before distribution. The respondents were given a day to fill the survey questionnaire to ensure the completeness of information. While collecting the questionnaire, the questionnaire was checked again for further confirmation. Table 2 shows that most of the respondents' experience was under the range of 5 to 10 years. It also exhibits the representation of consultants' and project managers' participated in a survey 54% and 46%, respectively. Large public sector organizations, such as the Public Works Department (PWD), Water and Power Development Authority (WAPDA), and Capital Development Authority (CDA), were selected for data collection because of their involvement in supervising a large number of projects with a wide area of operations. The potential respondents were identified from these organizations, and the authors conducted the self-administered data collection from the respondents. The identified public sector organizations were located in different regions. Table 2 shows that most of the respondents were executives and had enough experience to respond to the questions realistically. Table 2 summarizes the distribution of the questionnaires in the five regions, namely, Balochistan, Sindh, Khyber Pakhtunkhwa (KPK), Punjab, and Gilgit-Baltistan (GB). The study was conducted from an organizational perspective and collected data from respondents of the public sector construction industry, which covers both small and large projects. The total number of questionnaires delivered was 325 and 290 were returned. A total of 74 questionnaires were discarded because of incomplete or invalid information. Thus, only 216 were considered valid, a 66% response rate, which is considered to be reliable for further analysis [59]. According to the data, most of the respondents' years of experience showed that they had enough experience to respond to the questions. Table 2 shows a detailed summary of the respondents' profile.

Table 2. Summary of Respondents Profile.

		Respondent	
Category	**Ranges**	**Frequency**	**Percentage**
Year of Experience	<5 years	40	19
	5–10 years	84	39
	10–20 years	72	33
	>20 years	20	9
Designation	Project Manager	116	46
	Consultant	100	54
Region	Punjab	52	24
	KPK	44	20
	Balochistan	44	20
	Sindh	42	19
	GB	34	17
Organization	PWD	63	30
	WAPDA	105	48
	CDA	48	22

4. Data Analysis and Results

4.1. Ranking of the Uncertainty Factors that Escalate TC in Construction Projects

In research, the relative importance index (RII) and Spearmen's rank correlation are frequently used. For instance, El-Sayegh [14] studied the risk assessment and risk allocation of the United Arab Emirates (UAE) construction industry using the RII and Spearman's rank correlation as the primary tools of data analysis. El-Sayegh and Mansour [13] applied the same techniques to study risk in UAE highway infrastructure projects. Daniel et al. [61] ranked risks and analyzed contract costs while using similar techniques. Thus, this research also used same approach to investigate the uncertainty factors that escalate TC in construction projects. Firstly, to determine the ranking of the uncertainty factors, we applied the relative importance index (RII) for each uncertainty factor using Equation (1):

$$\mathrm{RII} = \frac{(\sum W)}{(A \times N)} \tag{1}$$

where W = weight assigned to the ith response of the respondents (ranging from 1 to 5), A = highest weight (in our case, 5 is the highest), and N = the total number of respondents.

4.2. Spearmen's Rank Correlation

Spearmen's rank correlation (r_s) is a nonparametric measure of correlation that is used to compare the degree of agreement or disagreement between two parties. This technique has been applied in the construction management literature involving ranking exercises. For instance, Sanyal [62] used this technique to identify and rank the schedule run factors in an Indian high-rise construction project. Muhweiz et al. [58] applied this tool to assess the causes of delays in building construction projects. Hussain et al. [63] used a similar analysis technique for the assessment of critical delaying factors. Hence, this method has been widely used in construction research [63–65]. The current study has also applied this technique to find the degree of agreement of project managers and consultants on uncertainty factors. A value of r_s falling between +1 and −1 is considered to be valid. The r_s can be found with the following formula [66].

$$r_s = \frac{(6\sum d^2)}{n(n^2-1)} \tag{2}$$

where r_s = Spearman's rank correlation coefficient between two parties, d = the difference between ranks assigned to each factor, and n = the number of pairs of rank.

