CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

Impact of Delays on the Construction Cost of Road Infrastructure: A Comparative Study

by

Osama Faisal

A thesis submitted in partial fulfillment for the degree of Master of Science

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I want to dedicate this achievement to my beloved parents, honorable teachers, friends, and classmates who always encouraged and supported me in every crucial time during my studies to achieve my tasks and secure this degree.

CERTIFICATE OF APPROVAL

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Osama Faisal

(MCE233012)

THESIS EXAMINING COMMITTEE

S. No.	Examiner	Name	Organization
(a)	External Examiner	Dr. Khurram Iqbal Ahmad	NUST, Islamabad
(b)	Internal Examiner	Dr. Maria Ghufran	CUST, Islamabad
(c)	Supervisor	Dr. M. Usman Farooqi	CUST, Islamabad

Dr. M. Usman Farooqi
Thesis Supervisor
September, 2025

Dr. Majid Ali
Head
Dept. of Civil Engineering
September, 2025

Dr. Imtiaz Ahmad Taj
Dean
Faculty of Engineering
September, 2025

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(Osama Faisal)

Abstract

Delays in road infrastructure projects significantly affect cost estimation and timely completion, undermining the efficiency and effectiveness of national development efforts. The overall aim is to assess how delays, caused by factors such as contractor inefficiencies, weather conditions, material shortages, and bureaucratic obstacles, impact project costs. This study investigates the causes and consequences of such delays in the context of road construction projects in Khyber Pakhtunkhwa, Pakistan. Specifically, it examines the role of project management practices, team performance, and risk mitigation strategies in controlling these delays. A structured quantitative research approach was used, with data collected through a validated questionnaire distributed among 200 professionals involved in road construction projects. Statistical analyses, including correlation and regression, were conducted using SPSS to evaluate the influence of delay factors on cost overruns.

The study identified cost estimation impacts (RII= 510.20), weather-related delays (RII=505.8) and material supply chain disruptions (β=-0.353) as the most significant cost drivers in road construction projects. Robust project planning (β=1.45-2.26) emerged as the most effective mitigation strategy, while inadequate risk management (RII=493.8) was found to exacerbate delays. The findings demonstrate strong correlations (r=0.537-0.607) between these factors and cost overruns, providing empirical evidence for targeted delay reduction strategies in infrastructure projects. The study recommends adopting advanced planning tools (CPM/PERT), AI-based risk prediction, and stronger contractor management to mitigate delays. Future research should explore blockchain-based contract systems and AI-driven delay analytics, along with cross-country comparative studies to develop globally adaptable solutions for road infrastructure projects.

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Abbreviations

AI	Artificial Intelligence
BIM	Building Information Modelling
CPM	Critical Path Method
PDM	Project Delivery Method
PMI	Project Management Institute
PPP	Public-Private Partnership
RII	Relative Importance Index
R&D	Research and Development
SPSS	Statistical Package for the Social Sciences

Chapter 1

Introduction

1.1 Background

Road infrastructure forms a cornerstone of national economic development, enabling connectivity, trade, and accessibility. Roads are essential for linking regions, promoting social and economic integration, and facilitating the efficient movement of goods and people [1]. As such, road infrastructure projects are among the most critical investments made by governments and private stakeholders worldwide. Not only are they costly, but also social expectations are very high because of the ability to provide economic growth and quality living. Delay however tends to undermine the success of these projects as they create huge obstacles to the completion of these projects and, as a result, to achievement of the planned economic gains. It is therefore important to know the dynamics of project delays and their consequences on development of road infrastructure in order to enhance the results of the project and the expectations of the people [2].

Time delays occur frequently in road construction projects and time as such is a major concern to project managers and project stake holders [3]. Examples of causes of delays are numerous and they are poor site conditions, poor weather, permits and approval waiting times and material resource scarcity. This kind of delays interrupts the project completion schedule, lengthening the delivery time and costs. The delays in the construction of roads are discouraging not only due to the financial aspect of the project but also due to the sociocultural and environmental consequences [4].

The influence of the delays on the performance measures of a project and its completion can be viewed in a number of ways since it impacts financial and non-financial measures. This paper is focused on the effects of delays on project completion and tries to establish the factors that specifically lead to project being delayed. Project completion is one of the performance indicators in the building industry and compliance with the deadline is highly valued.

Failure to achieve this objective, however, compels the stakeholders to find alternative solutions in order to reduce the anticipated difficulties [5]. In this respect, it becomes pertinent to explore the degree to which project management efficiency influences delays and project completion in time.

It appears that the high-performing groups are more able to handle the challenges that emerge as a result of delays since they are able to absorb the changes in no time, make decisions grounded on information and continue to be prolific even in the most unfriendly circumstances [6]. In the process of investigating how project management efficiency and team performance influence the factors, this paper tries to set out to venture on an all-round basis in relation to the factors of road infrastructure delays in project completion [7]. The objective is to propose guidelines that will allow the project managers and the stakeholders to mitigate the adverse effect of delays and improve the likelihood of the project being completed on time. This research is particularly significant to the field of construction management, where one must utilize resources efficiently, work together, and take action promptly to resolve the problems of project delay. Moreover, the findings of this research will influence policy and management in the construction environment in the sense that one would have stronger road infrastructure undertakings that can meet the shock. The significance of this work is highlighted in the way it may serve to fill in the gaps of the literature on the delay related to the projects in the road infrastructure [8]. The existing literature has focused on the causes of such delays and cost of such delays, however relatively little effort has been put on the impact of such delays, project management performance, team performance and completion of late projects.

The paper employs a comparative method to widen the range of the valuation of these variables in the various road infrastructure projects to serve the interests of both theoretical and practical works [7].

This breadth of this study can help in the endeavor to have an evidence-based toolbox that can be used to limit the delay, hence enabling the project managers, and stakeholders to use the available resources effectively to boost cooperation and ensure that the projects are completed within their due time frame [8].

One of the most important points of minimizing the connection between delays and on-time project completion is the management of a project. Here, management efficiency refers to the capacity of the project managers to plan, organize, and control the resources efficiently so as to ensure that the project is done on time and limited by the budget.

With regard to road infrastructure projects, project management involves the performance of various activities that include: scheduling, cost estimation, procurement, planning and management of risks in order to reduce interruptions and concentrate on completion of the project [9].

Project management efficacy acts as a go-between in the relationship between project delays and project completion by helping the teams to undergo and absorb project changes and delay. Good PM practices, including those of risk management, close follow-up and monitoring of the project schedule, and timely allocation of resources, are key to the control of delays and, more importantly, the chances of meeting the schedule. Apart from management efficiency, team performance is also another key attribute that impacts road infrastructure project performance.

In this instance, team performance can be defined as the joint activities of project team and their capacity to collaborate, socialize or address issues thereby facilitating them to meet the project goals [10].

1.2 Research Motivation and Problem Statement

The motivation of this study is the fact that there has always been a problem of delay in road infrastructure project, which often contributes to failure to perform projects in time, inefficient allocation of resources, lack of user confidence and delayed access to essential services. Since road infrastructure is a key component that enhances economic development as well as social comfort, the effects of these setbacks are far-reaching. This paper aims to examine the underlying causes and consequences of such delays, with an object to come up with practical measures to reduce their prevalence. Special emphasis is put in consideration of how effective project management strategies and group performance can deal with unforeseen problems and see to the timely delivery of projects. The research through this investigation aims at improving the practices of man- agement and the overall success rate of infrastructure projects.

Delays in road infrastructure projects are a significant challenge, leading to cost overruns, community disruptions, and overall project underperformance. Key factors contributing to delays include adverse weather conditions, regulatory is- sues, planning failures, and resource shortages. Although previous studies have highlighted the causes, there is a gap in understanding how project planning and management strategies, along with risk mitigation techniques, impact the timely completion of road projects. This research aims to fill this gap by examining the role of effective planning and management strategies in reducing delays. The goal is to provide recommendations for better management practices and risk mitigation strategies to improve project efficiency and success.

1.3 Research Questions

a) What are the main causes of delays in road infrastructure projects in Pakistan?

b) How do these delays impact the overall construction cost of road infrastructure projects?

c) What comparative insights can be drawn between different types of road projects to minimize delays and associated cost overruns?

1.4 Overall Objective of the Research Program and Specific Aim of this Research

The overall goal of this research program is the effective planning of road projects in developing countries like Pakistan, through risk management strategies to support their timely and cost-efficient completion. However, the specific objectives of this study are:

1. To determine the main causes of delays in road infrastructure projects.
2. To assess the effect of these delays on construction costs.
3. To suggest practical measures to reduce cost overruns by minimizing delays.

1.5 Scope of Work and Study Limitations

The study is oriented on understanding the relationship between the delays in projects, focusing on road infrastructure projects, and the efficiency of project management impacting the relationship between project delays and infrastructural development as a distinct form of investment productivity. Data collection mainly focuses on collecting both quantitative as well as qualitative data from the selected road infrastructure projects which assists in determining the factors that affect the time and rates of completion of the projects. The primary focus is also on the management practices applied during these projects and how they impact the timely delivery of road infrastructure. Having addressed the gaps in the existing literature, the current study aims at enhancing stakeholders' knowledge by providing practical solutions that construction managers, project teams and policymakers who are in charge of reducing road construction project time overruns and improving project completion seek within the context of the road sector.

1.5.1 Study Limitations

This study is limited in its geographic scope, as it focuses exclusively on road construction projects within Khyber Pakhtunkhwa (KPK), Pakistan. As a result, the findings may not be fully generalizable to other regions with different administrative frameworks, economic conditions, or environmental factors. Furthermore, the research is based on data obtained from project managers and contractors, which may differ in accuracy, consistency, and completeness, potentially influencing the reliability of the results. The study is confined to the road construction sector, and therefore, its conclusions may not be applicable to other types of infrastructure projects. Additionally, while various analytical tools such as descriptive statistics, reliability testing, normality assessment, correlation analysis, multiple regression analysis, and the Relative Importance Index (RII) are employed to examine the data, the complex and multifaceted nature of project delays (including weather conditions, resource limitations, and external disruptions) poses challenges in isolating the individual impact of each factor on project timelines.

1.5.2 Rationale Behind Variables Selection

The selection of variables in this study namely, causes of delays, risk management and mitigation strategies, and construction costs is grounded in the critical need to explore how delays affect financial outcomes in road infrastructure projects, particularly within the context of Pakistan. Delays are widely recognized as a major contributor to increased construction costs, often resulting from factors such as poor project planning, material shortages, labor inefficiencies, and environmental or regulatory issues [11]. Understanding these root causes is essential to mitigating their impact. In addition, risk management and mitigation strategies play a pivotal role in controlling project disruptions; proactive planning and early identification of potential risks can substantially reduce the likelihood and impact of delays [12]. Construction cost, selected as the dependent variable, is directly influenced by the occurrence and severity of such delays through additional expenditures on labor, materials, and extended project durations. By analyzing the interplay between these variables, this study seeks to generate evidence-based insights to support more effective project planning and control strategies in road construction. These variables were therefore chosen based on their direct relevance to project performance and their established significance in prior research.

1.6 Novelty of Work, Research Significance and Practical Implementation

This research investigates the persistent challenge of delays and cost escalation in road infrastructure projects within Khyber Pakhtunkhwa (KPK). While several past studies have broadly examined causes of delay in general construction projects worldwide [13–15], very limited research has specifically quantified the direct cost implications of delay factors in road infrastructure projects of Pakistan. Existing studies mainly focus on identifying and ranking delay causes without systematically linking them to cost overruns through advanced statistical validation. Furthermore, by focusing on the Khyber Pakhtunkhwa (KPK) road sector, the research provides region-specific insights that were missing from earlier literature. This approach bridges a critical research gap and offers a holistic contribution by combining descriptive, relational, and predictive statistical techniques, thereby enhancing both the academic value and the practical applicability of the findings.

This research results are of immeasurable importance to policy makers, construction managers and KPK stakeholders. Infrastructure, especially those that pertain to roads, are essential to the developments of a region, they enable trade, movement and linking of remote regions. Delays during the construction process, however, contribute to high-cost construction and prolong the construction projects, which are not beneficial to such projects. The present work presents the in-depth insight into how delays and cost increase may be reduced in the KPK scenario, and region-specific data could be used to enhance the planning of projects, scheduling, and resource allocation.

Besides these insights, the research gives practical recommendations on how project management practices should be improved. These comprise improved risk management strategies, efficient scheduling, efficient resource allocation that will reduce delays and control escalation of costs. Another important point presented in the study is the vital nature of team performance in the success of the project. By promoting good collaboration, communication, and problem-solving of project teams, significant reduction in delays, cost reduction, and improvement of project outcomes can be achieved. Moreover, the study demonstrates the necessity of training of construction managers, which will enhance their leadership competences and will allow them to be more dependent on avoidance of delays and cost concerns.

Finally, the research proposes reforms of the policies and enhanced regulations by focusing on external issues, including disruption caused by weather, regulatory delays in the community. These reforms would enable easier execution of projects and such external factors would have a lesser effect on the cost-effective and efficient completion of road infrastructure projects on time. Finally, the study also gives an outline of how it could develop more efficient, cost effective, and sustainable road-based infrastructure of KPK and other similar areas.

1.7 Brief Methodology & Design

This research design is comparative research because it involves research on the effect that project delays have on cost estimation in road infrastructure projects in Khyber Pakhtunkhwa (KPK), Pakistan. The overall aim of the investigation is to analyze the contribution of the various factors including project management practices, team performance, and external factors such as weather conditions, material supply chain disturbances and how they cause delays and, as a result, the impact of these delays on cost overruns in construction projects. In the study, quantitative data is employed, which was collected by the use of structured questionnaires filled in by the project managers, contractors, and team members who actively participated in the road infrastructure development in the KPK region. The following questionnaires were created to gather specific data about the frequency, nature, and effects of delays, and information about project man- agement efficiencies, team dynamics and cost estimation issues. This research paper has embraced the convenience sampling method, one of the most frequently used non-probability sampling methods in a study in construction management. The methodology was selected on the basis of the fact that the research involved reaching proximate professionals working in the road infrastructure projects including the project managers, contractors, engineers, and team members. Because it was not possible to have a complete sampling frame of all of the professionals in the area, and the time and resources were limited to conduct the research, convenience sampling was an effective and efficient means to gather the data [16].

The respondents were chosen according to their availability, readiness to answer, and the firsthand experience of construction delays and cost estimation of projects. This ensured that the respondents possessed relevant knowledge and practical insights, which strengthened the validity of the data collected. Despite being a non-probability method, convenience sampling was suitable for this research because it captured the perspectives of active industry practitioners, allowed the required sample size of 200 respondents to be achieved within the project's limited duration, and ensured that the data reflected real-world industry conditions.

Data collection was carried out using pre-tested, structured questionnaires. The data obtained were then subjected to a series of statistical analyses using SPSS software. The analysis includes Descriptive Statistics,Frequency Distributions, Pearson's Correlation, Multiple Regression Analysis and Relative Importance Index (RII).

