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Factors for Time and Cost Overrun in Public Projects

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Abstract: The construction industry in Pakistan is experiencing a surge in public sector projects due to major investments in infrastructure projects. Project delays and cost overrun are common features in public sector construction projects in Pakistan. Therefore, an understanding of the causes of time and cost overrun in public projects is essential. This paper investigates delay and cost overrun factors within the context of public sector projects in Pakistan. This study identifies 48 potential factors from existing literature and semi-structured interviews were used to refine the identified factors into ten categories. A questionnaire survey was used to establish a hierarchy of factors using descriptive statistics. The results showed that the major causes of time overruns in public projects were (1) legal issues, such as court stay orders, land acquisition, relocation of public facilities; (2) technical errors leading to low-quality drawings, rework, and errors at bidding stage; and (3) Poor project management. The findings of this research contribute to understanding the causes of project delays in public sector projects in Pakistan.

Keywords: Delays, public sector, projects, construction, delays, Pakistan

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1. Introduction

Public-sector construction projects are those projects financed, owned and operated by a government for the benefit of the general public, such as infrastructure projects (e.g., roads, bridges, and transport systems) or public facilities (e.g., schools, hospitals and libraries). Attributes of a successful construction project include completion on time, within budget, as per specifications and as per the satisfaction of its stakeholders (Al-Kharashi et al., 2009; Albogamy et al., 2013; Johnson and Babu, 2018). However, delays and cost overruns are commonly reported problems in the execution of public sector projects, especially in the construction industries of developing countries such as Pakistan (Fatima et al., 2015; Jarkas and Bitar, 2012; Motaleb and Kishk, 2010). Delays in public sector projects result in late completion of projects, additional costs, claims and disputes, disruption to public availability (Baloyi and Bekker, 2010; Zakaria et al., 2012; Ismail et al., 2012). In addition, public sector projects are often considered a measure of political performance and suffer immense political influence regarding their completion within challenging budget and time constraints. Therefore, any delays and cost overruns in public sector projects not only result in poor project performance but also summon criticism of related public office bearers for misusing taxpayer money.

In recent years, Pakistan's construction industry has experienced heavy investments in public sector projects. This trend is attributed to the stability of the political process in the country, improved security situation and initiation of China–Pakistan economic corridor (CPEC) projects. The gross domestic product (GDP) from the construction industry in Pakistan has increased to an all-time high of approximately 320 billion PKR for the year 2018 (Pakistan GDP from construction 2006-2019), mainly attributed to the start of CPEC projects in 2017 and other public sector infrastructure projects, in the Punjab region of Pakistan, including Lahore Metro and Lahore rapid bus transit projects. The CPEC stands as a long-term development project with the potential to serve as a gateway to connect China with Central Asia, the Middle East, Africa and Europe (Pakistan economic survey 2018-2019). The CPEC construction projects include road networks, power generation substations, dry ports and other supporting infrastructure across Pakistan to be completed between 2017 and 2030 in collaboration with China. In addition to the economic contribution of these infrastructure projects, they are also high-stakes political endeavours for current and upcoming governments in Pakistan. Therefore, delivering these projects within a stipulated time and budget, is a national as well as an international concern.

However, recent public sector projects in Pakistan have seen extensive delays and cost overrun. For example, the Rawalpindi–Islamabad Metrobus, a government-funded 22.5 km road development project, was to be constructed within one year from 28 February 2015 and to be

constructed within a budget of US$310 million (Rawalpindi–Islamabad Metrobus, 2015). The project commenced on 4 June 2015, which was well behind the earlier start period. Consequently, there was a need to speed up construction work. The project faced several controversies regarding workmanship and quality of work. The fast-tracking led to a mismatch between prescribed specifications and on-site execution. For example, the mega-project lacked a proper drainage outlet system. A manifestation of cracks raised serious concerns regarding concrete structure, and audit reports confirmed the sub-standard quality of steel and concrete materials used. Similarly, the TransPeshawar or Peshawar bus rapid transit (BRT), a project similar in nature, is completed in August 2020 and has faced substantial criticism for failure to comply with deadlines and allocated budget. Peshawar BRT, comprising 30 stations, was to be completed and commissioned within six months of the construction start date (November 2017). This project is the most expensive BRT project in Pakistan. The actual cost incurred in project execution has escalated from an estimated US$290 million to a projected US$500 million (TransPeshawar, 2020). Various audit bodies have concluded that the project is being executed without proper feasibility analysis, including major geotechnical, sewerage, traffic and water supply considerations, resulting in fiscal and time resource loss (TransPeshawar, 2020). Similarly, other major projects such as the Lahore Metro Train's Orange Line and Islamabad Airport also have faced major challenges regarding compliance with allocated time and budget. A study by Chaudhry et al. (2019) suggested that the time delays and cost overruns for the Lahore Metro Train project were due to contractual bindings, a conflict among stakeholders, cash flow problems, land-related issues, slow mobilisation of resources, faulty designs and traffic disruption.

Therefore, project delays and cost overrun have been serious challenges for public sector projects in Pakistan, yet there are limited studies investigating the factors responsible for poor project performance. A study conducted by Azhar et al. (2008) addressed these issues from the contractor's perspective. Similarly, Rahsid et al. (2013) researched construction projects in Punjab, analysing cost and time overruns, litigation and project abandonment. Along the same lines, Nawaz et al. (2013) conducted research pertaining to projects under construction and analysed these factors from the perspectives of clients (i.e., various government bodies), consultants, and contractors. Most of these studies are old and were limited to building projects. In the last five years, the Pakistan construction industry has experienced a surge of infrastructure development projects, where delays and cost overruns have been serious concerns. This defines a need for a more recent detailed investigation and identification of delay and cost overrun factors. A key issue is to prioritise delay and cost overrun factors for an in-depth understanding of the causes and effects of poor project performance in public sector projects, which provides scope for this study. This study investigates the key factors contributing to delays in public sector infrastructure construction projects in Pakistan and ranks these factors using statistical analysis. Finally, recommendations are provided for the effective control of these factors.