4.3. Identification of General Uncertainty Factors Influencing TC

Table 3 shows the critical delaying factors that escalate TC based on the project managers' and consultants' feedback, which were separated and examined individually and ranked based on RII values. The project managers' and consultants' views on the influencing uncertainty factors are presented in Table 3. The top 10 factors are competitive tendering (RII = 0.700), incomplete design and specification (RII = 0.669), late payments (RII = 0.667), conflict management (RII = 0.657), delayed possession of sites (RII = 0.639), force majeure (RII = 0.626), work acceleration (RII = 0.624), impractical tender estimation (RII = 0.606), owner negligence (RII = 0.598), and contractor's characteristics (RII = 0.567). Table 3 also shows that most of the uncertainty factors are either from the commercial, political, and project site groups that significantly influence the TC in construction projects.

Table 3. Relative Importance Index Values and Ranking of Significant Uncertainty Factor.

Uncertainty Factors	Project Manager's View		Consultant's View		Combine View	
	RII	Rank	RII	Rank	RII	Rank
Internal Sources						
Technical						
Incomplete design and specifications	0.659	5	0.680	1	0.669	2
Delay possession of sites	0.641	7	0.636	3	0.639	5
late issue of design and drawings	0.528	21	0.488	23	0.509	21
Impractical tender estimation	0.610	9	0.600	8	0.606	8
Incentive payments	0.534	19	0.467	27	0.503	24
Unclear project scope	0.517	22	0.500	21	0.509	21
Failure to investigate contractor's bidding	0.476	26	0.560	10	0.515	20
Inadequate investigation	0.372	30	0.480	24	0.422	30
Late payments	0.721	2	0.604	7	0.667	3
Contractor's Characteristics	0.531	20	0.608	4	0.567	10
Commercial						
Competitive tendering	0.752	1	0.640	2	0.700	1
Owner negligence	0.662	4	0.524	13	0.598	9
Strong relation seldom achieved	0.607	10	0.508	20	0.561	11
Project environment Uncertainty	0.514	23	0.492	22	0.504	23
Coordination cost	0.597	11	0.476	25	0.541	15
Project Environment Complexity	0.559	14	0.532	11	0.546	14
Fair risk Allocation	0.559	14	0.512	19	0.537	16
Rate escalation clauses	0.597	10	0.516	16	0.559	12
Project Site						
Dispute on claim evaluation	0.462	28	0.516	16	0.487	25
Work Acceleration	0.638	8	0.608	4	0.624	7
Trust deficit	0.597	11	0.516	16	0.559	12
Contractor-subcontractor relationship	0.497	25	0.476	25	0.487	25
Conflict Management	0.700	3	0.608	4	0.657	4
External Sources						
Environmental						
Differing site conditions	0.466	27	0.456	30	0.461	28
Labour strike	0.500	24	0.460	28	0.481	27
Inclement weather conditions	0.448	29	0.460	28	0.454	29
Socio-Economic						
Corrupt Practices	0.538	17	0.524	13	0.531	18
Political						
Change of regulations	0.545	16	0.528	12	0.537	16
Political uncertainty	0.538	17	0.524	13	0.531	18
Force majeure	0.659	5	0.588	9	0.626	6

4.4. Ranking and Analysis of Main Groups' Contribution to Overall Uncertainty

To identify and rank the general contribution of the main groups to overall uncertainty, we computed the RII of each group. RII is the average of the importance indices for the critical uncertainty factors in each group. Table 4 shows the RII rankings of all six groups according to their relative importance of uncertainty. The classification of external and internal uncertainty was made based on its origin. The uncertainty arising from external sources are political, socioeconomic, and environmental. Uncertainties resulting from internal sources are technical, commercial, and project site. A similar classification was made by other researchers for risk assessment in construction projects [13,14]. A concise explanation of each group according to rank is presented below.

Table 4. Relative importance index (RII) and Ranking of Uncertainty in Groups.