The use of this mixed statistical approach provides a comprehensive understanding of how delay-related variables influence cost outcomes and allows the identification of actionable strategies for improving project delivery within the road construction sector in KPK.

1.8 Thesis Structure

There are five chapters in this thesis:

Chapter 1 highlights the background and motivation behind this study, particularly focusing on the impact of delays in road infrastructure projects. The chapter discusses how these delays affect cost escalation and the overall timeliness of project completion. It also briefly outlines the scope, limitations, and methodology of the research.

Chapter 2 elaborates a comprehensive literature review on delays in road infrastructure projects, the factors contributing to cost escalation, and the impact of project management practices and team performance on reducing delays. The chapter also reviews external factors such as weather conditions, regulatory issues, and contractor delays in the context of road projects in KPK.

Chapter 3 discusses the detailed research methodology used in this study, including the research design, data gathering methods (such as surveys and interviews), data analysis techniques, and the framework formulation method used to assess the impact of delays on cost escalation in road infrastructure projects.

Chapter 4 contains the results and analysis with the discussion of the statistics, specific tests, and their interpretation. The correlation between delays and cost increase is also analyzed in this chapter with greater emphasis on how project management and team performance can be used to reduce delays.

Chapter 5 is the conclusion of the study where relevant findings are made based on the research. It provides feasible ideas on how to reduce delays and cost increase in future road infrastructural developments in KPK. Another aspect proposed in the chapter is the framework of enhancement of project management practices and team dynamics in order to minimize delays and improve the efficiency of road project.

Chapter 2

Literature Review

2.1 Background

The importance of road infrastructure in promoting socio-economic growth is difficult to overstate since road infrastructure promotes connectivity, trade, and access to vital services. The condition of the road's infrastructure is a major concern in most developing nations, such as Pakistan, in the quest to address the disparities that exist in the region and enhance economic development. The importance of road projects especially in less-developed and remote regions is that appropriate infrastructure has the ability to enhance the quality of life of the communities in that particular region. Nonetheless, failure of these projects to be implemented on time causes cost increase and failure to achieve developmental objectives. Various challenges that create delays in road infrastructure projects especially in the underdeveloped or conflict-prone regions are experienced in Pakistan. These questions frequently involve logistical difficulties, security threats, political instability, and inadequate governance, and it becomes even more challenging to ensure the completion of the projects in time. These elements add up to cost inflation and failure to meet the set deadlines thus defeat the expected benefits of such infrastructure projects.

According to the recent research findings, a set of factors that cause delays in road infrastructure projects in the world is determined. These involve poor scheduling of project, risk mismanagement, under-balanced resources and stakeholder conflicts. These problems are complicated by the geographical barriers, security concerns and limited government structures in the context of Pakistan in a way that these problems are aggravated in the marginalized or underdeveloped areas that compound the delays.

Thus, the solution to these delays would be a holistic approach toward the causes of the problem and the creation of efficient risk mitigation actions. The objective of the literature review presented is to look into the cause of delays in road infrastructure projects in Pakistan and especially in the underdeveloped areas. This review will offer information on how such challenges can be overcome by examining the reasons behind delays and how they would affect a project cost.

Knowledge of these factors will help the policy makers, contractors and other stakeholders in coming up with policies that will make road infrastructure projects successful and cost effective and in time.

2.2 Main Variables

2.2.1 Causes of Delays

Some of the high-desirability com- ponents with which the projects of infrastructure development in Pakistan are interwoven are; lack of proper management of the project, inadequate supply of technical knowledge and change of project design are common occurrences. Recent literature emphasizes the impact of externalities including political unrests, administrative hold-ups, and the problem of clearances being taken up later than desired [17]. Likewise, in the case of the developed districts in Pakistan, there are dominating factors of lack of construction resources, lack of skilled labor force, and unfavorable weather conditions contributing to the problem of overall delays [18].

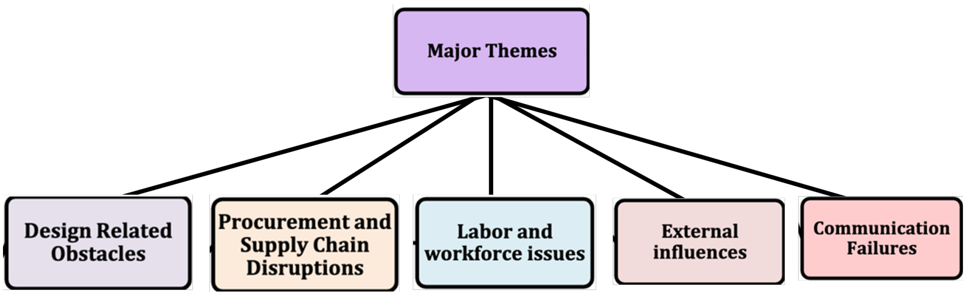

Figure 2.1: Portrays the major themes extracted from the thematic analysis [18].

2.2.2 Construction Costs

Pakistan infrastru cture projects on roads are infused with a number of desirous factors such as; lack of proper management of the project, a lack of availability of technical know-how as well as change of project design very often. Recent literature emphasizes the impact of some politically induced aspects like political unrests, administrative delays and those related to acquiring essential clearances as and when needed [19]. Similarly, regarding the constructed districts of Pakistan, the prevailing conditions of unavailability of construction assets, shortage of the required skilled labor force, and bad climate conditions add to the overall delays [18].

2.2.3 Risk Management and Mitigation Strategies

Delays should be anticipated and their consequences appropriately minimized through the implementation of sound risk management practices. More and more contemporary studies underpin the benefit of efficient advance planning, interacting with stakeholders and using modern-day approaches within management to address the issues of delay [20]. In that context of merged districts, better use of local knowledge, contractor motivation and enhancement of governance processes to deliver projects in time is necessary. In addition, it is worth mentioning that strategies to improve procurement systems and bureaucratic processes should be addressed as well [21].

Table 2.1: Knowledge of risk management in organization [20]

		Frequency	Percent	Valid %	Cumulative %
	Strongly Agree	56	36.4	37.3	37.3
	Agree	78	50.6	52.0	89.3
Valid	Neutral	14	9.1	9.3	98.7
	Disagree	2	1.3	1.3	100.0
	Total	150	97.4	100.0	
Missing	System	4	2.6		
	Total	154	100.0		

2.3 Factors Influencing Delays on the Construction Cost of Road Infrastructure

2.3.1 Delay Classification

Construction delays are often categorized into two major types of delays, firstly the excusable and secondly, the non-excusable but then there are further classifications of each type which include compensable and non-compensable delays. Different sorts of delays can result in different consequences both in liability terms for all stakeholders and in costs [22]. This allows choosing the more effective way of managing and reducing its negative effects as the cost overruns.

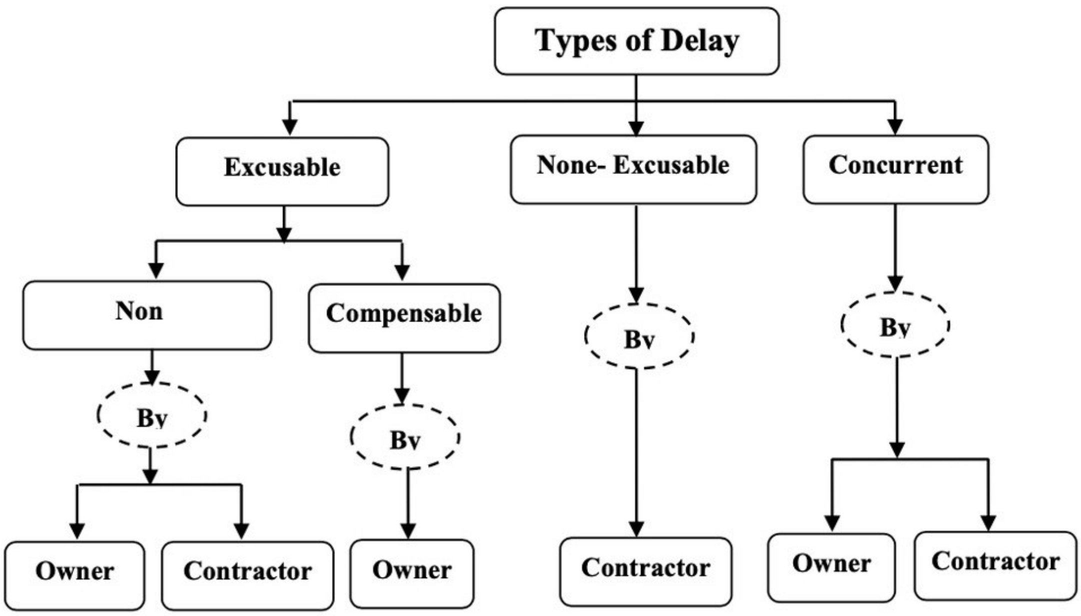

Figure 2.2: Types of Delay [22]

2.3.2 Contractor-Related Delays

Delays related to the contractor can also be caused by other factors such as poor site supervision, lack of manpower, financial issues, or inability to mobilize in time. The occurrence of these delays in road construction projects is costly as a result of penalty clauses that enhance time overruns [23].

However, the negative effects are likely to be reduced through effective contractor monitoring and performance assessment.

2.3.3 Client-Related Delays

Delays may be caused by clients as a result of late approvals making payments, changes in the scope of work, or too many demands. In developing areas, the situation is exacerbated due to the bureaucratic nature of these processes making the project cost higher than expected [24]. To reduce such delays, effective communication and quick decision-making should be emphasized.

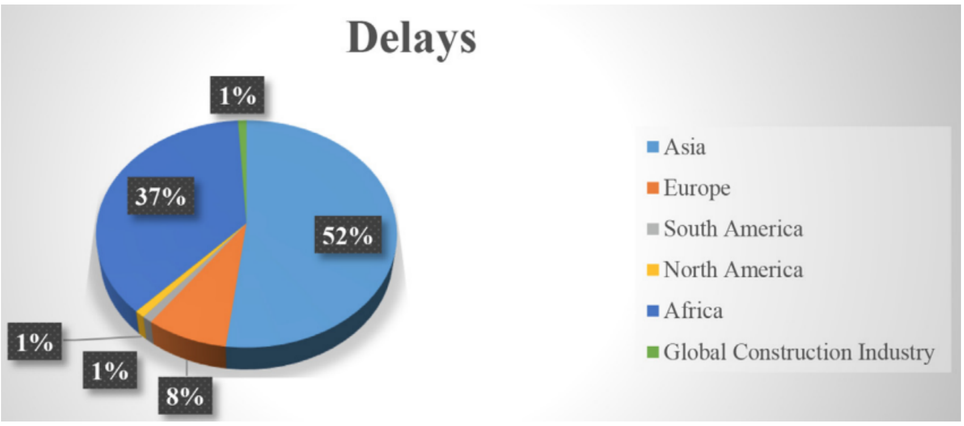

FIGURE 2.3: Geographical distribution of studies reviewed for delays [24]

2.3.4 Consultant-Related Delay

In any construction project, the Consultants control the pace of design by approving required documents and performing inspections and coordination. Late delivery of objective design documents or failure to achieve approval during the milestone stages of the relationship manager may lead to major capital cost increases on a project [25]. These problems can be dealt with through joint planning process involving consultants, contractors and clients.

2.3.5 External Factor

External agents – legal, political, or community actions – can bring about delays in the project timeframes, with higher integrated development costs in terms of extended downtime.

In the merged districts of Pakistan, such socio-political conditions are unique and can pose elevated costs due to prolonged project downtimes [26].

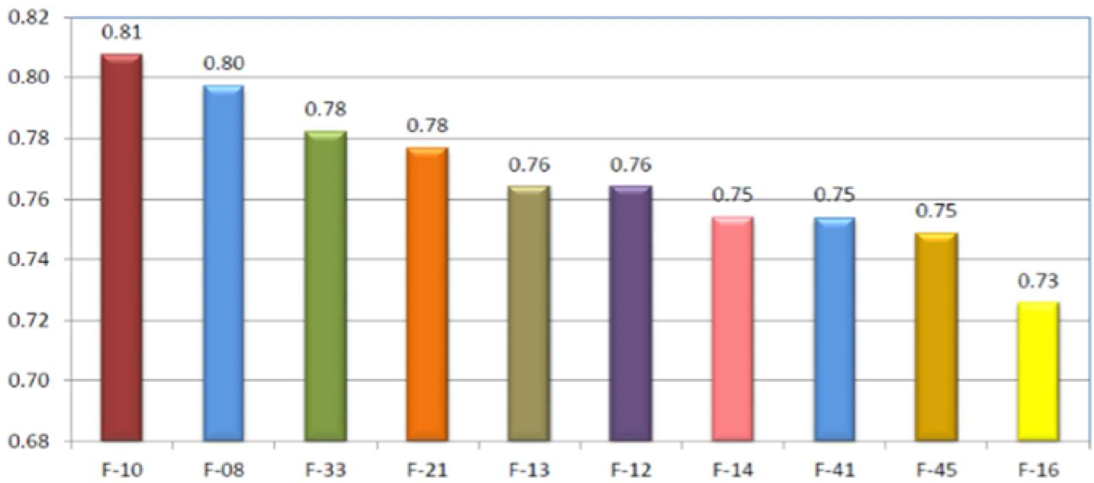

FIGURE 2.4: Top ten delay factors as per research results [26]

2.3.6 Weather-Related Delays

Severe weather conditions during construction, for example, heavy rainfall or hot weather, are more critical in remote or developing regions where construction timeframes are already set.

This leads to idle time for the equipment and the workforce and wastages of materials which exponentially increase costs [27]. These risks can combat weather prediction tools and contingency plans.

2.3.7 Material Supply Chain Issues

Furthermore, it is common to find logistics issues such as delays in deliveries, scarcity of materials, or inflation of prices in the supply chain management of road construction. Logistical issues create more problems in remote areas, which compound costs and delays of the project [28]. These risks require superior procurement planning and relationships with suppliers.

2.3.8 Project Planning and Scheduling Effectiveness

When the appropriate activities are not organized in a logical manner and there is no proper timing for the activities, critical parts of the projects are likely to be delayed, leading to time overruns and cost overruns. Application of more advanced project management tools and techniques such as critical path method (CPM) and program evaluation review technique (PERT) can alleviate this problem [29].

2.3.9 Impact of Delays on Cost Estimation

The inefficiencies and delays of any project magnify the costs through longer projects, additional costs to labor, and inflation of materials. With proper planning, such as appropriate estimation and provision of contingency plans, the losses caused by delays can be greatly minimized [30].

FIGURE 2.5: Flyover Project's Cost Revision with time [30]

2.3.10 Risk Management and Mitigation Strategies

Poor risk management practices only worsen the delays and the damages involved. Effective contracts using risk management techniques of proactive risk identification, regular risk reviews, and risk mitigation can help lessen the uncertainties and their cost implications [18].