2. Literature Review

An in-depth literature review was conducted to understand project delay factors in public sector projects, in general in developing countries and specifically in Pakistan. The literature review revealed that previous studies in this regard have focused on two broad areas: quantification of delay factors and cost analysis. According to Kim et al. (2012), project completion within time and cost are among the key project performance indicators. Previous studies have elaborated that although time is an important resource, more crucial is the price to the client and the cost to the contractor. Different stakeholders have different perceptions about project timelines. The client might be dealing with a single project, while a contractor might need to optimise the use of resources across the management of all current projects. Delays and cost overruns can occur during both preconstruction and construction phases. The advancement of auxiliary businesses (engineering, procurement, industrial and information technology) has led to a great demand for the shortening of the construction project duration. But this demand ultimately increases project complexity, leading to an increase in the number of challenges for stakeholders during the execution phase. Public sector projects are often under pressure to complete swiftly; however public sector projects are generally more prone to claims, as the contractor deploys high levels of indirect resources to achieve deadlines, making it vulnerable to delay claims. According to Mozzammi et al. (2011), public sector projects lose time amidst the execution of various activities, resulting in less time to recognise and amend mistakes, leading to rework in later stages of the project.

Doloi et al. (2012) analysed Indian projects and concluded that lack of commitment' is the most crucial delay factor. In Malaysia, 'fluctuation of prices of material' is the primary reason for cost overrun. Most of the Malaysian construction projects (55%) saw cost overruns, though public sector projects adhered to project deadlines better than private sector projects (Shehu et al., 2014). Cost overruns occur globally throughout the construction industry, and it is very rare for a project to be completed within the allocated cost. Furthermore, Marzouk and El-Rasas (2014) evaluated and ranked delay factors impacting construction in Egypt. Their study ranked 43 potential factors pertaining to owner, consultant, contractor, material, labour, equipment, project and external delay factors. Olawale and Sun (2015) concluded that delaying or shortening project timelines drastically impacts cost, and hence cost and time controls are inseparable parameters, making it hardly effective to deal with each separately. Cheng (2014) devised a novel methodology to control expenditures. According to that study, 'clearly defined scope in contract' and 'cost control' can significantly impact the project cost. Haseeb et al. (2011) discussed the critical factors pertaining to large construction projects in Pakistan. That study revealed that clients are the major source of delay, so in order to reduce project delays, clients should be fiscally strong in the first place to bear forthcoming challenges. Similarly, Memon et al. (2011) identified 59 common factors impacting cost overrun; the study ranked 'poor design and delays in design', 'unrealistic contract duration' and 'lack of experience' as predominant cost overrun factors. Similarly, Durdyev et al. (2010) determined the major factors resulting in cost overrun in residential construction projects in Turkey. The most significant factors causing excessive cost overruns were improper planning, inaccurate cost estimation, costly resources (man, material and machinery), lack of skilled labour and land cost. Alinaitwe et al. (2013) investigated

project delays and cost overruns in Uganda's public sector, reporting changes in scope, poor monitoring and control, delayed payment to the contractor and high inflation and interest rates as the major factors responsible for time overruns. Pakistan's construction industry also faces major exchequer loss due to construction project delays. Gardezi et al. (2014) researched time overruns in the Pakistani construction industry and concluded that across 50 different projects, the primary delay factor was political instability. According to Azhar et al. (2008), both internal and external aspects of business settings are prime to cost overruns. Similarly, Nawaz et al. (2013) concluded that Pakistani construction projects experience schedule overruns at all levels of implementation.

3. Research Methodology

A detailed literature review was conducted identifying various delay and cost overrun factors encountered in the construction industry across the globe.

From the literature review, a total of 48 delay factors were identified, which are listed in 10 broad categories, as shown in Table 1. Since the dynamics of construction projects in Pakistan may differ from globally relevant factors, semi-structured interviews were conducted to confirm these factors. A total of 5 semi-structured interviews were conducted with construction professionals, which were in the Pakistan construction industry in senior positions (i.e., project director, general manager, head of a consultancy and a senior transportation engineer). The interviews helped the study in refining and confirming identified delays factors from literature, which were used for the questionnaire design for primary data collection in this study.

The factors presented in Table 1 were formulated in a questionnaire to obtain responses. A five-point Likert scale was used. Respondents were asked to ordinally rate the factors for these factors' possible effects on delay and cost overrun: very high effect (5), high effect (4), average effect (3), little effect (2), or no effect (1). In the questionnaire, the grouping of the factors was eliminated; all the questions were shuffled in order to avoid bias and to divert the focus of respondents from a certain group, as all stakeholder groups (client, consultants and contractors) were represented among the respondents. The target population included professionals who had prior experience pertaining to public sector infrastructure projects in projects either as clients, consultants, or contractors. According to this research inquiries and site visits, each of the 13 firms visited hires 55 to 65 technical personnel for any given project similar to those understudies in the present research. In all, the study population comprised 780 technical personnel. A random sampling technique was used to ensure a representative sample of all targeted respondents, according to the formula presented by Tanis and Hogg (2008) as shown in Eq. (1).

$$n = \frac{m}{1+(\frac{m-1}{N})} \quad (1)$$

where n, m and N respectively represent the sample sizes of the limited, unlimited and available population. "m" itself can be calculated using Eq. (2).

$$m = Z2 \times P \times \frac{(1-P)}{e^2} \quad (2)$$

where Z is the statistical value for the confidence level used, P is the value of the population proportion being estimated and e is the sampling error or confidence interval of the point estimate. Since the value of P is unknown, McClave and Sincich (2018) suggested a conservative value of 0.50. Using a confidence level of 95% and a sampling error of 10%, m is calculated as Eq. (3).

$$m = (1.96)^2 \times 0.5 \cdot \frac{(1-0.5)}{(0.1)^2} = 96.04 \quad (3)$$

Then "n" is calculated as Eq. (4), shown in the following

$$n = \frac{96.04}{1+\frac{(96.04-1)}{780}} = 84 \quad (4)$$

The "n" calculated here represents the sample size needed for this study.