Groups	RII Project Manager		RII Consultant		RII Combine		EXT/INT
Political	0.580	2	0.547	1	0.564	2	EXT
Technical	0.559	4	0.546	2	0.552	4	INT
Commercial	0.606	1	0.537	4	0.571	1	INT
Environmental	0.521	6	0.459	6	0.490	6	EXT
Socio-Economic	0.538	5	0.524	5	0.531	5	EXT
Project Site	0.579	3	0.545	3	0.562	3	INT

4.4.1. Commercial Group

This group is considered the most critical for uncertainty, as shown in Table 4, on which both the project managers and consultants agreed. Table 4 shows that project managers and consultants both ranked this group as the highest (RII = 0.571). Also, both groups of respondents' perceptions were highly similar to the attributes of this group, which confirms the high uncertainty and thus a high influence on TC escalation. Further group analysis revealed that the factor "competitive tendering" was ranked (RII = 0.700) as the most significant uncertainty factor that escalates the TC, as shown in Table 3. Three other critical uncertainty factors in this group are project manager negligence (RII = 0.598), strong relations seldom achieved (RII = 0.561), and rate escalation clauses (RII = 0.559). According to the r_s, the degree of agreement between project managers and consultants for this group was $r_s = 0.62$.

4.4.2. Political Group

Table 4 shows the political group as the second most important (RII = 0.564) uncertainty factor that influences the TC. The project managers and consultants both perceived this group to be very critical. Table 3 shows the factors in the group ranking. Under this group, three other critical factors on which both parties agreed are force majeure (RII = 0.626), change of regulations (RII = 0.537), and political uncertainty (RII = 0.531). The r_s helps us to find the degree of agreement between the parties. The $r_s = 1$ shows the substantial agreement of both parties on the uncertainty factors in this group.

4.4.3. Project Site Group

Table 4 shows the combined view of both parties who placed this group on the third level (RII = 0.562) of the overall group ranking. The respondents' views on this group were similar, and they found it to be very crucial for the uncertainty that significantly influences the TC. Table 3 shows the factors in the group ranking. Both parties agreed that "conflict management" is very critical for uncertainty (RII = 0.657), which increases TC. Similarly, both parties' opinions were also the same for other factors in this group, such as work acceleration (RII = 0.624), trust deficit (RII = 0.559), and relationship with subcontractor and claim evaluation (RII = 0.487). The degree of agreement of both parties according to our calculations shows $r_s = 0.70$.

4.4.4. Technical Group

This group was placed on the fourth level (RII = 0.552) of the priority list, as shown in Table 4. According to this table, project managers' and consultants' perceptions of uncertainty ranking are not the same regarding the influence on TC. Table 3 shows, in the group ranking of uncertainty factors that influence TC, project managers ranked the "incomplete design and specifications" (RII = 0.669) factor somewhat important, but consultants ranked it comparatively high. The perceptions of both parties for the remaining factors in this group were late payments (RII = 0.667), delayed possession of sites (RII = 0.639), impractical tender estimation (RII = 0.606), and contractor's characteristics (RII = 0.567), all of which were considered to be very critical for uncertainty.

4.4.5. Socioeconomic Group

Table 4 showed that this group is placed on the fifth level on the group ranking upon which both parties agreed (RII = 0.531). Only one factor, i.e., corrupt practices (RII = 0.531), was recognized as being a type of uncertainty that can influence the TC, as shown in Table 3.

4.4.6. Environmental Group

This study found that the environmental group (RII = 0.490) was the least influential group on the ranking of causes of uncertainty that influence the TC in construction projects, as shown in Table 4. The RII shows that, although the project managers' and consultants' views on this group were similar, they placed it at the lowest level of critical uncertainty factors that influence TC. Table 3 displays the remaining factors and the analysis shows that the three most significant factors that cause uncertainty and influence TC are labor strike (RII = 0.481), differing site conditions (RII = 0.461), and inclement weather conditions (RII = 0.454), as shown in Table 3.