Where construction and infrastructure road projects are concerned, the use of Building Information Modeling [BIM] among other technological inventions can improve the risk management processes.

2.4 Previous Work - Related

Table 2.2: Factors Affecting Delays

Sr.	Author	Year	Title	Country	Factor
1	[31]	2021	Investigating Delays in Road Infrastructure Projects and Their Impact on Cost and Time	Iran	Delay Classification, Contractor-Related Delays, Client-Related Delays, Risk Management, Impact on Cost Estimation
2	[32]	2020	The Influence of Project Delivery Methods on the Performance of Construction Projects	Egypt	Flexibility of Delivery Methods, Risk Management, Communication Efficiency, Resource Allocation
3	[33]	2019	Comparing the Effectiveness of Project Delivery Methods in the Construction Sector	USA	Cost Performance, Schedule Performance, Risk Management, Quality Standards
4	[34]	2017	The Role of Project Delivery Methods in Achieving Construction Project Objectives	South Korea	Flexibility of Delivery Methods, Schedule Performance, Resource Allocation, Communication Efficiency

Table 2.2 continued from previous page

Sr.	Author	Year	Title	Country	Factor
5	[35]	2015	The Impact of Project Delivery Methods on Construction Project Risk Management	Jordan	Risk Management, Flexibility of Delivery Methods, Resource Allocation, Cost Performance
6	[10]	2013	Analysis of Project Delivery Methods in the Construction Sector	UK	Team Collaboration, Communication Efficiency, Cost Performance, Schedule Performance

2.5 Tools and Methods to Address Factors

In construction management, such as road infrastructure projects, project management assists in reduction of time and cost. As defined by the Project Management Institute (PMI), construction management has some built-in processes that include planning, inspection, evaluation, and control with relevance to appropriate PDMs. According to these methods, meeting performance measures is possible, which should be taken especially while remembering parameters like cost efficiency and schedule completion in relation to project success. Different approaches like surveys, case studies, and comparative analyses have been adopted by various scholars to establish the PDM construction project performance relation- ship. For example, surveys, one of the most practical methods with respondents drawn from Industry experts, outlined some of the delay factors as contractor's delay, sums of Supply Chain Management of materials, as well as communication effectiveness across the board [36]. A statistical (SPSS) analysis of the information is therefore done with the help of charts to depict trends and correlations that are used in decision making.

Among other advantages, one of the popular and most popular methods of ranking the delay factors is the Relative Importance Index (RII) which helps project managers to determine cost and schedule determinants. Regarding the surveyed participants, RII allocates scores to delay factors that have a rating of one or above, and determine the mean estimates on a scale of one to five that are formulated in survey questionnaires [32]. The approach enables focusing on the reasons of postponement which demand immediate action and investment to which they are entitled. These techniques allow evaluation of the level of management and communication in the rest of the regards and, therefore, understand deeper how the delays influence the work of projects in general. When the qualitative and quantitative approaches are implemented, project managers can determine the risks of each delay quantitatively by its cost and develop effective strategies to mitigate it. The surveys, RII calculations, SPSS techniques, and so on define critical factors, and factors that must be considered in the proper selection of PDMs.

Therefore, these techniques offer an integrated framework for the management of delays, risk mitigation, and project completion of road infrastructure most efficiently and effectively possible.

2.6 Summary

The existing detours in the literature around the impact of time on the construction of road infrastructure cost suggest delays as one of the major contributors to the cost overrun in any construction project, especially in the case of road infrastructure projects. Different scholars point out the importance of Project Delivery Methods (PDMs), which are essential in forecasting the completion parameters of construction projects, including cost, time, and quality. PDM methods are chosen to address the project descope, budgetary expectations, and timeline slippage, which, as a result, can determine the possibility of time slippages. The delays in question include various types of Contractor-induced delays, Client-induced delays, Consultant-induced delays, Exogenous delays, Weather-induced delays, Material supply chain delays, and Project planning and scheduling efficiency. Literature notes that the delays that Contractor aspects causes are caused by poor management practices, inadequate skilled personnel, or financial constraints, while the Client attributes delays are usually associated with alterations in the project objectives and Indecision. Delays, which in this case are client-related, can be experienced as a result of poor integration, lack of supervision, or modification of the designs. Other factors which are beyond the control of the parties in- volved, such as government policies or unpredictable social/political environment, can also cause major disturbances. In construction works, schedule overruns are experienced during the rainy seasons when infrastructure projects are undertaken and seem to add to the already existing chaos. Also, material supply chain factors are barriers to the timely completion of construction events since the materials may be purchased but not delivered, leading to those projects being postponed.

These multifaceted delays collectively contribute to significant cost overruns and compromised project quality, underscoring the critical need for comprehensive risk management strategies. Addressing these challenges requires improved coordination among stakeholders, adoption of more efficient Project Delivery Methods, and enhanced planning to mitigate delays. Future research should focus on developing integrated frameworks that proactively identify and manage delay factors to ensure timely and cost-effective completion of road infrastructure projects.

Chapter 3

Methodology

3.1 Background

With the purpose of defining the methodology utilized for the analysis of the productivity of construction projects in relation to different project delivery systems within the construction industry, this chapter does this in a few steps. It outlines the methodological framework that guides the study, explaining how the research problem is approached and how relevant data is collected, analyzed, and interpreted. Given the complexity and multifaceted nature of construction projects, especially in regions with logistical, economic, and administrative constraints, a combination of both qualitative and quantitative research methods is employed. This mixed-methods approach allows for a more comprehensive understanding of the factors influencing delays and cost overruns.

To build a solid foundation for the methodology, a thorough review of existing literature was conducted to identify common delay factors and cost-related challenges in infrastructure development. Insights from previous studies helped shape the research design and inform the selection of variables. Additionally, expert opinions were integrated into the research process through structured questionnaires and interviews, enhancing the relevance and reliability of the collected data. More refined steps are discussed in the following parts of the text.

3.2 Research Design

To evaluate performance of construction project in relation to various delivery systems, this research uses an exploratory sequential design. At first, a qualitative phase is conducted where detailed literature review is done to identify the fundamental features of the outlooks the project is scoped to achieve.

After that, a survey is conducted with the aid of a structured questionnaire which utilizes the Delphi technique for the validation of content to gather the input of key and critical stakeholders in the area being studied.

It could be broadly described by the well-known issue of the interdependence of the de- livery systems and measure of performance in a construction project which is examined in a very concerning way and gives much- needed advice to the construction industry.

3.3 Preliminary Investigation

This investigative study begins with the examination of causes of delays such as the presence of the administrative errors, the absence of funds, and grossly limited funding of the planning, and procurement and weather constraints.

Additional costs related to the long labor duration, the rise in material costs, and higher equipment wearage in the event of increased resource consumption relative to the initial estimates imply that, these factors are likely to increase costs.

A careful analysis of these projects will be used to assist in the provision of an insight into trends, an examination of the costs that are associated with the delays, as well as the formulation of possible solutions to the problems.

The results will assist in bettering the project management, allocation of resources, interactions between the stakeholders all of which will lead to the reduction of delays and cost management in road infrastructure development by focus on aspects that matter.

3.4 Research Methodology

The methodology offers a methodical connection between approaches of project delivery and construction activity productivity. The work starts with the identification of what is known about the problem area and its underlying theories through an extensive review of literature. Thereafter, data collection is performed through expert interviews and a pretested structured questionnaire that utilizes the Delphi method. The results are then presented, discussed, and a proposed model is crafted that aims to change the practices in the industry as well as the outcomes of future projects.

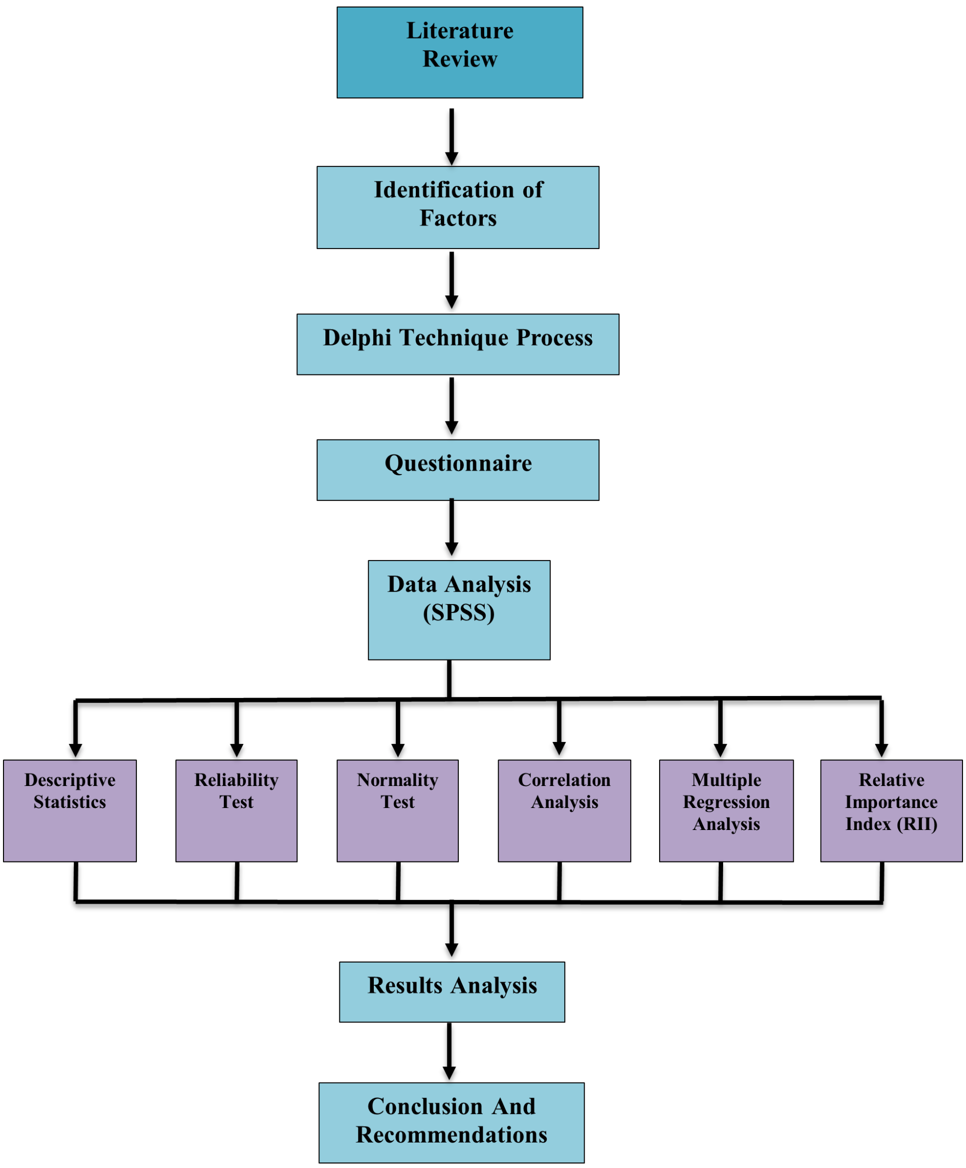

FIGURE 3.1: Research Methodology

3.5 Questionnaire Design

A set of 39 delay factors were identified in this study based on an extensive review of previous literature on construction delays. Numerous studies conducted across different countries have highlighted a wide range of causes, often numbering between 28 and 70 factors, depending on the scope and regional context. For instance, [13] identified 73 delay causes in large construction projects in Saudi Arabia, while [15] reported 28 critical factors in the Jordanian construction industry. Similarly, [14] documented 28 significant delay causes in Malaysia, focusing on client-related, contractor-related, and external issues. From this broad pool, factors that were repeatedly cited in the literature and were contextually relevant to the local construction environment were carefully shortlisted. Redundancies and overlaps were eliminated, and closely related factors were merged to avoid duplication. Thus, the 39 delay factors represent a refined synthesis of global empirical findings, adapted to suit the research objectives and regional context. The questionnaire is developed, using the Delphi approach, by expert respondents from the construction industry over 2 to 3 rounds. Through these professionals, the team was able to bolster and assess the criteria deduced from the literature review and ensure they are relevant to the performance of construction projects and accurate so as to be able to measure the implementation of varying methods of project delivery.

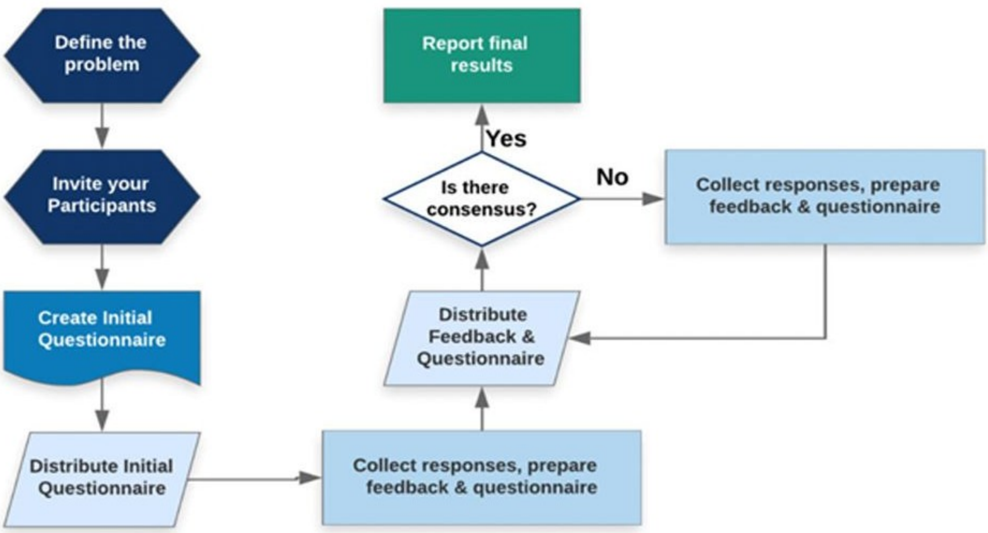

Figure 3.2: Delphi Technique Process

The Delphi technique was adopted in this study to refine and validate the selection of delay factors and to ensure the questionnaire achieved both reliability and contextual relevance. The Delphi method is a structured, iterative process that relies on the collective judgment of experts through multiple rounds of consultation, with the goal of reaching consensus on complex issues [37]. Unlike traditional surveys, the Delphi process reduces bias by maintaining anonymity of responses and allows experts to reconsider their views in subsequent rounds based on group feedback.

In this research, the Delphi technique was particularly suitable because delay causes in construction projects often overlap and vary depending on regional practices and delivery methods. By engaging a panel of experts from the construction industry, the process allowed refinement of the initially broad pool of delay factors derived from literature. In Round 1, experts reviewed the preliminary list of factors and provided feedback on their relevance and clarity. In subsequent rounds, factors were merged, reworded, or eliminated based on consensus, until a final set of 10 validated factors was confirmed. This iterative refinement process ensured that only the most pertinent and widely recognized delay causes were retained, while context-specific issues were also incorporated.