Data for the study was collected using questionnaire i. The potential respondents working at outstations were located after inquiries from the offices of the respective companies. The questionnaires were distributed to the respondents, and completed forms were collected after an appropriate duration. According to Aziz (2013), this method has the added benefit of making clarifications to respondents about the questionnaire and gives a chance to further explore project delay management practices and concerns. Over a period of three months, a total of 78 responses were collected from the respondents, which is very close to the required sample for this study (i.e., 84, as per calculations shown in Eq. (4).

Table 1. Identification and categorization of delay factors based on existing literature

ID	Description	Code	Factor description	Authors
G-01	Political factors	F-01	Political unrest in the country	Doloi et al. (2012), Iyer and Jaha (2005)
		F-02	Transition/change of govt.	Assaf and Al-Hejji (2006), Sweis et al. (2008), Doloi et al. (2012)
		F-03	Undue influence by political personnel	
		F-04	Conflict of interest among stakeholders	
G-02	Economic	F-05	Increase in wages	Arditi et al. (1985)
		F-06	Increase in govt. taxes	
		F-07	Fluctuations in exchange rate of currency	Azhar et al. (2008), Durdyev et al. (2010)
G-03	Legal-related factors	F-08	Land acquisition and payment settlements	Mansfield et al. (1994), Doloi et al. (2012), Datta (2002)
		F-09	Possibility of popular court decisions	Rahsid et al. (2013)
		F-10	Stay orders by court	

Table 1. Identification and categorization of delay factors based on existing literature (continued)

ID	Description	Code	Factor description	Authors
G-04	Project-related factors	F-11	Increase in scope of work	Doloi et al. (2012)
		F-12	Unrealistic time schedule imposed in contract	Assaf and Al-Hejji (2006), Doloi et al. (2012), Memon et al. (2011)
		F-13	Non-availability of drawings/design on time	Memon et al. (2011), Doloi et al. (2012), Hamzah et al. (2012)
		F-14	Rework due to error in design/variation orders	Al-Kharashi and Skitmore (2009), Aziz (2013), Memon et al. (2011), Doloi et al. (2006)
		F-15	Rework due to error in execution	Marzouk and El-Rasas (2014), Moazzami et al. (2011), Hamzah et al (2012)
		F-16	Unrealistic cost estimates	Azhar et al. (2008), Durdyev et al. (2010), Moazzami et al. (2011)
		F-17	Difference in perception of contract clauses	
		F-18	Conflict between owner and other parties	
		F-19	Ill-defined /ambiguous specifications	Azhar et al. (2008), Moazzami et al. (2011), Al-Kharashi and Skitmore (2009), Gardezi et al. (2014)
G-05	Site- related factors	F-20	Restricted access to the site	Doloi et al. (2006)
		F-21	Delay in payments	Marzouk and El-Rasas (2014), Gardezi et al. (2014), Doloi et al. (2006), Haseeb et al. (2011)
		F-22	Delay in handing over /commissioning of site	Doloi et al. (2012)
		F-23	Slow decisions from owners	
		F-24	Unforeseen weather conditions	Sweis et al (2008), Assaf and Al-Hejji (2006), Gardezi et al. (2014)
		F-25	Other natural disasters (winds, earthquake)	Cheng (2014)
G-06	Equipment and materials - related factors	F-26	Shortage of equipment	Haseeb et al (2011), Sweis et al (2008), Rahsid, et al. (2013)
		F-27	Equipment breakdowns	Sweis et al (2008), Fugar and Agyakwah-Baah 2010, Assaf and Al-Hejji (2006)
		F-28	Inefficient use of equipment	
		F-29	Shortage of material in the market	Sweis et al (2008), Cheng (2014), Fugar and Agyakwah-Baah (2010), Assaf and Al-Hejji (2006), Rahman et al. (2013)
		F-30	Delay in supply of material at site	Assaf and Al-Hejji (2006), Memon et al. (2011), Marzouk and El-Rasas (2014)
		F-31	Delay in selection and ordering of materials	Assaf and Al-Hejji (2006)
G-07	Technical issues - related factors	F-32	Unavailability of work fronts to be started at same time	
		F-33	Relocation of underground and overhead services	
		F-34	Poor Planning at bidding stage	Doloi et al. (2012)
		F-35	Use of outdated technology	
		F-36	Financial constraints of contractor	
		F-37	Poor assessment for pre-qualification of contractors	

Table 1. Identification and categorization of delay factors based on existing literature (continued)

ID	Description	Code	Factor description	Authors
G-08	Environment-related factors	F-38	Noncompliance with EPA codes and conduct	Doloi et al. (2012)
		F-39	Influence by NGOs and pressure groups	
G-09	Authority-related factors	F-40	Poor site management and supervision	Assaf and Al-Hejji (2006), Rahman et al. (2013), Doloi et al. (2012), Hamzah et al. (2012)
		F-41	Lack of coordination between site teams	Doloi et al. (2012)
		F-42	Bureaucratic behaviour in the organisation	
		F-43	Misuse of authority	
G-10	Human-related factors	F-44	Designers reluctance/rigidity for change in design	Doloi et al. (2012)
		F-45	Lack of coordination among stakeholders	Memon et al. (2011), Iyer and Jaha (2005)
		F-46	Shortage of manpower	Haseeb et al. (2011)
		F-47	Low productivity of skilled workers	Marzouk and El-Rasas (2014), Aziz (2013)
		F-48	Frequent changes of subcontractor	Doloi et al. (2012)