4.5. Comparison of Project Managers' and Consultants' Views

Table 3 shows the ranking of uncertainty factors within the groups that are crucial for TC escalation. Table 4 depicts the perceptions of project managers, consultants, and their combined ranking of uncertainty among the groups that escalate TC. The commercial group is placed by project managers on top of the ranking list, but consultants ranked it fourth. This shows that project managers consider the commercial group to be more critical in creating uncertainty as compared to the consultants, who placed it fourth. The difference of opinion between them is because these groups have different organizational experiences. Project managers belong to the public sector industry, but consultants mostly come with experience from the private sector. The difference of experience is due to differences in organizational culture, for instance, contractual formalities and legal issues in public sector organizations are not strictly followed [67,68]. Similarly, project managers find the political group to be less important and rank it second, whereas consultants placed it first. However, for the project site, socioeconomic and environmental groups, both the project managers and consultants had similar opinions and ranked them third, fifth, and sixth, respectively. The group analysis shows that, in general, both project managers and consultants have similar perceptions of these group rankings of factors that contribute to uncertainty and thus influence TC. We have used a formula (Equation (2)) to calculate the r_s to identify and rank the most significant uncertainty factors that escalate TC, as mentioned in Tables 3 and 4. The general agreement of the parties on the overall factor ranking can be seen from the $r_s = 0.67$ value. Similarly, the r_s value for the main group was $r_s = 0.60$ which shows the agreement of both parties on general factors.

5. Discussion

In this study, each uncertainty factor was identified, analyzed, and ranked to examine their contribution in overall uncertainty. According to the survey data, the RII was calculated for uncertainty factors that escalate the TC. The Spearmen's rank correlation was used for the ranking of the factors drawn from the literature, as shown in Table 3. Table 5 illustrates the combined ranking of the critical uncertainty factors that escalate TC.

Table 5. Ranking of Importance Index of Major factors that escalate transaction cost (TC).

Uncertainty Factors	Project Manager's View		Consultant's View		Combine View	
	RII	Rank	RII	Rank	RII	Rank
Competitive tendering	0.752	1	0.640	2	0.700	1
Incomplete design and specifications	0.659	5	0.680	1	0.669	2
Late payments	0.721	2	0.604	7	0.667	3
Conflict management	0.700	3	0.608	4	0.657	4
Delay possession of sites	0.641	7	0.636	3	0.639	5
Force majeure	0.659	5	0.588	9	0.626	6
Work acceleration	0.638	8	0.608	4	0.624	7
Impractical tender estimation	0.610	9	0.600	8	0.606	8
Owner negligence	0.662	4	0.524	13	0.598	9
Contractor's characteristics	0.531	20	0.608	4	0.567	10

5.1. Competitive Tendering

For this uncertainty factor, both project managers and consultants agreed that it influences TC. Table 5 shows that both parties ranked this factor on top (RII = 0.700). In most developing countries, traditional procurement, i.e., competitive tendering, is commonly practiced by awarded the project to the lowest bidder. In the public sector, this type of procurement is known to select the perfect contractor for which easy accountability can be conducted [69]. However, it is likely that competitive tendering increases contracting uncertainty [38]. Some reasons for this are inexperienced contractors, a lack of financial capability, incompetency [70], and opportunistic bidding on the contract [71]. In competitive tendering, if an over-ambitious contractor wins a contract, then the chances of facing post-contract financial problems increase due to the volatile market situation. The contractor cannot sustain the associated financial uncertainty, and this is mitigated by either submitting a claims bill [72] or compromising on the quality and quantity of the work to maximize profitability [73], which increases the TC. It is also verified from other studies that competitive procurement creates uncertainty [43] and is not always a better option to control the total project cost escalation [74,75].