The Delphi method has been widely used in construction management research to identify and prioritize risk factors, delay causes, and critical success elements because of its ability to capture expert knowledge systematically and build consensus [37–39]. Thus, its use in this study provided methodological rigor and enhanced the credibility of the questionnaire design.

3.6 Development of Factors

There was an attempt to combine the expert opinions and literature reviews with other frameworks. The previous building projects studies were analyzed for possible factors pertaining in performance and delivery systems of projects in question [40, 41]. Thereafter, the study was sent to professionals in the field of construction both through emails and handouts with the aim of improving and modifying the selected factors [42]. The respondents were asked to evaluate each factor in terms of its importance and relevance in building projects vis-a-vis their experience or research in the area [43].

Before arriving at the four factors, we validated them using a pilot study when appropriate feedback was provided in the questionnaire. The experts offered insight on which factors were most critical for project delivery and performance [41, 44]. These selected experts are drawn from the cut-throat construction industry. Hence, the specialist factors would be appropriate and tactical as factors under consideration. In formulating the specialist factors, the experts regarded key industry challenges and broadened the factors for the questionnaire, resulting in more useful data [42, 44]. Furthermore, careful respondent selection facilitates a high level of confidence in the trustworthiness of the information obtained [40].

Table 3.1: Development of Factors

Factors	**Responses from Experts**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Changes in project scope or design modifications	✓				✓		✓			3
Incomplete or unclear project specifications		✓		✓		✓		✓		4
Poor project planning and scheduling		✓		✓						2
Risk Management and Mitigation Strategies	✓	✓	✓	✓	✓	✓	✓	✓		8
Dela✓s in approvals and permits				✓						1
Poor financial management by the contractor		✓			✓			✓		3
Lack of skilled workforce or labor shortages	✓			✓						2
Material Supply Chain Issues		✓	✓	✓	✓		✓	✓		6
Poor site management and supervision	✓		✓			✓				3
Delayed procurement of materials and equipment	✓									1
Inefficient resource allocation		✓		✓		✓		✓		4
Delay in decision-making by the client	✓									1
Late payments to contractors	✓		✓			✓		✓		4

Table 3.1 continued from previous page

Factors	**Responses from Experts**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
Contractor-Related Delays	✓	✓	✓	✓	✓					5
Frequent changes in project requirements		✓								1
Bureaucratic processes and slow approvals	✓		✓						✓	3
Delay in design approvals and revisions		✓		✓						2
Weather-Related Delays	✓	✓	✓	✓	✓	✓				6
Inadequate supervision and quality control		✓	✓							2
Poor communication between stakeholders				✓			✓		✓	3
Shortages or unavailability of materials		✓								1
Price fluctuations of materials and equipment			✓		✓					2
Client-Related Delays		✓			✓		✓	✓	✓	5
Delays in the delivery of materials and machinery	✓									1
Shortage of skilled labor		✓		✓		✓				3
External Factors	✓		✓		✓		✓	✓	✓	6
Low productivity of workers		✓		✓			✓			3
Labor strikes and disputes	✓		✓		✓					3
Adverse weather conditions				✓		✓		✓	✓	4
Political instability and policy changes		✓								1
Unexpected ground conditions and site constraints			✓		✓					2
Economic fluctuations affecting project funding				✓						1
Project Planning and Scheduling Effectiveness		✓		✓	✓	✓	✓	✓	✓	7
Disputes between stakeholders		✓		✓						2
Inadequate contract clauses related to delays			✓		✓		✓			3
Consultant-Related Delays		✓		✓		✓	✓	✓	✓	6
Legal claims and arbitration processes										
Impact of Delays on Cost Estimation		✓	✓	✓	✓	✓	✓	✓	✓	8
Unforeseen geological or environmental conditions			✓				✓			2

3.7 Impact Scale (Likert)

The results of construction projects, especially concerning the delay-related variables, were measured with the help of a five-point Likert scale. The approach is common in the construction management studies to quantify the perceptions, attitude, and the relative significance of the various variables associated with the project [45].

Under this research, the respondents were requested to rate every identified delay factor according to the perceived influences on the performance of the project. The Likert scale provided a systematic and measurable method of obtaining expert data and allowed the statistical treatment of trends on the responses.

The project performance factors that were selected and evaluated based on the following matching criteria:

1. 1 – Very Low Impact
2. 2 – Low Impact
3. 3 – Moderate Impact
4. 4 – High Impact
5. 5 – Very High Impact

The scaling method made it possible to classify the delay factors successfully based on their seriousness and applicability in the performance of road infrastructure projects.

TABLE 3.2: Impact scale (Likert scale)

Descriptive Range	**Range**
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly Agree	5

3.8 Data Acquisition

The first component of the data collection procedure was an extensive search through the available literature to determine the fundamental parameters that will determine successful implementation of construction projects [40, 41].

On the basis of this review, a number of pertinent delay factors were formulated. To confirm and narrow down these factors, the Delphi technique has been used whereby a panel of construction industry specialists have been consulted at least two or three times [37].

Based on the result of this expert panel, a structured questionnaire was developed. This process of iteration was to achieve an agreement about the most important factors that influence the performance of road infrastructure projects. After its completion, the questionnaire was sent to a more generalized group of construction professionals to reflect the view concerning the significance of each of the identified factors.

The five-point Likert scale was used to obtain data where respondents would be asked to rate the perceived importance of each of the factors that affected the success or delay of construction projects being undertaken under various project delivery systems.

This approach ensured the quantification of expert opinions, making it possible to conduct meaningful statistical analysis and draw reliable conclusions [45].

3.9 Tools for Data Analysis

The survey data was analyzed using the IBM SPSS Statistics with the intent of determining how effective construction projects are based on their types of deliveries. IBM SPSS is one of the most widely used construction software due to its advanced user-friendly characteristics and ability to execute a wide range of computations from basic bivariate statistics to multivariate analyses.

[46] claim that construction management scholars find it popular because it processes big datasets and performs both parametric and non-parametric analyses at macro and micro levels resulting in credible outcomes. Once the data were determined to be reliable, the next task was to examine the distribution pattern of the results so that one could get to know the level of consistency and validity of the responses provided by the participants.

As it was explained in [47], IBM SPSS contributes to analyzing the research conclusions providing the opportunity to create reports, graphs, charts, and other visual summarizing data.

The software possesses advanced statistical functions to perform correlation and regression analysis which aid in establishment of relationships between project delivery systems and project key performance indicators including cost, schedule and quality.

In addition, studies indicate that construction industry research employing IBM SPSS is very common since most complex and large datasets that complicate the process of solving specific research areas can be handled by the use of this software.

3.9.1 Descriptive Statistics

Descriptive statistics were initially applied to summarize the key characteristics of the collected data. This involved calculating measures of central tendency, such as the mean, and measures of dispersion, including the standard deviation, for important variables like contractor-related delays, client-related delays, material supply chain issues, and project planning effectiveness [48, 49].

Additionally, frequency distributions were employed to analyze how often each delay factor was reported by respondents. This provided valuable insights into the most common challenges encountered in road infrastructure projects in Khyber Pakhtunkhwa (KPK), enabling the identification of predominant causes of delay and prioritization for further analysis.

3.9.2 Reliability Test

The relationship between variables was measured with Cronbach's alpha, which determines internal reliability, and in this case the reliability threshold was set at 0.7 or above. Following general reliability of the study can be checked through results obtained from the application of a Likert scale, The results obtained a high value of Cronbach's Alpha, implying that the internal consistency of the questionnaire was satisfactory, and hence analysis of construction project delivery systems from the perspective of project performance could be conducted on the data [50].

3.9.3 Normality Test

The Skewness and kurtosis were applied to assess whether the collected data sets follow a normal distribution [51]. In the normality test, skewness measures the symmetry of the data distribution. A skewness value close to zero indicates that the data is approximately symmetric, while positive or negative values show right- or left-skewed distributions.

Kurtosis, on the other hand, measures the peakedness or flatness of the distribution compared to a normal curve. A kurtosis value close to zero (after adjusting for excess kurtosis) indicates a distribution similar to normal, whereas high positive values indicate a sharper peak and negative values indicate a flatter distribution.

Testing for normality is crucial to determine the suitability of parametric statistical methods for subsequent analysis. A significance level (p-value) greater than 0.05 indicates that the data do not significantly deviate from a normal distribution, suggesting parametric methods can be appropriately used. Conversely, a p-value less than 0.05 implies a significant deviation from normality, indicating the data are non-parametric [52].

The normality test informs the choice between parametric and non-parametric tests when analyzing the influence of project delivery methods on construction project performance. If data approximately satisfy normality and exhibit linear relationships, parametric tests (e.g., Pearson correlation, regression) are preferred due to their efficiency and power. However, non-parametric tests (e.g., Spearman's rank correlation, Mann-Whitney U) are better suited when data are non-normally distributed, non-linear, or measured on ordinal scales [53, 54].

3.9.4 Correlation Analysis

Pearson's correlation coefficient was employed to measure the strength and direction of linear relationships between various delay factors (e.g., contractor-related delays and cost estimation) and project performance indicators. This statistical technique allowed for the quantification of how strongly each delay factor influenced key outcomes such as cost overruns and project delays [43, 49].

By applying correlation coefficients, the study was able to identify which delay factors, such as financial delays, material shortages, or poor site management, had the strongest association with cost escalation. This preliminary step ensured that the analysis did not only depend on frequency-based rankings (e.g., RII) but also tested for statistical associations, thereby improving the robustness of the findings [55].

3.9.5 Multiple Regression Analysis

Multiple regression analysis was performed to quantify the impact of independent variables, such as contractor-related delays, weather-related delays, and project planning effectiveness, on the dependent variable-cost estimation or overall project performance [44, 48].

Building upon this, regression analysis was employed to further quantify the predictive power of significant delay factors on project cost overruns. While correlation indicates the existence of a relationship, regression goes a step further by estimating the magnitude of influence and determining how much variation in the dependent variable (cost overrun) can be explained by one or more independent variables (delay factors). For example, regression allowed the study to determine the extent to which contractor-related issues or client payment delays contributed to increased project costs, while controlling for other factors.

This statistical modeling approach has been widely used in construction management research to validate findings and provide predictive insights.

3.9.6 Relative Importance Index (RII)

To prioritize the 10 delay factors identified, in this study, we used the Relative Importance Index (RII) that has been used extensively in construction management studies to rank important factors [56, 57].

The RII finds its application especially well in converting ordinal Likert scale responses into similar indicators to demonstrate the relative importance of each of the factors. The respondents were asked to rank the importance of each delay factor in a five-point Liking scale with the lowest being 1 (least important) and the highest being 5 (most important).

RII of each factor was then calculated by using the formula:

$$RII = \sum \frac{W}{A} \times N \tag{3.1}$$

In which W is the weight that each factor will have with the respondent, A is the maximum number of points one can achieve on the scale (5 in our case), and N is the number of respondents. This calculation results in a number between 0 and 1 with higher numbers signifying higher perceived importance.

RII was used to rank factors in a decreasing order which created an opportunity to identify the most important causes of construction delay. This approach has been validated in prior studies examining delay causes and construction performance issues in various countries, thereby ensuring methodological robustness and comparability with earlier research [13–15].

3.10 Summary

The methodology describes the expert evaluation process of the performance factors of construction projects by using Expert Consensus Methods, multi-criteria decision-making processes, and statistical methods. The Delphi technique, which combines questionnaires and interviews, is employed to elicit the expert's opinion on the critical factors and criteria to be analyzed. In data collection, we made the participants answer self-designed survey questionnaires which helped ensure that all points of view are incorporated. An IBM SPSS Statistics software was used to analyze the data in order to ensure reliability and effectiveness and it's the same system that was previously perceived to address the identified gaps in data analysis and control. The internal consistency of the data correlating responses received forms the reliability test. The methodology for data analysis in this study employed a series of statistical techniques, including descriptive statistics, correlation analysis, regression analysis, and RII. These methods allowed for a comprehensive understanding of the delays affecting road infrastructure projects in KPK and provided valuable insights into how these delays impact cost estimation and project completion times. The findings from these analyses offer actionable recommendations for improving project management practices and mitigating delays in future projects. In contrasts to one of the earlier methodologies mentioned, this one incorporates the expert's opinion of the decision-making paradigm along with relevant calculations cumulatively determining a construction project's criteria of successful implementation. The merging of this tools leads to the ultimate ranked selection of parameters which decisively impact the forecasted results of the project.

Chapter 4

Results and Discussion

4.1 Background

This chapter outlines the data collection methods, including surveys and statistical analysis. The study employs purposive sampling to select participants based on key characteristics. Following this, the demographic data of the respondents is presented.

A Likert scale is utilized to assess participants' attitudes toward various issues. The collected data is then analyzed using statistical techniques, with the results thoroughly examined to highlight key findings and their implications.

4.2 Demographic Results of Data

The demographic data contained in this research includes gender, experience, education, and designations, as shown in Table 4.1. The selection of respondents from diverse professional roles such as client representatives, contractors, consultants, and project managers align with previous studies [14, 58].

The inclusion of varying experience levels, from 0–2 years up to more than 10 years, is supported by research indicating that delay analysis benefits from input across a range of 38 expertise levels [59]. Similarly, the educational background of respondents, including diploma holders, B-Tech, bachelor's, and master's degree holders, reflects the standard profile used in similar research [60].

The demographic data contained in this research includes gender, experience, education, and designations as shown in Table 4.1.

TABLE 4.1: Demographic Data

Age	Qualifications	Professional Role	Experience
18-25	Diploma Holder	Client Representative	0-2
26-35	B-Tech	Contractor	3-5
36-45	Bachelor	Consultant	6-10
46-50	Masters	Project Manager	11-15
50+	PhD	Other	15+

4.2.1 Age

The age frequency of respondents is categorized as follows: 18–25 years, 26–35 years, 36–45 years, 46–50 years, and above 50 years. Fig 4.1 shows these results. The data shows that the frequency of each age group is 12, 9, 21, 50, and 78 respectively.

In the age bracket of 50 and above, there is a commendable representation of respondents in the dataset. In fact, this group represents the highest number of participants (78 responses), constituting more than 50% of the sample. This suggests that the data collected in this study is most likely directed toward representatives of this particular age group, a pattern also observed in similar construction industry studies [15, 60].

The 46-50 age group also has a significant presence (50 responses). As a result, upper age groups dominate by far. The younger age groups are relatively underrepresented-36-45 (21 responses), followed by 18-25 (12 responses) and 26-35 (9 responses)-which aligns with findings in previous studies showing that older professionals often hold senior roles and are more involved in delay-related decisions[14, 59].

The age-related demographic results show a mean value of 4.018 with a standard deviation of 1.990, indicating that most respondents belong to relatively higher age categories, with moderate variation in responses. The skewness value of −1.222 suggests a negative skew, meaning that more participants were from older age groups, while the kurtosis value of 0.623 indicates a moderately peaked distribution. This demographic factor is important because age is often linked with professional maturity and practical experience in handling road projects. Older respondents, with more field exposure, tend to provide deeper insights into recurring delay causes and cost overruns, whereas younger respondents may be more familiar with modern management practices but less experienced in dealing with unforeseen disruptions. Therefore, including age in the analysis ensures a balanced perspective, linking professional maturity with the identification and management of delays in road infrastructure projects.