The objective of the study was to rank the factors in accordance with their relative importance index (RII). Cronbach's alpha and mean rating were used in analyzing the data. Cronbach's alpha was used to check the reliability of the data to be analyzed, and then we calculated the RII. Given the ordinal (i.e., Likert scale) nature of the responses to each questionnaire question, the questionnaire needed to be evaluated for statistical consistency across factors, and each individual factor needed to be evaluated for statistical consistency across respondents. In order to show a correlation with one another, the items should all measure the same thing. Cronbach's alpha statistic assesses intrinsic consistency on the basis of the average correlation between data elements that were measured in an identical manner. Cronbach's alpha can be calculated as shown in Eq. (5).

$$\alpha = \frac{K}{(K-1)}\left[1 - \frac{\sum \sigma i^2}{\sigma i^2}\right] \quad (5)$$

where K is the number of items (here, questionnaire questions), σi2 is the variance of values for each item and Σσi2 is total variance. Cronbach's alpha measures the reliability of data on a scale from 0 to 1, with scores above 0.7 considered reliable. Using SPSS, the overall reliability of the 48 factors was calculated and found to be 0.93. Hence the reliability of the survey was good. The mean-variance and standard deviation of each of the 48 factors were calculated, as was the frequency of each response for each question. Because mean and standard deviation alone does not reflect relationships among factors (Doloi, 2012), they are not suitable for assessing overall ranking. Hence various studies (Aziz, 2013; Kazaz et al., 2008; Chan and Kumaraswamy, 1997; Durdyev et al., 2010; Patil and Desai, 2013) have used RII to rank the factors on a scale from 0 to 1, calculated as shown in Eq. (6).

$$RII = \frac{\sum W}{A \times N} \quad (6)$$

where W is the sum of weights, A is the highest weight given and N is the number of respondents. This is the ranking model used to rank all identified factors in the 10 categories according to the questionnaire results.

4. Research results

Based on the results of the mean rating, factors responsible for time overruns were ranked as presented in Table 2.

Table 2. Respondent scores, RII scores and ranks of delay factors

Factor group	Factor No.	Factors causing delays	Respondent scores					RII	Rank
			1: No effect	2: Little effect	3: Average effect	4: High effect	5: Very high effect		
Political-related factors	F-01	Political unrest in the country	2	17	27	14	18	0.674	21
	F-02	Transition/change of govt.	5	16	17	22	18	0.682	20
	F-03	Undue influence by political personnel	2	20	26	23	7	0.633	30
	F-04	Conflict of interest among stake holders	8	14	30	19	7	0.592	36
Economic-related factors	F-05	Increase in wages	6	9	21	23	19	0.544	45
	F-06	Increase in govt. taxes	5	8	26	26	13	0.569	44
	F-07	Fluctuations in exchange rate of currency	4	12	22	22	18	0.456	46
Legal-related factors	F-08	Land acquisition and payment settlements	0	3	18	34	23	0.797	2
	F-09	Possibility of popular court decisions	1	7	14	22	34	0.608	34
	F-10	Stay orders by court	1	9	14	33	21	0.808	1

Table 2. Respondent scores, RII scores and ranks of delay factors (continued)

Factor group	Factor No.	Factors causing delays	Respondent scores					RII	Rank
			1: No effect	2: Little effect	3: Average effect	4: High effect	5: Very high effect		
Project-related factors	F-11	Increase in scope of work	2	8	13	38	17	0.690	17
	F-12	Unrealistic time schedule imposed in contract	1	11	23	30	13	0.764	5
	F-13	Non availability of drawings/design on time	2	10	17	35	14	0.764	5
	F-14	Rework due to error in design/variation orders	0	12	29	26	11	0.754	7
	F-15	Rework due to error in execution	1	6	20	25	26	0.710	12
	F-16	Unrealistic cost estimates	4	26	25	18	5	0.726	10
	F-17	Difference in perception of contract clauses	1	16	29	23	9	0.582	43
	F-18	Conflict between owner and other parties	0	7	16	32	23	0.608	34
	F-19	Ill-defined /ambiguous specifications	6	18	23	16	15	0.587	40
Site-related factors	F-20	Restricted access to site or limitations of ROW (built-up areas)	3	17	27	23	8	0.692	16
	F-21	Delay in payments	3	24	29	17	5	0.777	4
	F-22	Delay in handing over /commissioning of site	16	29	28	5	0	0.585	41
	F-23	Slow decisions from owners	0	8	37	23	10	0.685	19
	F-24	Unforeseen weather conditions	1	6	22	26	23	0.659	25
	F-25	Other natural disasters (winds, earthquake)	3	23	33	14	5	0.633	30
Equipment and material-related factors	F-26	Shortage of equipment	5	14	20	21	18	0.703	13
	F-27	Equipment breakdowns	3	23	31	17	4	0.590	37
	F-28	Inefficient use of equipment	4	18	31	18	7	0.615	32
	F-29	Shortage of material in the market	0	15	23	27	12	0.685	19
	F-30	Delay in supply of material at site	4	23	28	19	4	0.687	18
	F-31	Delay in selection and ordering of materials	3	16	36	18	5	0.590	37
Technical issues-related factors	F-32	Unavailability of workfront to be started at same time	4	12	16	26	20	0.615	32
	F-33	Relocation of underground and overhead services	4	9	23	27	15	0.782	3
	F-34	Poor planning at bidding stage	5	16	22	26	9	0.718	11
	F-35	Use of outdated/old technology	3	12	28	23	11	0.703	13
	F-36	Financial constraints of contractor	1	8	23	22	24	0.646	27
	F-37	Poor assessment for pre-qualification of contractors	2	6	24	24	22	0.667	22
Environment - elated factors	F-38	Noncompliance with environmental protection codes and conduct	2	21	19	27	9	0.585	41
	F-39	Influence by NGOs and pressure groups	9	28	24	10	7	0.644	28
Authority-related factors	F-40	Lack of co-ordination between site teams	6	26	28	10	8	0.662	23
	F-41	Poor site management and supervision	3	20	32	17	6	0.754	7
	F-42	Bureaucratic behaviour in the organisation	3	24	32	15	4	0.662	23
	F-43	Misuse of authority	4	19	26	18	11	0.641	29
Human-related factors	F-44	Designers reluctance/rigidity for change in design	6	14	21	22	15	0.641	29
	F-45	Lack of co-ordination among stake holders (owner, consultant, contractor, and govt. departments)	5	23	29	15	6	0.749	9
	F-46	Shortage of manpower	8	19	17	16	18	0.697	15
	F-47	Low productivity of skilled workers	5	18	20	18	17	0.651	26
	F-48	Frequent changes of subcontractor	4	24	30	12	8	0.590	37