5.2. Incomplete Design and Specifications

Table 5 shows that this factor (RII = 0.669) was ranked second on the combined ranking list. Both parties agreed that incomplete design and specifications are very critical in creating uncertainty due to the information asymmetry between the contracting parties, which causes TC escalation. Studies have also confirmed that this factor is very significant for the uncertainty that increases TC [30,76]. In Pakistan, a proper feasibility study and project designing are not conducted by the estimators and designers, especially in rural areas due to remoteness and access problems [77]. Similarly, in DBB contracting, if the design is faulty or incomplete, this may create operational challenges for the contractor, with additional resources being demanded from the project site. For instance, if the project manager revises the contract frequent requests for information (RFI) from the contractor increase, which requires additional resource. This situation also causes disputes due to frequent claims bills and claim evaluation [29]. In general, contractors in developing countries face execution problems due to poor surveying, incomplete site investigation, and ambiguous designs, which cause post-contract uncertainty, resulting in disputes between the contracting parties. Such issues cause severe delays that increase the frequency of claims from the contractor, thus increasing the TC [57]. Such uncertainties can be overcome in the pre-contract phase by focusing more on planning and designing.

5.3. Late Payments

On this factor, both project managers and consultants have the consensus that late payments to the contractor create uncertainty. Table 5 shows the value (RII = 0.667) of the relative importance

level of both parties, who recognized it as the third most significant factor. Delayed payments create uncertainty in two ways. First, while making initial payments to start a project, and second, on progress payments. If the payments are delayed in either case, then it creates uncertainty for the work schedule on the project site. In Pakistan, a third party (Department of Planning and Development) has financial control over project payments. The lack of coordination, work inefficiency, and lengthy official procedures in public office for payments hamper the project manager and its parties to make payments on time, creating an uncertain situation. Late payments increase the chances of disputes between the contracting parties, which increases the probability that the contractor will forward claims [39], thus escalating the TC. To reduce uncertainty, it is suggested to improve the coordination between the departments to cope with delayed payments. Furthermore, uncertainty can be avoided by delegating financial powers to the project managers so that timely payments can be made and work can be accomplished on time, which will ultimately reduce the chances of TC escalation.

5.4. Conflict Management

This is another critical uncertainty factor that increases the TC. According to the importance index, it has a value (RII = 0.657) on which both parties agreed, as shown in Table 5. In a contracting relationship, conflicts and disputes are inevitable between contracting parties, which enhances uncertainty [32]. Under such circumstances, mismanaging the situations may exacerbate uncertainty and aggravate the relationship between the project manager and contractor, resulting in various cost claims being demanded from the project site [52]. Yates and Epstein [78] mentioned multiple sources of disputes and claims that are related to different phases of construction projects. The situations become more detrimental to escalate TC because a contractor may file various claims due to conflicting situations, eventually causing the total project cost to increase. To reduce the uncertainty due to conflicting issues, it is recommended to have continuous information sharing and regular meetings between the contracting parties to discuss the problems and issues. The project manager can build trust by providing technical suggestions on the project site to reduce the TC.

5.5. Delayed Possession of Sites

This factor is ranked fifth on the importance level (RII = 0.639) upon which both project managers and consultants agreed. Project managers and consultants believe that delayed possession of project sites create uncertainty that influences TC. Noor et al. [79] referred to an annual development budget (ADB) report and argued that land acquisition laws in Pakistan are in conflict with international norms and thus create uncertainty. In Pakistan, acquiring land for a project is the responsibility of the Revenue Department. The lack of departmental coordination and lengthy official procedures for compensatory payments create uncertainty related to the timely possession of a project site. If the project manager contracts out the project with the expectation that the payment to the landowner will be made on time but payments are delayed, this creates uncertainty. The landowner could refuse to sell the property on old or scheduled rates and ask to revise the payments on the market rate. However, in extreme cases, if the property owner commences litigation against the project manager, this can lead to suspension of the project work for a longer period. If the matter is not resolved on time, this may cause severe delays on project sites. Resultantly, contractors often refuse to work for the previous rate and ask for schedule extensions and rate revisions, which increases the TC. To reduce uncertainty, it is recommended to strengthen departmental coordination and the quarterly review of property rates.