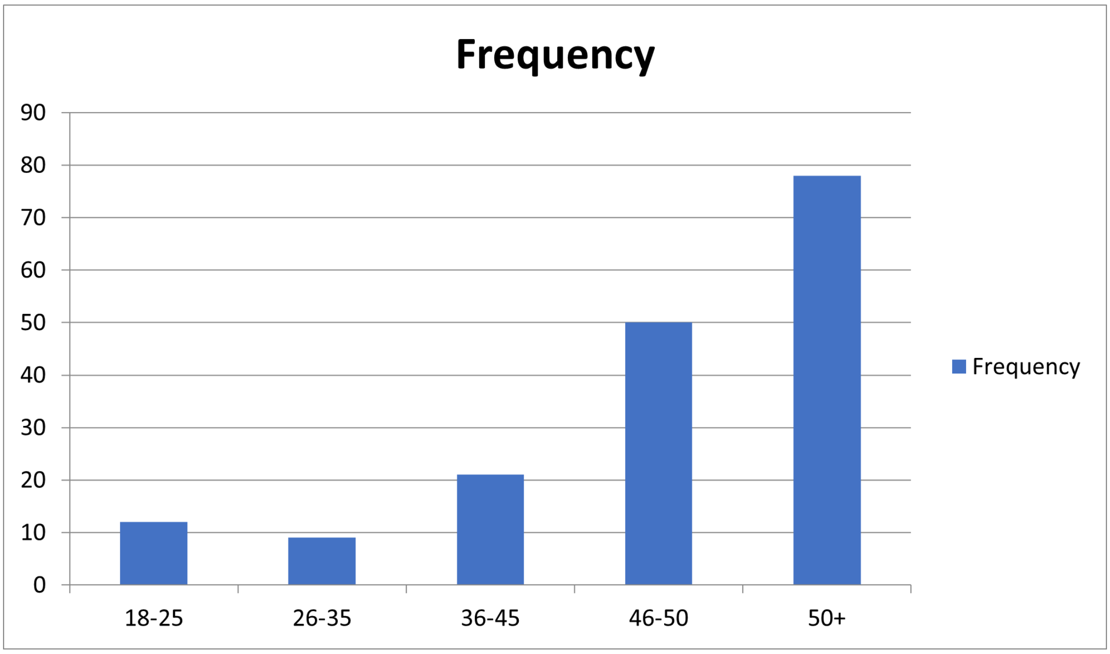

Figure 4.1: Age of Respondents

4.2.2 Qualification

The qualification distribution of the respondents sampled shows a marked concentration of higher education levels. The highest number of participants are Master's degree holders (73 responses), followed by Bachelor's degree (38 responses), and

PhD holders (37 responses). This suggests that the level of education stratum indicates a majority of participants in the study are well-educated, which arguably contributes to the quality of responses given.

A similar trend has been observed in prior studies where construction industry professionals with higher education levels were found to be more engaged in delay analysis and cost estimation processes [14, 58].

On the other side, respondents with lower educational qualifications are relatively few. Diploma holders (5 respondents) and B-Tech respondents (17 respondents) form a small segment of the sample. Diploma holders were included in the survey because they play a direct and practical role in road infrastructure projects as site supervisors, foremen, and field engineers.

Their on ground experience gives them valuable insights into day-to-day project delays, resource constraints, and cost implications, which are sometimes overlooked by higher management. Including their perspectives ensured that the study captured a more comprehensive and realistic understanding of delay factors and their cost impacts across all levels of project execution.

The mean education level of respondents is 3.71, suggesting that most participants fall within the mid-to-higher education categories, including diploma and undergraduate degree holders. The standard deviation of 1.01 indicates a moderate variation in educational backgrounds.

The skewness value of –0.662 shows a negative skew, meaning that a larger proportion of respondents possess relatively higher educational qualifications compared to lower levels.

The kurtosis value of 0.012 indicates a near-normal distribution, suggesting that the responses are moderately balanced without extreme peaks or flatness. These results highlight that the sample effectively represents respondents with diverse but predominantly higher educational backgrounds, which is essential for capturing informed perspectives on delays and cost impacts in road infrastructure projects.

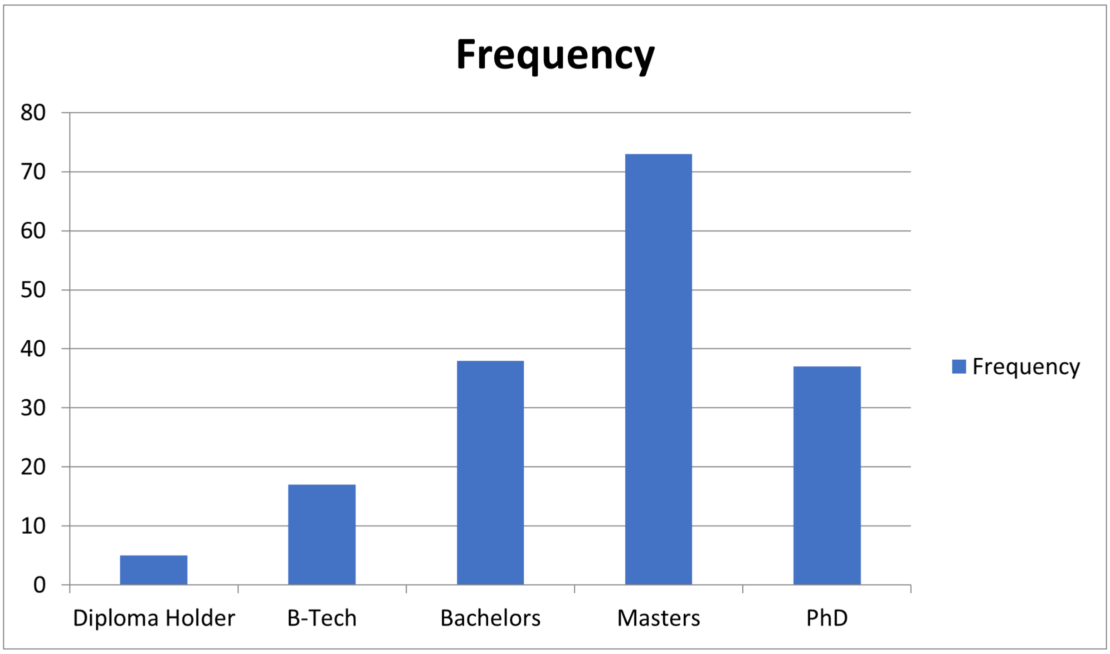

FIGURE 4.2: Qualifications

4.2.3 Professional Role

The distribution of respondents highlights the preponderance of employees who work in project management and consultancy-related positions. The biggest group is formed by Project Managers (59 responses), and the second group comprises Consultants (49 responses).

This suggests that the study is largely skewed to the views of people who manage or consult on projects, which might be why the results are biased towards strategic and managerial concerns. Similar respondent patterns have been observed in earlier studies focusing on delay impacts, where consultants and project managers were frequently the dominant groups [14, 58].

Besides, there is another group of respondents constituting a significant number (42) of Others, indicating different roles that can be of assistance to the study. Granularity in the definition of this group can turn out to be interesting in terms of the definite job functions that can be concealed under this broad division. As presented in the literature that multi-stakeholder input is useful in the study of delay factors [60].

In contrast, Client Representatives (10 responses) and Contractors (10 responses) are relatively scarce. The lack of participation from client and contractor circles may mean an incomplete understanding of their problems and perspectives in the execution of the projects.

Previous research also emphasizes that contractors and clients play crucial roles in identifying delay causes, and their underrepresentation may affect the comprehensiveness of the findings [59, 61].

The mean value of respondents' professional role is 3.665, indicating that participants represent a mix of mid- to higher-level positions within the construction industry. The standard deviation of 1.093 reflects moderate variation across different roles, showing that respondents were spread across site engineers, project managers, contractors, and supervisory staff.

The skewness value of −0.676 shows a negative skew, suggesting that more respondents belonged to higher professional roles compared to entry-level positions. The kurtosis value of 0.060 indicates a near-normal distribution. These results confirm that the survey included professionals from diverse roles, ensuring balanced insights into delay factors and their cost implications in road infrastructure projects.

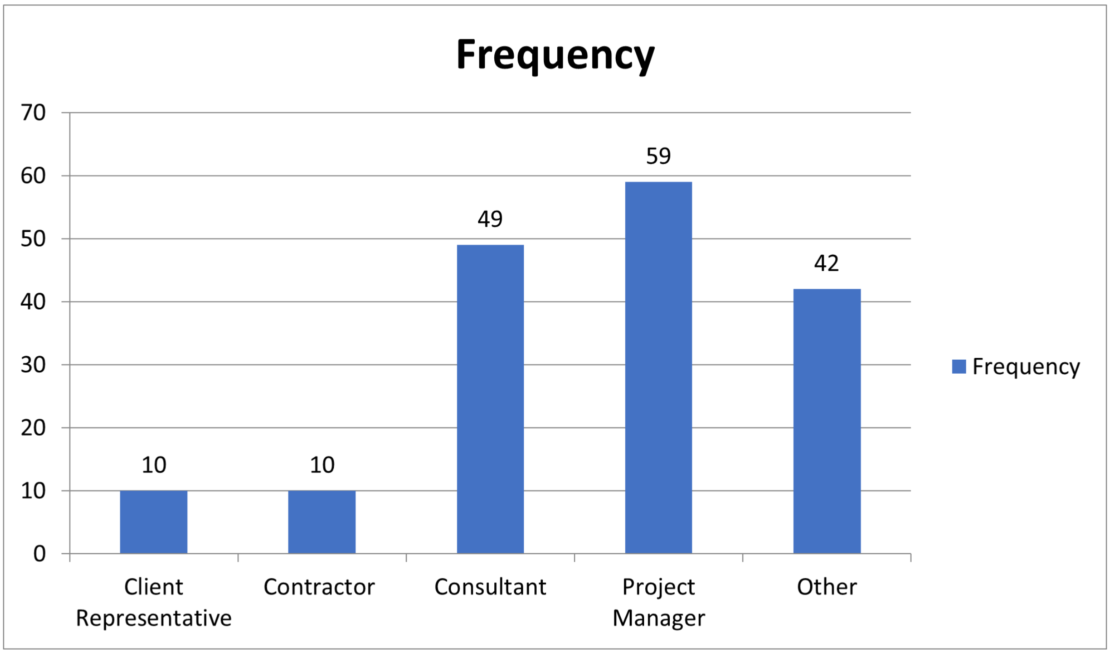

FIGURE 4.3: Professional Role Distribution

4.2.4 Experience

The experience distribution of respondents suggests that there is a high concentration of seasoned professionals. The majority of participants (53 each) have been working for over six years, with the 11–15 years and 15+ years categories suggesting that the study is conducted from the point of view of seasoned professionals, who tend to have better perspectives owing to practical experience.

This aligns with earlier findings where experienced professionals were shown to have deeper insights into delay causes and cost implications in construction projects [14, 58].

A notable chunk of respondents (46 responses) falls within the 6–10 years category, which suggests that mid-level professionals are well represented. While they have considerable experience, they are still growing in their respective roles.

This balance reflects the typical workforce structure in construction-related research, where both senior and mid-level professionals contribute significantly to practical project knowledge [59].

In comparison, respondents with less experience (0–2 years: 6 responses, 3–5 years: 12 responses) form a considerably smaller part of the sample. The relatively low engagement of less experienced respondents can hinder a construct like this which attempt to understand the challenges faced in the domain by newcomers. Prior studies have also highlighted the importance of including early-career professionals to explore training gaps and onboarding challenges within the construction industry [60].

The mean experience level of respondents is 3.794, which indicates that most participants possess moderate to higher levels of professional experience in road infrastructure projects. The standard deviation of 1.071 reflects some variation across respondents' experience levels.

The skewness value of –0.633 indicates a negative skew, suggesting that a greater proportion of respondents belong to higher experience categories. The kurtosis value of –0.161 points to a relatively flat distribution, implying that responses were spread without sharp peaks. These results confirm that the sample included professionals with varied but predominantly higher levels of experience, ensuring reliable insights into delay factors and their cost implications.

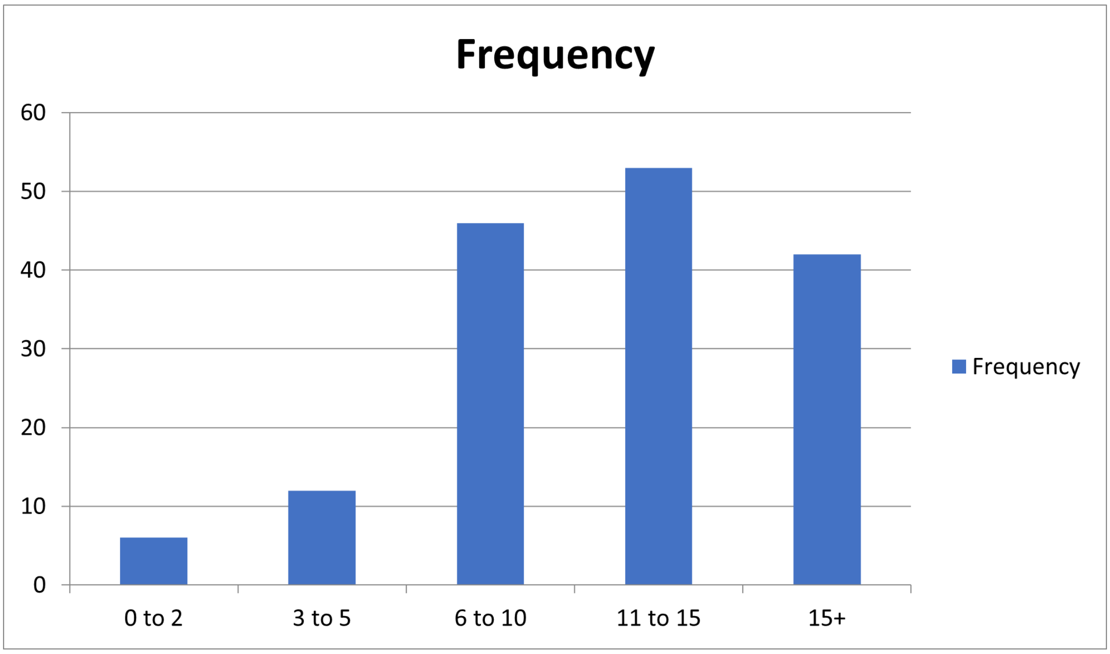

FIGURE 4.4: Experience Distribution

4.3 Examination of Statistics

The collected data is efficiently analyzed using statistical methods in Excel and SPSS.