- Legal-related factors

The legal-related group of delay factors was the most important group causing delays, with a mean RII of 0.738. This strong effect was mainly due to three factors: stay orders by a court (RII=0.808), land acquisition and payment settlements (RII=0.797) and the possibility of popular court decisions (RII=0.608).

- Technical issues-related factors

The second-most-important group was the technical issue-related group, with a mean RII of 0.688. This group's most significant factors were the relocation of underground and overhead services (RII=0.782), poor planning at the bidding stage (RII=0.718) and use of outdated technology (RII=0.703).

- Project-related factors

After the technical issue-related factors, the next-most-important group of delay factors was the project-related factor group, with a mean RII of 0.687. This group's most significant factors were delay due to unrealistic time schedule imposed in a contract (RII= 0.764), unavailability of drawings/designs on time (RII= 0.764) and rework due to error in design/variation Orders (RII= 0.754).

- Authority-related factors

Following the project-related factors, the authority-related group of delay factors ranked as the next-most-important group, with a mean RII of 0.679. The notable factors were poor site management and supervision (RII= 0.754), lack of coordination between site teams (RII= 0.662) and bureaucratic behaviour in the organization (RII= 0.662).

- Site-related factors

The fifth most important group was the site-related group, with a mean RII of 0.672. The prominent factors were delay in payments (RII= 0.777), restricted access to site or limitations of ROW (built-up areas) (RII= 0.692) and slow decisions from owners (RII= 0.685).

- Human-related factors

The human-related factors were sixth-most important, with a mean RII of 0.666. The significant factors were lack of coordination among stakeholders (owner, consultant, contractor, and government departments) (RII=0.749), shortage of manpower (RII= 0.697) and low productivity of skilled workers (RII= 0.651).

- Political-related factors

The politics-related factors ranked seventh among the delay factor groups, with a mean RII of 0.646. The important factors causing delay were transition/change of government (RII= 0.682), political unrest in the country (RII= 0.674) and undue influence by political personnel (RII= 0.633)

- Equipment and material-related factors

The equipment- and material-related factor group ranked as the eighth-most-important group, with a mean RII of 0.645. The notable factors were a shortage of equipment (RII= 0.703), delay in supply of material at the site (RII= 0.687) and shortage of material in the market (RII= 0.685).

- Environment-related factors

The ninth-most-important group was the environment-related group, with a mean RII of 0.614. The two prominent factors from this group were influence by NGOs and pressure groups (RII=0.644) and non-compliance with environmental protection codes and conduct (RII= 0.585).

- Economics-related factors

The economics-related group of delay factors was the last and least important group, with a mean RII of 0.523. The notable factors were an increase in government taxes (RII= 0.569), the increase in wages (RII= 0.544) and fluctuations in the exchange rate of currency (RII= 0.456).

Based on the results of Table 2 and Table 3. The top ten delay factors are presented in Fig. 1 and their frequency of occurrence in Fig. 2.

Table 3. Mean RII and ranking of delay factor groups

Factor groups	Mean RII	Rank
Legal-related factors	0.738	1
Technical issues-related factors	0.688	2
Project-related factors	0.687	3
Authority-related factors	0.679	4
Site-related factors	0.672	5
Human-related factors	0.666	6
Political-related factors	0.646	7
Equipment and material-related factors	0.645	8
Environment-related factors	0.614	9
Economic-related factors	0.523	10