5.6. Force Majeure

The project managers and consultants both agreed that this factor creates uncertainty, which consequently increases the TC. Table 5 shows the importance index value (RII = 0.626) on which strong agreement of both parties was found. Previous studies have discussed the causes of construction project delays in developing countries [70]. In Pakistan, construction projects are prone to various external influences that cause severe and unexpected delays on project sites. One important

reason for delays is the uncertain law and order situation in the country. Security threats have been rampant in the region, which influences the construction industry most because a majority of projects operate in remote areas. Security incidents on a daily basis devastate not only the life of ordinary people, but also a project's progress, and many projects have failed to be accomplished on time. In many instances, project sites seem difficult to reach for the participants because of security threats. Most of the contractors also complained about the unexpected price hikes of the supply chain due to such security issues [80]. The sudden closure of projects due to security issues causes demands for rate revisions. Moreover, inflationary problems create various claims to be forwarded from the project site, which escalates the TC. To reduce the uncertainty of force majeure, it desirable to keep realistic contingencies in the initial budget.

5.7. Work Acceleration

Table 5 shows the value of the seventh factor (RII = 0.624) on which both the project managers and consultants have similar opinions. A project manager's demand for work acceleration shows the unpredictable behavior, which creates uncertainty. Although projects are planned interventions that are prepared after thorough deliberation, delays are inevitable, especially in construction projects which are mitigated by accelerating the work schedule [36]. Apart from the project delays, work acceleration can be demanded by the project manager, which has a TC. In Pakistan, work acceleration often happens when the financial year is closing and public authorities, to show their efficiency of utilizing the annual budget, ask to accelerate the work, which requires additional resources for a contractor. Due to the uncertainty situation, an opportunistic contractor can exploit the situation. Similarly, the demand for work acceleration is enhanced more when the country's general elections are approaching, and political parties want to show infrastructure development progress by counting the projects that were completed during their tenure. In either case, the demand for work acceleration increases costs because contractors have to employ additional labor and equipment on project sites and opportunistic contractors usually ask for other claims regarding incentive payments, which escalate the TC [81]. To discourage such uncertainty behavior, strict policies are required at the organizational level, otherwise strict supervision is needed on such issues.

6. Conclusions

Projects in the construction industry of developing countries, such as Pakistan, encounter more uncertainty than in developed countries, due to which project cost overrun issues frequently occur [82]. This study was conducted to approach the problem by using a survey of 216 professionals in public sector construction projects. The results of the research show that the external sources have a minor influence on uncertainty in Pakistani construction projects. The research indicates that uncertainty from internal sources is more crucial in influencing the TC as compared to uncertainty from external sources. The groups' findings show that the political stability group is not significant in creating uncertainty. There is also a small contribution from the environmental group in creating uncertainty. Although governance issues exist, they do not remarkably add to uncertainty, hence, the low socioeconomic group influence on TC escalation. However, the commercial, project site, and technical group are considered more influential to escalate TC. This study shows that there is a relationship gap among the contracting parties. This leads to furthering uncertainty due to competitive tendering, incomplete design and specifications, late payments, conflict management, delayed possession of sites, force majeure, and work acceleration.

This research provides the basis to recognize opportunities from uncertain situations and to bring about improvements by tightly integrating the systems. The identified variables are not only useful to improve the cost performance but also provide opportunities to enhance the project operational efficiency. Studying uncertainty factors establishes that managers' behavior should be proactive rather than reactive to deal with project costs. This study suggests that the project manager should focus more on the procurement process. It is too early, however, to advise replacing the prevailing low bid

tendering mechanism, because the policy, regulatory, and governance institutions of the country are at the initial stage of development. To reduce uncertainty, it would be appropriate to innovate the current tendering mechanism by incorporating a localized systematic approach composed of monetary and non-monetary aspects (qualification, experience, and skills) that better describe the contractor's qualifications. Furthermore, the relationship of the project manager with the contracting parties (consultant, contractor, and supplier) is significant to reduce uncertainty. The more trust between the contracting parties, the fewer the chances of claims from the project site. Assessment of uncertainty provides an opportunity to categorize the potential future risk of TC escalation, allowing for project managers and consultants to make early decisions. The data collection for this research was made from different sized projects in public sector organizations in Pakistan. However, industrial cultural differences and institutional environment are likely to be different in different countries, which would influence the projects differently. Hence, future research can be conducted in developed countries with a broader sample to generalize the outcome.

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