4.3.1 Reliability Analysis

When collecting data, particularly with a Likert scale, the Cronbach's Alpha technique is commonly used to assess internal consistency. A reliability coefficient above 0.7 indicates consistent data 7 [62]. The results of the reliability test for various improvement factors are presented in Table 4.2.

Analyzing reliability enables evaluation of the measurement scale's internal consistency and how the instrument provides stable results. Cronbach's Alpha is one of the most recognized forms of reliability testing, which assesses the correlation of items within a construct [63]. A score of greater than 0.7 is generally deemed acceptable, while scores exceeding 0.8 are categorized as good reliability. Any results over 0.9 would indicate excellent reliability [64].

The analysis for reliability was carried out in this research based on different delay factors pertaining to project management. The analysis revealed a strong internal consistency across the factors. The most effective rating was obtained for Project Planning and Scheduling Effectiveness ($\alpha = 0.902$), where respondents self-evaluated their performance at an excellent level of planning and scheduling. Impact of Delays on Cost Estimation ($\alpha = 0.895$) and Delay Classification ($\alpha = 0.894$) were also reliable, as respondents reached consensus on how they perceive delays to impact cost estimation and how they categorize delays. Likewise, Contractor-Related Delays ($\alpha = 0.897$) and Risk Management & Mitigation Strategies ($\alpha = 0.971$) produced high internal consistency scores, indicating reliable measurement of contractor performance and risk-related practices. Other factors, such as Weather-Related Delays ($\alpha = 0.866$), External Factors ($\alpha = 0.855$), and Material Supply Chain Problems ($\alpha = 0.804$), were also found to be reliable, suggesting strong respondent agreement on the external causes of project delays. Despite showing lower reliability than the other constructs, Consultant-Related Delays ($\alpha = 0.841$) and Client-Related Delays ($\alpha = 0.767$) still achieved acceptable levels. This indicates that perceptions of delays related to consultants and clients may vary more widely, yet remain dependable. In general, the findings support that the survey instrument used in this study is reliable, as it exceeds the recommended threshold. All constructs have shown results above 0.7, instilling confidence in the trustworthiness of the data collected and its appropriateness for further analysis. The results of the reliability test for various improvement factors are presented in Table 4.2.

Table 4.2: Reliability test

Improvement of factors	**No. of items**	**Cronbach's Alpha**
1. Delay Classification	4	.894
2. Contractor-related delays	4	.897

Table 4.2

Improvement of factors	**No. of items**	**Cronbach's Alpha**
3. Client-related delays	4	.767
4. Consultant-related delays	4	.841
5. External factors	4	.855
6. Material supply chain issues	4	.804
7. Weather-related delays	4	.866
8. Impact of delays on cost estimation	4	.895
9. Project planning & scheduling effectiveness	4	.902
10. Risk management & Mitigation Strategies	4	.897

Analyzing reliability enables evaluating the measurement scale's internal consistency and how the instrument is able to provide stable results. Cronbach's Alpha is one of the most recognized forms of testing reliability, which assesses the correlation of items within a construct. A score of greater than 0.7 is generally deemed acceptable, while scores exceeding 0.8 are categorized as good reliability. Any results over 9 would indicate excellent reliability.

The analysis for reliability was carried out in this research based on different delays factors pertaining to project management and the analysis conducted revealed a strong internal consistency across the factors. The most effective rating was obtained for Project Planning and Scheduling Effectiveness where respondents self-evaluated their performance rating a great ($\alpha = 0.902$) level of planning and scheduling.

Impact of Delays on Cost Estimation ($\alpha = 0.895$) and Delay Classification ($\alpha = 0.894$) were also reliable as respondents' reached consensus on how they perceive that delays will impact cost estimation and how they categorize those delays. Likewise, Contractor Related Delays ($\alpha = 0.897$) and Risk Management & Mitigation Strategies ($\alpha = 0.897$) produced high internal consistencies as it relates to the accuracy of the issues of contractor performance and risk management strategies.

Other Weather-Related Delays ($\alpha = 0.866$), External Factors ($\alpha = 0.855$), and Material Supply Chain Problems ($\alpha = 0.804$) were also reliable providing evidence that this outer perception on project delays is true and more respondents believe so.

Despite showing lower reliability than the other constructs, Consultant-Related Delays ($\alpha = 0.841$) and Client-Related Delays ($\alpha = 0.767$) still made it to an acceptable level. Therefore, it can be assumed that the perceptions of delays relating to consultants and clients are somewhat divergent, but still dependable. In general, the findings support that the survey instrument used in this study is reliable as it exceeds the threshold.

All constructs have shown results above 0.7 which instills the confidence of trustworthy data collection and is appropriate for subsequent evaluation.

4.3.2 Descriptive Analysis

Descriptive statistics capture the important information of a dataset by examining the minimum, maximum, average (mean), and standard deviation. The average response, referred to as the mean, shows the overall direction of the perceptions, while the standard deviation indicates dispersion and helps reveal the extent to which observations vary from one another [53, 55]. Higher values in standard deviation indicate greater variability in respondents' perceptions. Everything was rated on a broad five-point Likert scale, where each factor had 170 responses. The average score for each factor was calculated and recorded. The Impact of Delays on Cost Estimation had the highest mean score at 3.7515, suggesting that respondents strongly believe cost estimation is particularly vulnerable to delays. In addition, Weather-Related Delays scored a notable 3.7191, and Delay Classification also scored high at 3.7088. These indicate that participants commonly encounter these issues in project execution. Other delay factors scored slightly lower, with External Factors earning 3.6735, Consultant-Related Delays at 3.6426, Client-Related Delays at 3.6412, and Contractor- Related Delays at 3.6309. These values still reflect general agreement that such factors contribute meaningfully to project delays. This is consistent with literature highlighting that delays typically stem from multifaceted causes—contractor inefficiencies, client decisions, consultant delays, and environmental or logistical issues [14, 65]. Moderate variation in responses was observed. The lowest standard deviation, implying more consistent responses regarding its role in minimizing delays, was observed for Project Planning & Scheduling Effectiveness at 0.7434. On the other hand, Delay Classification and Weather-Related Delays had higher standard deviations of 0.9733 and 0.9029 respectively, indicating notable disagreement among respondents on their significance. From the descriptive statistics, it is evident that project delays are influenced by a broad set of internal and external issues. These findings confirm prior research that suggests integrating risk management with robust planning practices is essential for reducing delays in road infrastructure projects [47, 61].

Table 4.3: Descriptive statistics analysis

Improvement Factors	**N**	**Min**	**Max**	**Mean**	**Std. Deviation**
Delay Classification	170	1.0	5.0	3.7088	.97327
Contractor-related delays	170	1.0	5.0	3.6309	.92636
Client-related delays	170	1.0	5.0	3.6412	.82082
Consultant-related delays	170	1.0	5.0	3.6426	.88580
External factors	170	1.0	5.0	3.6735	.88338
Material supply chain issues	170	1.0	5.0	3.5735	.84731
Weather-related delays	170	1.0	5.0	3.7191	.90291
Impact of delays on cost estimation	170	1.0	5.0	3.7515	.92127
Project planning & scheduling effectiveness	170	1.0	5.0	3.6614	.74342
Risk management & Mitigation Strategies	170	1.0	5.0	3.6309	.92636

4.3.3 Normality Test

Normality tests are essential in statistics as they determine whether the data or a dataset follows a normal distribution. The symmetry of the data is quantified using skewness, while kurtosis indicates the “peakedness” of the distribution.

For a distribution to be considered normal, skewness should be close to 0, indicating symmetry, and kurtosis should be near 3, indicating a mesokurtic (normal) distribution [66, 67].

In this study, we analyzed the skewness and kurtosis values to determine the normality of the data. The skewness values for all variables were approximately 0, suggesting that the data is symmetrically distributed. The kurtosis values remained within the acceptable range, indicating that the distributions are neither too flat nor excessively peaked.

Given these results, no transformation of the data or use of non-parametric tests is necessary. The skewness and kurtosis results demonstrate that the dataset approximates normality. As a result, the assumptions for conducting further parametric statistical analyses are not violated. This confirms the validity of using techniques such as regression or ANOVA in subsequent stages of the study [54].

Table 4.4: Normality Test

Question	Skewness	Kurtosis	Normal/ Not Normal
DC1	-.766	-.054	Normal
DC2	-.019	.300	Normal
DC3	-.654	-.174	Normal
DC4	-.686	-.028	Normal
ContractorRD1	-.479	-.295	Normal
ContractorRD2	-.605	-.090	Normal
ContractorRD3	-.754	.064	Normal
ContractorRD4	-.634	.114	Normal
ClientRD1	-.743	.121	Normal
ClientRD2	-.776	-.076	Normal
ClientRD3	-.686	-.093	Normal
ClientRD4	-.633	-.273	Normal
ConsultantRD1	-.784	.126	Normal
ConsultantRD2	-.683	.167	Normal
ConsultantRD3	-.724	.095	Normal
ConsultantRD4	-.502	-.302	Normal
EF1	-.645	-.180	Normal
EF2	-.741	.013	Normal
EF3	-.625	-.189	Normal
EF4	-.520	-.213	Normal
MSCI1	-.596	-.213	Normal
MSCI2	-.639	-.302	Normal

Table 4.4 continued from previous page

Question	Skewness	Kurtosis	Normal/ Not Normal
MSCI3	-.722	-.110	Normal
MSCI4	-.781	.382	Normal
WRD1	-.811	-.054	Normal
WRD2	-.606	-.333	Normal
WRD3	-.911	.390	Normal
WRD4	-.767	.434	Normal
IDCE1	-.914	.493	Normal
IDCE2	-.033	.850	Normal
IDCE3	-.789	.097	Normal
IDCE4	-.733	.011	Normal
PPSE1	-.977	.749	Normal
PPSE2	-.997	1.333	Normal
PPSE3	-.757	.561	Normal
PPSE4	-.159	1.063	Normal
RMMS1	-.479	-.295	Normal
RMMS2	-.605	-.090	Normal
RMMS3	-.754	.064	Normal
RMMS4	-.634	.114	Normal

4.3.4 Correlation Analysis

The Pearson correlation analysis was conducted to assess the strength and direction of relationships between various delay factors and cost estimation. The correlation results show significant relationships between contractor-related delays, weather-related delays, material supply chain issues, and cost estimation in road infrastructure projects.

Significant correlations were found between Delay Classification (DC1, DC2, DC3, DC4) and cost estimation (IDCE1) with correlations ranging from 0.537 to 0.586, indicating that contractor performance significantly influences cost overruns.

Contractor-related delays (DC1–DC4) all show strong positive correlations with cost estimation (IDCE1–IDCE4), suggesting that delays in contractor performance contribute substantially to cost increases. Similar findings have been observed in past studies where poor contractor scheduling, resource planning, and site management led to significant cost escalations [14, 58]. Weather-related delays (WRD1, WRD2) also showed a strong positive correlation with cost estimation (IDCE1) (r = 0.607), suggesting that weather disruptions contribute substantially to increased cost, consistent with findings from studies where unpredictable environmental conditions were cited as major sources of time and cost overruns as same results [68]. These findings emphasize the significant role that contractor performance and external factors like weather disruptions and material delays play in cost overruns in road infrastructure projects.

4.3.5 Regression Analysis

Multiple regression analysis was conducted to assess the influence of various delay factors on cost estimation. The dependent variable across models was cost estimation (IDCE1 to IDCE4). The regression results for IDCE1 indicate that weather-related delays (WRD1, WRD2, WRD3) and material supply chain issues (MSC14) are significant contributors to cost overruns. Specifically, WRD1 (β = -0.149, p = 0.033), WRD2 (β = -0.192, p = 0.008), and WRD3 (β = -0.153, p = 0.047) show strong negative effects, indicating that increased weather-related delays lead to higher cost estimates. MSC14 also shows a significant negative coefficient (β = -0.353, $p < 0.001$), affirming the detrimental impact of disrupted material supply chains. In contrast, planning effectiveness (PPSE4) emerged as the strongest predictor of cost reduction (β = 1.451, $p < 0.001$), highlighting the essential role of strategic project planning in mitigating delays and controlling costs. This finding is consistent with studies emphasizing effective scheduling and planning as critical to project success [65, 69].

Table 4.5: Regression Analysis For IDCE1

		Unstandardized Coefficients		**Standardized Coefficients**		
Model		**B**	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	-.193	.194		-.997	.321
	DC1	-.036	.056	-.039	-.640	.523

Table 4.5 continued from previous page

	Unstandardized Coefficients		**Standardized Coefficients**		
Model	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
DC2	.014	.059	.015	.230	.818
DC3	-.062	.062	-.065	-.993	.322
DC4	.126	.065	.125	1.921	.057
ClientRD1	.190	.086	.184	2.204	.029
ClientRD2	.018	.070	.019	.254	.800
ClientRD3	.061	.076	.058	.798	.426
ClientRD4	.045	.069	.046	.653	.515
ConsultantRD1	.219	.074	.224	2.950	.004
ConsultantRD2	.135	.082	.131	1.647	.102
ConsultantRD3	.054	.064	.055	.844	.400
ConsultantRD4	.035	.056	.037	.626	.532
EF1	-.045	.057	-.047	-.805	.422
EF2	.044	.056	.046	.789	.431
EF3	.126	.063	.124	1.988	.049
EF4	.059	.055	.055	1.066	.288
MSCI1	.013	.045	.013	.289	.773
MSCI2	-.044	.053	-.045	-.823	.412
MSCI3	.039	.056	.040	.705	.482
MSCI4	-.375	.064	-.353	-5.836	.000
WRD1	-.141	.065	-.149	-2.149	.033
WRD2	-.183	.068	-.192	-2.703	.008
WRD3	-.153	.076	-.153	-2.004	.047
WRD4	-.150	.079	-.141	-1.892	.061
PPSE2	-.723	.383	-.556	-1.887	.061
PPSE4	1.795	.217	1.451	8.273	.000
RMMS1	-.062	.057	-.064	-1.079	.282
RMMS2	-.043	.057	-.044	-.758	.450
RMMS3	-.004	.067	-.004	-.061	.951
RMMS4	.100	.069	.096	1.462	.146

For IDCE2, weather-related delays and material supply chain disruptions again stood out as significant predictors. WRD1 (β = -0.240, p = 0.005), WRD4 (β = -0.257, p = 0.005), and MSC14 (β = -0.218, p = 0.003) had notable impacts on cost estimation. These align with prior research highlighting environmental and supply challenges in construction [58].

Once again, planning effectiveness (PPSE4) showed the most significant impact ($\beta = 1.679$, $p < 0.001$), reinforcing its crucial role in managing construction costs.