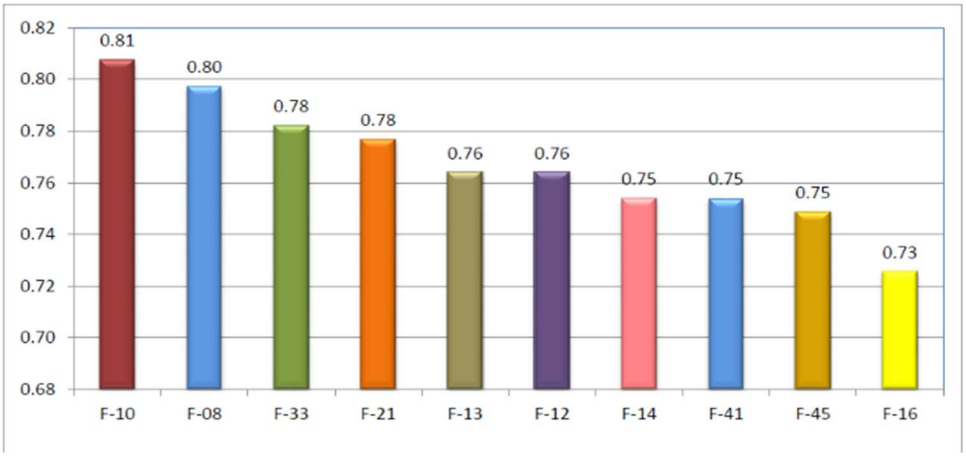

Fig. 1. Top ten delay factors as per research results

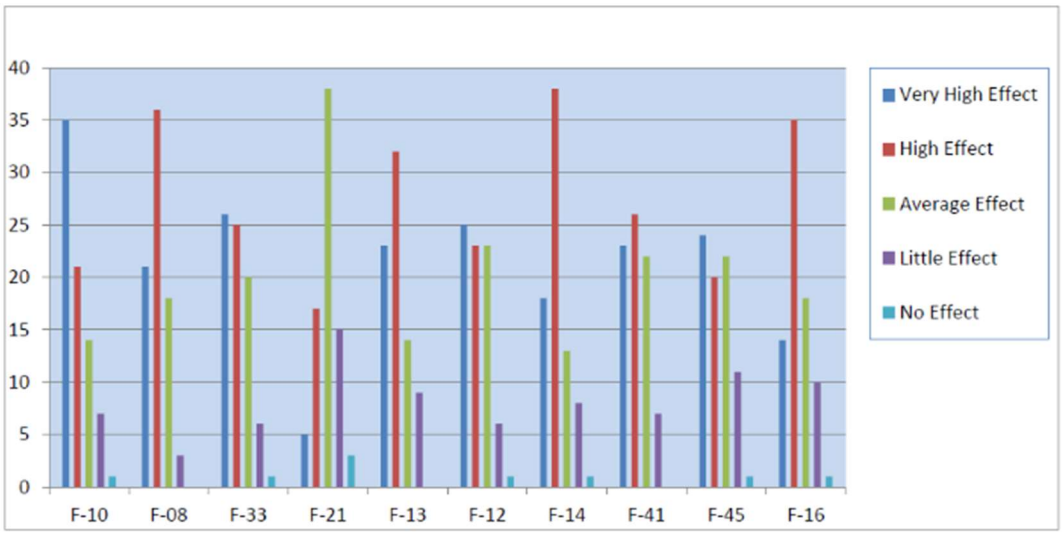

Fig. 2. Frequency of occurrence for the top ten delay factors

5. Discussion of Results

This section discusses the top ten delay factors for public sector projects identified in the research results.

5.1. Stay Order by Court

The research result has shown that the foremost factors responsible for delays in public sector projects in Pakistan are legally related, which is F10- stay orders by a court due to multiple legal reasons. According to Pakistan's constitution any person who may have an objection, or is being affected by a project, can file a legal petition to claim his or her rights as provided by Article 4 of the Pakistani constitution. If the court agrees, then a stay order will be issued to halt the work proceedings until the issue is completely resolved.

Legal stay orders have negative effects on an ongoing construction project in many ways. After the stay has been ordered, it becomes necessary for the contractor working on the project to completely suspend all activities immediately. This results in the waste of useful resources, both materials and machinery. For project projects, the contractor always remains vigilant about materials availability. Construction materials with a certain storage life can be the greatest casualty in this scenario. On the other hand, the contractor deploys heavy machinery at the site to meet the targets set in the schedule. If the machinery is purchased by the contractor, then the contractor has to bear depreciation costs. On the other hand, if machinery is acquired on a rental basis, the contractor is compelled to pay an additional cost to extend the rental. Such costs are ultimately submitted to the owner in the form of claims, raising the owner's project costs. Another effect of this delay factor is unemployment. If the work is suspended, it becomes difficult for the contractor to pay the workforce. The contract would have to lay off these workers for resumption on a later date when issues have been resolved and work has resumed on-site.

One possible solution to this issue would seem to be adjudication by the Parliament. Adjudication could follow some specific criteria or rules legislatively established for stay orders on public sector projects. Secondly, the judicial system could remove the pendency in hearings of public projects owned by the government. If removal is not feasible, then the proceedings could at least take place at a quicker pace so as to decide the future of civil works and avoid additional delays.

5.2. Land Acquisition and Compensation

The second major factor responsible for delays is land acquisition and compensation. This issue becomes more severe if the land is to be acquired in a built-up area, involving a massive displacement of residents. In such cases, stakeholders raise their concerns about the proposed acquisition of land in their area.

For example, one of the work packages of the Metro Multan project has been delayed due to land acquisition issues as it involves a displacement of more than 500 families. Some of the families did have agreed to hand over their homes to the government and were protesting against the government through rallies and sit-ins, leaving this package far behind schedule compared to the progress of other packages. A similar situation was faced by the officials in the Orange Line Metro project in Lahore. People protested to avoid as much as possible the acquisition of their land and suggested changes in routes or station locations, causing serious project delays.

Of serious concern to landowners is the compensation that the government decides to pay them. It is always the preference of government officials to acquire the land at district collector (DC) rates. DC rates set for different areas are usually much lower than market rates, in some cases as low as approximately 20% of prevailing market rates. People are reluctant to sell or hand over their lands at these low rates. This issue might be resolved by motivating people, explaining the necessity and significance of the project and paying them a market price for the land with a premium along with a resettlement option. Another solution might be to minimize the land acquired by careful choice of facility locations and design review.

5.3. Relocation of Overhead and Underground Facilities

For this issue, various departments are stakeholders. It becomes difficult to carry out construction activities in such areas with a variety of services because any impairment to these services may affect a huge population in the vicinity.

The contractor is always at risk while working in an area where these services are likely to be encountered. For example, if during excavation a water line is damaged, the respective department is at liberty to take legal action against the contractor. Similar dynamics ensue in the case of other services like electricity, sewerage and natural gas. The ultimate action by the contractor is to postpone of all construction activities in such an area while waiting for formal approval from the owner. This idles the resources deployed by the contractor, and contractually the contractor can submit an extension of time and cost claims resulting in an increase in budgeted project cost and duration.