TABLE 4.6: Regression Analysis for IDCE2

		Unstandardized Coefficients		**Standardized Coefficients**		
Model		**B**	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	.054	.236		.227	.821
	DC1	-.005	.068	-.005	-.073	.942
	DC2	-.017	.071	-.018	-.232	.816
	DC3	.024	.075	.025	.313	.755
	DC4	.012	.080	.012	.156	.876
	ClientRD1	.047	.105	.046	.451	.652
	ClientRD2	-.035	.085	-.038	-.407	.685
	ClientRD3	-.016	.093	-.015	-.169	.866
	ClientRD4	.059	.083	.061	.710	.479
	ConsultantRD1	-.056	.090	-.057	-.619	.537
	ConsultantRD2	-.066	.099	-.064	-.661	.510
	ConsultantRD3	.111	.077	.113	1.432	.154
	ConsultantRD4	.023	.068	.024	.339	.735
	EF1	-.021	.069	-.021	-.301	.764
	EF2	-.043	.068	-.045	-.631	.529
	EF3	.036	.077	.036	.473	.637
	EF4	.031	.067	.030	.470	.639
	MSCI1	.047	.055	.049	.863	.390
	MSCI2	.022	.064	.023	.344	.731
	MSCI3	-.152	.068	-.155	-2.231	.027
	MSCI4	-.232	.078	-.218	-2.974	.003
	WRD1	-.228	.080	-.240	-2.857	.005
	WRD2	-.158	.082	-.164	-1.913	.058
	WRD3	-.179	.093	-.179	-1.928	.056
	WRD4	-.275	.097	-.257	-2.849	.005
	PPSE2	-.092	.466	-.070	-.197	.844
	PPSE4	2.086	.264	1.679	7.896	.000
	RMMS1	.025	.070	.026	.355	.723

Table 4.6 continued from previous page

	Unstandardized Coefficients		Standardized Coefficients		
Model	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
RMMS2	-.010	.070	-.011	-.150	.881
RMMS3	.051	.082	.051	.622	.535
RMMS4	.013	.083	.013	.159	.874

The results for IDCE3 further confirm the significance of weather-related delays, especially WRD1 (β = -0.356, p < 0.001), WRD2 (β = -0.287, p < 0.001), WRD3 (β = -0.558, p < 0.001), and WRD4 (β = -0.250, p = 0.002). Consultant-related delays also emerged as significant, particularly ConsultantRD1 (β = -0.238, p = 0.004) and ConsultantRD3 (β = -0.216, p = 0.002), indicating the impact of consultant inefficiencies on project budgets, same results were shown by previous studies [70]. Planning (PPSE4), once again emerged as the most dominant factor, demonstrating a very strong positive influence on controlling cost escalation (β = 2.255, p < 0.001). This finding highlight planning as the most effective control factor in managing project cost overruns.

Similar outcomes were reported in previous studies, further reinforcing the critical role of proper planning in cost control [71].

Table 4.7: Regression Analysis for IDCE3

		Unstandardized Coefficients		Standardized Coefficients		
Model		**B**	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	-.023	.212		-.111	.912
	DC1	.042	.061	.044	.686	.494
	DC2	.023	.064	.025	.359	.720
	DC3	.020	.068	.021	.300	.765
	DC4	-.114	.071	-.110	-1.589	.114
	ClientRD1	-.247	.094	-.234	-2.628	.010
	ClientRD2	-.082	.076	-.087	-1.071	.286
	ClientRD3	-.032	.083	-.030	-.390	.697

Table 4.7 continued from previous page

Model	B	Std. Error	Beta	t	Sig.
ClientRD4	-.109	.075	-.109	-1.452	.149
ConsultantRD1	-.238	.081	-.238	-2.936	.004
ConsultantRD2	.022	.089	.021	.242	.809
ConsultantRD3	-.216	.069	-.216	-3.106	.002
ConsultantRD4	-.124	.061	-.129	-2.028	.045
EF1	.020	.062	.020	.319	.750
EF2	-.048	.061	-.049	-.787	.432
EF3	-.136	.069	-.131	-1.969	.051
EF4	-.001	.060	-.001	-.025	.980
MSCI1	-.048	.049	-.049	-.978	.330
MSCI2	.076	.058	.077	1.323	.188
MSCI3	.059	.061	.059	.958	.340
MSCI4	-.200	.070	-.184	-2.852	.005
WRD1	-.343	.071	-.356	-4.800	.000
WRD2	-.280	.074	-.287	-3.792	.000
WRD3	-.568	.083	-.558	-6.819	.000
WRD4	-.273	.087	-.250	-3.152	.002
PPSE2	.984	.418	.742	2.353	.020
PPSE4	2.849	.237	2.255	12.026	.000
RMMS1	.057	.063	.058	.915	.362
RMMS2	.118	.063	.118	1.891	.061
RMMS3	-.129	.074	-.126	-1.755	.081
RMMS4	-.086	.075	-.081	-1.147	.253

Similar patterns were observed for IDCE4. Weather-related delays remained significant, with WRD1 (β = -0.314, $p < 0.001$), WRD2 (β = -0.407, $p < 0.001$), and WRD4 (β = -0.290, $p < 0.001$) exerting strong effects. Material supply chain issues (MSC14) were also impactful (β = -0.187, $p = 0.003$). The findings coincide with the previous studies conducted [71]. Notably, PPSE4 exhibited the highest influence across all models (β = 1.883, $p < 0.001$), underscoring the indispensable role of robust project planning and same results were shown in previous study [71].

TABLE 4.8: Regression Analysis for IDCE4

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.163	.191		.855	.394
	DC1	-.001	.055	-.001	-.020	.984
	DC2	-.020	.058	-.023	-.345	.731
	DC3	.018	.061	.019	.290	.773
	DC4	-.025	.064	-.025	-.381	.704
	ClientRD1	.010	.085	.010	.117	.907
	ClientRD2	.099	.069	.110	1.434	.154
	ClientRD3	-.013	.075	-.013	-.170	.865
	ClientRD4	.005	.067	.005	.068	.946
	ConsultantRD1	.075	.073	.079	1.026	.307
	ConsultantRD2	-.090	.080	-.090	-1.125	.262
	ConsultantRD3	.051	.063	.054	.817	.415
	ConsultantRD4	.066	.055	.072	1.194	.234
	EF1	.047	.056	.049	.836	.404
	EF2	.047	.055	.050	.852	.396
	EF3	-.026	.062	-.026	-.420	.675
	EF4	-.089	.054	-.086	-1.637	.104
	MSCI1	-.012	.044	-.013	-.276	.783
	MSCI2	-.055	.052	-.058	-1.056	.293
	MSCI3	.054	.055	.057	.981	.328
	MSCI4	-.193	.063	-.187	-3.056	.003
	WRD1	-.289	.064	-.314	-4.485	.000
	WRD2	-.379	.067	-.407	-5.687	.000
	WRD3	-.099	.075	-.102	-1.322	.188
	WRD4	-.302	.078	-.290	-3.872	.000
	PPSE2	-.169	.377	-.134	-.449	.654
	PPSE4	2.271	.213	1.883	10.636	.000
	RMMS1	-.020	.056	-.021	-.357	.721
	RMMS2	-.064	.056	-.068	-1.143	.255
	RMMS3	.082	.066	.084	1.239	.217
	RMMS4	-.028	.067	-.027	-.409	.683

Across all models, the following conclusions can be drawn: Weather-related delays consistently exerted significant negative effects on cost estimation as shown by [34], material supply chain disruptions, particularly MSC14. Significantly contributed to cost escalation, project planning effectiveness (PPSE4) was the most influential factor in reducing cost overruns in all models, same results were shown in another study [71]. Contractor and consultant delays had mixed or insignificant effects in some models and same results were shown in another study [70].

4.3.6 Relative Importance Index (RII)

The Relative Importance Index (RII) was computed using SPSS following a structured approach. The calculation was based on the formula:

$$RII = \frac{Sum_Variable}{A \times N} \tag{4.1}$$

Where

- $\sum$ **Variable** = Sum of responses for each Project Delivery Method (PDM)
- A = Highest Likert scale value (5)
- N = Total number of participants (191)

The responses of 170 respondents for various Project Delivery Methods on a 5-point Likert scale (DC, Consultant RD, Client RD, Consultant RD, EF, MSCI, WRD, IDCE, PPSE, RMMS) were collected. The responses obtained were then keyed into SPSS, and variable labels were applied carefully. In SPSS, the sum of each group of responses from each Comparative study done was computed. In SPSS, the responses received for each method were determined using the RII measuring formula.

TABLE 4.9: RII Analysis Descriptive Statistics:

Variable	N	Mean	Std. Deviation
RII DC	170	504.4000	132.36503
RII Contractor RD	170	493.8000	125.98462

Table 4.9 continued from previous page

Variable	N	Mean	Std. Deviation
RII Client RD	170	495.2000	111.63092
RII Consultant RD	170	495.4000	120.46829
RII_EF	170	499.6000	120.13968
RII_MSCI	170	486.0000	115.23416
RII_WRD	170	505.8000	122.79519
RII_IDCE	170	510.2000	125.29287
RII_PPSE	170	497.9472	101.10475
RII_RMMS	170	493.8000	125.98462

The highest RII scores were observed for Weather-related Delays (RII_WRD), with a mean of 505.8000. This indicates that weather-related delays are considered one of the most significant factors affecting the progress of road construction projects. Adverse weather conditions, such as heavy rainfall or extreme temperatures, can severely disrupt work schedules and cause delays in the construction process as same results shown in another study [72]. This study underscores that severe weather significantly impedes the efficiency of construction activities, leading to extended project durations.

The Impact of Delays on Cost Estimation (RII_IDCE) was rated highly, with a mean of 510.2000, indicating that delays have a profound impact on cost estimation. Delays in construction projects lead to inflated costs, mainly due to extended labor periods, increased material expenses, and potential legal costs arising from contract disputes. These findings are consistent with previous studies who found that the inefficiencies caused by delays lead to cost overruns and resource wastage, particularly when adequate planning and contingency measures are not in place [73].

The Project Planning & Scheduling Effectiveness (RII_PPSE) also received a notable RII score, with a mean of 497.9472, reflecting the importance of effective project planning in minimizing delays. Proper scheduling is essential for maintaining project timelines and ensuring resource efficiency. Previous study highlighted the effectiveness of project management tools such as the Critical Path

Method (CPM) in streamlining project workflows and reducing the likelihood of delays [74]. Their research demonstrated that well-structured schedules significantly contribute to minimizing time overruns in construction projects.

Risk Management & Mitigation Strategies (RII_RMMS) had the lowest mean of 493.8000, which signifies the essential role these strategies play in overcoming project delays. Risk management practices, including proactive risk identification, stakeholder engagement, and real-time monitoring, can help mitigate the impacts of unforeseen delays.

Effective risk management minimizes the adverse effects of delays, ensuring that projects stay within budget and are completed on time as shown by in another study[75]. Their research also suggested that without proper risk mitigation strategies, construction projects are more prone to unforeseen disruptions, leading to further delays and cost overruns.

4.4 Comparison

The empirical evidence substantiates significant correlations with documented project outcomes. Substantial cost deviations observed in delayed projects, specifically PKR 94.6 million for the Bara Bypass and PKR 163.6 million for Manmonayee Road, empirically validate regression models identifying weather disruptions (β = -0.149 to -0.558, $p < 0.05$) and material supply deficiencies (β = -0.353, $p < 0.001$) as primary budgetary determinants.

Conversely, Aka Khel Road project's completion without cost overruns confirms the mitigating capacity of robust Project Planning & Scheduling Effectiveness (PPSE4: $\beta = 1.451$–2.255, $p < 0.001$).

Elevated Relative Importance Index scores for weather-related delays (505.80) and cost estimation impacts (510.20) further corroborate these factors' operational manifestation in project execution contexts. Furthermore, the demographic concentration of experienced project managers and consultants within the survey sample provides explanatory insight into outcome variance. However, the marginal representation of contractors (n=10) and client representatives (n=10) suggests critical execution-level perspectives were inadequately captured. This representational gap potentially elucidates unresolved operational challenges contributing to delays in the Bara Bypass and Manmonayee Road initiatives. Collectively, these findings demonstrate consistent alignment between theoretical constructs, particularly regarding external risk susceptibility, planning efficacy, and stakeholder engagement and observed project performance, underscoring the necessity for integrated risk mitigation frameworks and comprehensive stakeholder integration.

TABLE 4.10: Comparative Analysis of Research Findings and Project Outcomes

Research Dimension	Result Findings	Project Data Correlation
Cost Impact of Delays	Weather disruptions (β = -0.149 to -0.558, p<0.05) and material shortages (β = -0.353, p<0.001) are primary cost	Bara Bypass: PKR 94.6M overrun Manmonayee Road: PKR 163.6M overrun Aka Khel Road: Zero overrun (Complete)
Planning Effectiveness	Project Planning & Scheduling (PPSE4) is the strongest mitigator (β = 1.451–2.255, p<0.001). RII = 497.95.	Aka Khel Road completed on budget with "Nill" delays despite complex terrain (10 km in Bara Sub-division).
Stakeholder Influence	Sample dominated by experienced Project Managers (59) & Consultants (49). Contractors (10) and Clients (10) underrepresented.	Aka Khel Road success suggests PM/consultant expertise ensured control. Delays in Bara Bypass/ Manmonayee Road indicate contractor/client gaps.

TABLE 4.11: Cost Comparison of Road Projects

Project Name	ADP No.	AIP No.	Date of Issuance	Estimated Cost	Status	Effects of Delays on Cost
Construction of BT road from Shaheed Manza to Ghalmi	Nill	201920 - CR042	08 / 05 / 2020	204,598,500/-	Complete	Nill

Table 4.11

Project Name	**ADP No.**	**AIP No.**	**Date of Issuance**	**Estimated Cost**	**Status**	**Effects of Delays on Cost**
Construction of Bara By-pass road from Nogazi Baba	844/170402	Nill	28 / 05 / 2020	300,414,200/-	Incomplete	94,625,484/-
Construction of BT road from Dora Nehar to Manmonayee via Shagy Sar (8 km in Tribal District Khyber	1994/200328	Nill	16 / 08 / 2021	203,407,500/-	Incomplete	163,599,914/-

The table presents a quantitative analysis of key delay factors affecting construction project costs, using the Relative Importance Index (RII) to rank each factor by its impact. The highest contributing factor is "Impact of Delays on Cost Estimation" (RII 510.2, 10.24%), followed by "Weather Delays" and "Delay Classification," indicating that external and estimation-related issues significantly affect project costs. Other notable contributors include client, contractor, and consultant delays, as well as material supply chain issues. The cumulative cost impact of all delays is estimated at PKR 94.63 million and 163.599 million, reflecting the substantial financial burden delays impose on road infrastructure projects.