To minimize such issues, a strong liaison between the various departments is necessary. The contractor should assign a utility coordinator who can work with utility owners to make sure all utilities that needed to be relocated were relocated, and those that simply need to be avoided will be. For example, it can be checked whether a utility is deep enough that the required excavation can go on without disruption. The project owner should conduct utility coordination meetings with all stakeholders during the design phase. This will allow planning for identification and relocation of those utilities before construction work commences. Also, the project owner should pay for all utility coordination meetings; this will help to protect the project from delays and cost overruns due to utility coordination conflicts.

5.4. Delay in Payments

Delay in payments can result in serious delays on construction projects, which is an overall problem of the construction industry globally. Delayed payments to contractors can have knock-on effects on sub-contractors, vendors and suppliers, resulting in severe delays. Delay of payments is usually caused by bureaucracy in the public sector, lack of proper documentation, lack of transparency and inflation.

In the International Federation of Consulting Engineers (FIDIC), the general contract condition of time for payment to the subcontractor is explained in Clause 60.1, which states that if the contractor has submitted an interim payment certificate and it has been verified by the consultant or the competent authority, the owner is then bound to pay the contractor's sum within 28 days of invoice delivery. In the case of the final invoice, the time-lapse increases to 56 days after verification and delivery of the requisite documents. If the owner fails to pay such amounts to the contractor within the time stipulated by FIDIC, the owner will then pay interest on all unpaid sums from the date from which these should have been paid.

Contractors tend to transfer the burden of accumulated interest to the client, leading to cost overrun. These delayed payments from the owners are not a justification for the contractor to slow down the pace of work, although international law obliges authorities to pay contractors within 28 days of maturity, as mentioned above in Clause 60.2 of FIDIC. The evaluation of the contractor for financial strength may be one possible solution for this issue. Second, the contractor should be motivated to maintain the pace of work by spending from the contractor's own account instead of waiting for owner payments. Such motivation may be drawn from the fact that the contractor and the contractor's direct and indirect staff are all beneficiaries of such projects, to which they also have contributed through their taxes.

5.5. Unrealistic Time Schedule Imposed in the Contract

The unrealistic time schedule imposed in the contract has emerged as a critical reason for delays in public sector projects in Pakistan. In most public sector projects, the government departments are usually under political pressure to complete projects along with political timelines (i.e., with respect to elections), which result in bidding projects on tight and sometimes unrealistic schedules.

Whenever a contract is signed between owner and contractor, the contractor is provided a form affirming that the contractor has visited the site and is fully aware of the conditions prevailing in the vicinity. This form is a part of the bidding document. Unfortunately, most contractors pay little attention to this form and sign the contract without care for the time of its delivery or completion. Ignoring site conditions and difficulty factors leads to the signing of agreements with impractical timelines. Contractors then deploy massive resources and rush to meet the deadline. This dynamic gives rise to excessive indirect contractor expenses. If there is a slight variation or the owner or consultant stops the work for some reason, the contractor is then obliged to issue claims, which if denied can move the matter to litigation, thereby wasting precious time.

The solution to this issue lies in the preparation of level four schedules at the time of the bid. The owner should give reasonable time to understand the practicalities and the necessary sequence to be followed. In addition, detailed site visits by all parties must be arranged to gain insight into the risks involved during construction.

5.6. Unavailability of Drawings/ Designs on Time

Another project-related delay factor among the top ten is the non-availability of drawings and approved documents, which can cause delays in public projects. Doloi et al. (2012) recognized the impact of the unavailability of drawings/designs on time. This issue falls in the category of compensable delays. A delay that is compensable to a contractor is one that was not predicted when the contract was made and is due to some indecision or action for which the owner or those working under the owner are responsible. In such a situation, the contractor may recover damages in the form of money from the owner to cover the extra costs spent as a result of the delay and may also receive a time extension. Unavailability of drawings/ designs on time leads to (1) it idles resources already mobilized, and (2) substantial loss of work moment which would require time to regain.

Such issues may be resolved by adopting better project management techniques and transferring traditional document-oriented practices to digitized construction and management practices (such as using building information models).

5.7. Rework due to Error in Design / Variation Orders

Rework due to error in design/variation orders was ranked seventh among delay factor groups in terms of RII (0.70). Variations in design not only put work behind schedule but also are a major cause of claims put forward by contractors, ultimately raising the total project cost. Rework may push both parties to litigation as well. The problem of variation orders stems from a variety of causes that may be further

divided into owner-caused, consultant caused and contractor-related.

Owner-caused variations include those due to change of original plans, change in scope, revision in the specification of materials/finishing items, addition or subtraction of items, and financial problems.

Consultant-caused variations in construction projects are mostly due to design changes, faulty design (errors), conflicting contract clauses, and inadequacy in scope for the contractor to work on complex design and unawareness of the materials available in the market.

The main reasons for contractor-caused variations are the contractor's failure to participate in the design process in both design and construction phases, lack of manpower, unskilled manpower causing error during execution and financial strain to meet the deadlines set in baseline plans.

Sometimes major variations in the originally proposed project are due to political pressure or personal interests involved. A landowner may refuse to dispose of the land in his or her possession, resulting in a change of route or relocation of a facility. Regardless of the cause, major variations have to move through a long process of approvals, thereby prolonging the project delivery period. The addition or subtraction of cost in relocation is again calculated and put forward for its budgetary approval. However, if the new design or plan is approved by the authorities, it brings with it new challenges that need to be dealt with and resolved.

Variations caused by an error in execution require dismantling and reworking of those aspects, incurring massive waste of time and resources. If these errors are due to the contractor's then the contractor will perform all the dismantling at his or her own cost; if it is due to the consultant's or owner's misconception, then the contractor will definitely submit a cost claim to the owner for reimbursement. These can be ameliorated by the usage of the latest project management information systems (MPIS) to reduce the communication gap while engaging in faster systems of approval.

5.8. Poor Site Management and Supervision

Poor site management and supervision can lead to various delays in project completion. Poor site management and supervision show the incapability of the contractor to suitably manage the project. This factor can result from late acquiescence with an obligation to a statutory body, or poor communication with subcontractors and material suppliers, thus affecting project progress. This issue may be resolved by conducting more frequent briefing and debriefing sessions. Moreover, the development and implementation of a proper hierarchy for site staff are necessary. Every person should be aware of his or her own place in the hierarchy of direct reports. A daily meeting after each working day should be established to bridge communication gaps among the staff.

5.9. Lack of Coordination among Stakeholders

Lack of coordination among stakeholders has emerged as another human-related delay factor in the research results. This may also result in the duplication of work on one hand and underutilization of resources, on the other hand, resulting in material wastage. The tasks and duties of all members of the project team should be well defined to confirm that activities can continue without any problems. During the development process, a vibrant, temporarily multi-organization system is often formed that is continuously faced with strains between two levels of objectives: the momentary objectives of the construction project and the long-term objectives of the contributing organizations in the operative phase of the project. The main contractors need to launch dynamic administrative systems that expedite the coordination of activities and control the activities of their members.

The main contractor of the project should focus more on developing a management system that can provide more efficient site coordination as well as coordination with other project stakeholders. Coordination among stakeholders can also be improved by holding weekly or fortnightly project review meetings, with the client ensuring the presence of responsible representatives from each party. Second, the use of digitalized project management tools and decision support systems (such as extranets and MPIS) may help in improving coordination.

5.10. Unrealistic Cost Estimates

Cost estimation is affected by the complexity of the project, scope of construction, unpredictable market conditions, material price fluctuations, construction methodology, site limitations, client financial issues, buildability, and project locality. Normally the initial cost of the construction project is evaluated from tender drawings that do not contain the complete scope and specifications of the project. The bidders are provided with these drawings and a bill of quantities to quote their rates accordingly, but due to certain departmental criteria, the contractor may be bound to bid with 4.5% of the estimated cost of the project. Moreover, the owner prepares a tender or initial project cost based on a market rate standard basis that is updated twice per year by the finance department of Pakistan. The economy and fuel price fluctuations can make it impossible to maintain stable rates for materials for a period beyond six months. Unrealistic cost estimates can occur when prices in the market rise rapidly, resulting in an overall increase in project cost or reduced profit for the contractor.

As a result, the cost at which the project is awarded is often less than its expected cost, which will rise when the detailed scope and specifications of the project are finalised. The appointment of an advisory committee by the government, which provides recommendations related to costs of construction projects, would help in solving this problem. Secondly, allowances for riskier infrastructure projects may be provided within the rates to ensure that the contractor maintains the pace of work while meeting all necessary quality standards.

6. Conclusions

Completion of construction projects within time and budget is a key performance indicator for measuring project performance. However, the problem of project delays and cost overrun is well known in the construction industry, especially in developing countries, including Pakistan. This study aimed to analyse the factors that cause project delays and cost overrun in public sector projects in Pakistan. The s identified 48 delay factors from literature, which are divided into ten broad categories, forming the basis to conduct a survey questionnaire in this study. The survey questionnaire obtained 78 valid responses from industry professionals in Pakistan. The research data were

analyzed using descriptive statistics approach with relative importance index calculations to analyze and prioritize the delay factors. The research results reveal that the most critical factors for delays in public sector projects in Pakistan are related to legal issues. The research data has shown that stay orders issued by Pakistani Courts over legal petitions filed by objections on public projects are the top reason for delays in executing public projects in Pakistan. This is followed by delays caused due to problems in land acquisition and payment of compensations to affected residents within the area of infrastructure projects. The second category of delay factor was within technical issues reflecting poor initial planning of public projects. This includes the relocation of overhead and underground facilities, rework due to design errors, wrong estimates and rushed contracts with unrealistic completion targets due to bureaucratic and political pressure. Last but not least, project management-related factors manifesting in delays in payments, poor site supervision and lack of coordination among the stakeholders were other project delay factors highlighted.

The results of this research show that the most critical reasons for delays in public sector projects are related to issues and problems beyond the control of a contractor and are more related to government institutions involved in planning and managing public sector projects. Nine out of ten factors in the top ten list are directly under the control of government organizations, which are contractually the project owner's responsibility. Therefore, this study recommends that government institutions involved in managing public sector projects in Pakistan and in other developing countries should introduce regulations.

- To ensure land acquisition and payment compensation settlement before a public sector project can be tendered.
- To settle any legal issues related to under-construction projects using alternative dispute resolution or equivalent measures.
- To capacity building, especially to upskill project management employees in related government institutions
- To transfer the existing document-oriented project management practices to digital systems to enhance collaboration and better management of design and execution of construction activities.

It is believed that the findings of this study will enable the government in Pakistan and other developing countries formulating clear policies and procedures to avoid major causes of project delays and cost overrun, as identified and discussed in this study.

The results of this research are based on a questionnaire survey, which has received 78 complete responses. The number of responses is low because the research was conducted in the Punjab region of Pakistan and only includes responses from one province of the country. In addition, the survey respondents are not evenly distributed among industry roles, as well as their experience within the private and public sector projects. The identified delay factors shall be investigated with larger data size and should include case studies for an in-depth analysis. In future work, research will be conducted to analyse the existing project management practices and procedures of public sector projects in Pakistan and a proposal will be developed to transform traditional procedures into modern and digitalised management practices of public sector projects.

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