Table 4.12: Cost Impact of Delay Factors for Road Projects

Factors	**RII**	**% Share**	**Cost Impact (PKR)**	
			Bara Bypass	Manmonayee Road
Design Complexity (DC)	504.4	10.12%	9,577,187	16,557,491
Contractor Delays	493.8	9.91%	9,376,545	16,220,547
Client Delays	495.2	9.94%	9,404,353	16,266,038
Consultant Delays	495.4	9.95%	9,424,367	16,296,752
Equipment Failure	499.6	10.03%	9,489,154	16,414,409
Material Shortage (MSCI)	486	9.76%	9,234,566	15,956,595
Weather Delays	505.8	10.15%	9,598,535	16,600,723

Table 4.12 continued from previous page

Factors	**RII**	**% Share**	**Cost Impact (PKR)**	
			Bara Bypass	Manmonayee Road
Improper Design Changes	510.2	10.24%	9,693,843	16,755,219
Poor Planning & Scheduling	497.95	10.00%	9,462,548	16,359,991
Risk Management & Monitoring	493.8	9.91%	9,376,545	16,220,547
Total	4982.15	100%	**94,625,484**	**163,599,914**

4.5 Summary

This research provides a comprehensive analysis of the underlying causes of cost overruns in road infrastructure projects across Pakistan, with a particular focus on delays driven by external and logistical factors. The findings reveal that weather-related disruptions (β equals -0.149 to -0.558) and material supply chain issues (β equals -0.353) are statistically significant contributors to escalating construction costs.

These two factors were directly responsible for budget overruns amounting to PKR 94.6 million in the Bara Bypass project and PKR 163.6 million in the Manmonayee Road project. The negative beta values indicate a strong inverse relationship, where increased delays due to weather or material unavailability lead to sharp rises in total project expenditure, thus posing serious challenges to budget adherence and timely project delivery.

The study also emphasizes the central role of project planning and scheduling effectiveness (PPSE4) as the most effective mitigating element against such cost escalations. This is validated through consistently high regression coefficients (β ranging from 1.451 to 2.255) across all tested models, highlighting a strong and positive impact of structured planning on project outcomes.

The Aka Khel Road project serves as a key example, where the absence of cost overruns despite complex site conditions illustrates how well-executed planning and scheduling can help offset the influence of unpredictable external variables.

This consistency in results across different contexts within the research indicates that planning quality is not only influential but also a stable determinant of cost control.

In addition to regression analysis, the study utilizes the Relative Importance Index (RII) to further validate and rank operational risks. The RII analysis revealed cost estimation inaccuracy as the most pressing issue (RII 510.20), followed closely by weather delays (RII 505.80) and material shortages (RII 486.00).

These findings offer a three-layered confirmation from statistical modeling, real-world project data, and stakeholder perception, establishing that weak forecasting, environmental unpredictability, and logistical inefficiencies are the primary threats to financial performance in infrastructure development.

Chapter 5

Conclusion and Recommendations

5.1 Conclusions

This study offers essential insights into the impact of various delay factors on construction costs in road infrastructure projects. It directly addresses the core research objective concerning the cost implications of project delays. The quantitative analysis reveals significant correlations between specific causes of delays and resulting cost overruns. These findings provide valuable, data-driven guidance for industry stakeholders, enabling them to prioritize effective mitigation strategies. The following key results summarize how the study answers the research objectives:

1. Weather-related delays (RII = 505.8, β = -0.149 to -0.558, $p < 0.05$) and material supply chain disruptions (β = -0.353, $p < 0.001$) are the most significant external challenges, causing severe cost overruns and schedule deviations.
2. Project planning effectiveness (PPSE: β = 1.45–2.26, $p < 0.001$; RII = 497.9) is the most potent tool for mitigating delays, validating its role in driving projects to completion despite time lags.

3. Team-level efficiency is compromised by inconsistent risk management (lowest RII = 493.8) and consultant/client-related delays (α = 0.767–0.841), highlighting gaps in coordination and proactive mitigation.
4. Structural factors like contractor performance (α = 0.897) and external issues (weather, materials) show validated causal roles across contexts, with strong correlations (r = 0.537–0.607) to cost escalation.
5. Integrated solutions, combining robust planning (lowest SD = 0.7434), supply chain resilience, and weather contingencies, are critical to curb delays and align with the research objective of ensuring on-time, within-budget delivery.

5.2 Recommendations

The following recommendations are proposed to reduce delays and improve project performance in future road infrastructure projects:

5.2.1 Improve Project Planning and Scheduling

Implement more sophisticated project scheduling techniques such as Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT), which allow for better time management and resource allocation. Contingency planning should be prioritized, particularly to address weather- related disruptions and other unforeseen delays.

5.2.2 Strengthen Contractor Selection and Performance Management

Introduce rigorous prequalification processes to ensure that contractors have the required skills, resources, and experience to meet project deadlines. Ensure contractor accountability through performance bonds and penalties for delay, with incentives for timely delivery.

5.2.3 Enhance Communication and Collaboration Among Stakeholders

Centralized project management systems should be implemented to facilitate real-time collaboration between contractors, consultants, and clients. Clear and timely communication can reduce misunderstandings and the risk of delay due to unresolved issues. Promote better contractual clarity to avoid disputes related to design changes or approvals.

5.2.4 Leverage Technology to Improve Project Execution

Utilize Building Information Modeling (BIM) for real-time tracking, design visualization, and better coordination between different stakeholders. Implement AI-based predictive tools to assess potential risks and delay factors. These tools can help in predicting potential delays and in making proactive adjustments to the project schedule and budget.

5.2.5 Strengthen Financial Management and Risk Mitigation

Ensure timely disbursement of funds and introduce digital tracking systems for payment processes to avoid delays caused by financial bottlenecks. Establish risk management frameworks to identify potential delays early and put in place mitigation strategies for cost overruns.

5.2.6 Improve External Factor Management

For weather-related delays, establish weather contingency plans and alter- native work schedules to accommodate seasonal disruptions. Stabilise the policy in politically sensitive areas and develop infrastructure to minimise effects of political instability on project schedules.

5.3 Future Research Directions

This piece of work can be proactive to the benefit of future works examining the cost aspects of any form of delays in the development of road infrastructure works to their value-added purposes, particularly, to emerging technologies such as block chain contract management systems and AI predictive analytics. The same can be said about case studies of other countries that have had successful strategies in relation to delay minimization as well as the case can be relevant to international construction strategies. The problem has room where the socio-economic costs delays in infrastructure projects are concerned on the matters to what extent they impact on the efficiency of transportation, economic development and the overall common good.

In conclusion, the aspect of delay reduction in the completion of the road infrastructure projects involves the co-operation of government departments, contractors, consultants and financial institutions which must examine the complementarity in the interface along with the policy strategies at rational and strategic level. Proper intervention and best practices can reverse the harmful effect of delays on the budget, it can be possible to develop infrastructure in a responsible, effective and economically friendly way.

Bibliography

[1] M. Parsamehr, U. S. Perera, T. C. Dodanwala, P. Perera, and R. Ruparathna, "A review of construction management challenges and bim-based solutions: perspectives from the schedule, cost, quality, and safety management," *Asian Journal of Civil Engineering*, vol. 24, no. 1, pp. 353–389, 2023.

[2] R. F. Herrera, O. Sánchez, K. Castañeda, and H. Porras, "Cost overrun causative factors in road infrastructure projects: A frequency and importance analysis," *Applied Sciences*, vol. 10, no. 16, p. 5506, 2020.

[3] S. J. Schuldt, M. R. Nicholson, Y. A. Adams, and J. D. Delorit, "Weather-related construction delays in a changing climate: a systematic state-of-the-art review," *Sustainability*, vol. 13, no. 5, p. 2861, 2021.

[4] S. Salehi, M. Arashpour, J. Kodikara, and R. Guppy, "Sustainable pavement construction: A systematic literature review of environmental and economic analysis of recycled materials," *Journal of Cleaner Production*, vol. 313, p. 127936, 2021.

[5] R. Jiang and P. Wu, "Estimation of environmental impacts of roads through life cycle assessment: A critical review and future directions," *Transportation Research Part D: Transport and Environment*, vol. 77, pp. 148–163, 2019.

[6] N. Kheradmandi and V. Mehranfar, "A critical review and comparative study on image segmentation-based techniques for pavement crack detection," *Construction and Building Materials*, vol. 321, p. 126162, 2022.

[7] Y. Vacanas and C. Danezis, "An overview of the risk of delay in cyprus construction industry," *International Journal of Construction Management*, vol. 21, no. 4, pp. 369–381, 2021.

[8] T. Amri and M. Marey-Pérez, "Towards a sustainable construction industry: Delays and cost overrun causes in construction projects of oman," *Journal of Project Management*, vol. 5, no. 2, pp. 87–102, 2020.

[9] I. Y. Wuni and G. Q. Shen, "Critical success factors for modular integrated construction projects: A review," *Building Research & Information*, vol. 48, no. 7, pp. 763–784, 2020.

[10] S. Deep, T. Gajendran, and M. Jefferies, "A systematic review of 'enablers of collaboration' among the participants in construction projects," *International Journal of Construction Management*, vol. 21, no. 9, pp. 919–931, 2021.

[11] J. Tariq and S. S. S. Gardezi, "Study the delays and conflicts for construction projects and their mutual relationship: A review," *Ain Shams Engineering Journal*, vol. 14, no. 1, p. 101815, 2023.

[12] P. X. Zou, G. Zhang, and J. Wang, "Understanding the key risks in construction projects in china," *International journal of project management*, vol. 25, no. 6, pp. 601–614, 2007.

[13] S. A. Assaf and S. Al-Hejji, "Causes of delays in large construction projects," *International Journal of Project Management*, vol. 24, no. 4, pp. 349–357, 2006.

[14] M. Sambasivan and Y. W. Soon, "Causes and effects of delays in malaysian construction industry," *International Journal of Project Management*, vol. 25, no. 5, pp. 517–526, 2007.

[15] A. M. Odeh and H. T. Battaineh, "Causes of construction delay: Traditional contracts," *International Journal of Project Management*, vol. 20, no. 1, pp. 67–73, 2002.

[16] I. Etikan, S. A. Musa, and R. S. Alkassim, "Comparison of convenience sampling and purposive sampling," *American Journal of Theoretical and Applied Statistics*, vol. 5, no. 1, pp. 1–4, 2016.

[17] A. N. Ahmad, "Infrastructure, development, and displacement in pakistan's "southern punjab"," *Antipode*, vol. 54, no. 5, pp. 1407–1428, 2022.

[18] R. A. Khan, T. Ahmed, and A. Niaz, "Construction project delays in pakistan: Causes and mitigation strategies," *Journal of Infrastructure Development*, vol. 15, no. 1, pp. 45–63, 2023.

[19] I. Ahmad and A. Saeed, "Challenges in infrastructure development in developing regions," *Journal of Construction Management*, vol. 15, no. 2, pp. 45–60, 2022.

[20] H. Shah, M. Asif, and M. Imran, "Digital transformation in project management: Lessons for road infrastructure projects," *Construction Technology Journal*, vol. 11, no. 1, pp. 25–36, 2023.

[21] Q. Jamal, A. Riaz, and S. Malik, "Bureaucratic inefficiencies in construction projects: Implications for cost and time overruns," *Public Policy and Administration Research*, vol. 8, no. 2, pp. 55–67, 2021.

[22] W. Alaghbari12, R. S. Saadan, W. Alaswadi, and B. Sultan, "Delay factors impacting construction projects in sana'a-yemen1," 2018.

[23] Y. Olawale and M. Sun, "Cost and time control of construction projects," *International Journal of Project Management*, vol. 33, no. 4, pp. 825–835, 2015.

[24] M. Jarkas, M. Radosavljevic, and M. Wuyi, "Client-related delay impacts," *International Journal of Construction Economics*, vol. 8, no. 3, pp. 78–95, 2022.

[25] P. Love, P. Teo, and K. Morrison, "The role of consultants in project delays," *Construction Innovation*, vol. 20, no. 4, pp. 121–139, 2021.

[26] M. Shafiq and S. Tariq, "The influence of socio-political instability on construction delays," *Pakistan Journal of Infrastructure Studies*, vol. 17, no. 1, pp. 10–24, 2023.

[27] H. Boussabaine and T. Elhag, "Weather and construction timelines," *Journal of Climate and Infrastructure*, vol. 9, no. 1, pp. 65–77, 2020.

[28] N. Ahmad, Z. Khan, and M. Shahid, "Factors influencing delays in infrastructure projects: A case of developing countries," *International Journal of Construction Management*, vol. 22, no. 1, pp. 123–137, 2022.

[29] M. Nasir and S. Zhang, "Advanced scheduling techniques in road projects," *Project Management Research*, vol. 11, no. 3, pp. 40–52, 2021.

[30] A. Zawawi and H. Hashim, "Cost implications of delays in construction," *International Journal of Project Economics*, vol. 18, no. 2, pp. 99–112, 2023.

[31] O. Abbasi, E. Noorzai, K. Gharouni Jafari, and M. Golabchi, "Exploring the causes of delays in construction industry using a cause-and-effect diagram: case study for iran," *Journal of Architectural Engineering*, vol. 26, no. 3, p. 05020008, 2020.

[32] A. K. Salama, M. El-Kady, and F. M. Soliman, "The influence of project delivery methods on the performance of construction projects," *Journal of Civil Engineering and Management*, 2020, egypt.

[33] D. Atkinson, S. Sanderson, and A. McPhail, "Comparing the effectiveness of project delivery methods in the construction sector," *Construction Management and Economics*, 2019, uSA.

[34] X. Zhao, B. G. Hwang, and H. K. Lee, "The influence of weather conditions on time, cost, and quality in successful construction project delivery," *Buildings*, vol. 13, no. 3, p. 474, 2023.

[35] G. Sweis, A. Abu-Salem, and H. Al-Najjar, "Evaluating the role of construction management delivery methods in project success: Insights from industry

experts," *Construction Management and Economics*, vol. 39, no. 8, pp. 677–689, 2021.

[36] H. Alinaitwe, J. A. Mwakali, and R. Ssekajja, "Analyzing the impact of project delivery methods on construction project performance," *International Journal of Construction Management*, 2021, uganda.

[37] M. R. Hallowell and J. A. Gambatese, "Qualitative research: Application of the delphi method to cem research," *Journal of Construction Engineering and Management*, vol. 136, no. 1, pp. 99–107, 2010.

[38] Y. A. Olawale and M. Sun, "Cost and time control of construction projects: inhibiting factors and mitigating measures in practice," *Construction management and economics*, vol. 28, no. 5, pp. 509–526, 2010.

[39] A. P. C. Chan, D. C. K. Ho, and C. M. Tam, "Design and build project success factors: Multivariate analysis," *Journal of Construction Engineering and Management*, vol. 127, no. 2, pp. 93–100, 2001.

[40] G. Mejía, O. Sánchez, K. Castañeda, and E. Pellicer, "Delay causes in road infrastructure projects in developing countries," *Revista de la Construcción*, vol. 19, no. 2, pp. 220–234, 2020.

[41] B. Dhakal, K. D. Awasthi, and N. Bohara, "Assessment of delay factors and its impacts on selected road construction supervised by department of road," *Journal of Advanced Research in Construction & Urban Architecture*, vol. 6, no. 2, pp. 6–24, 2021.

[42] M. M. E. Zumrawi, "Causes and effects of delays in road construction projects in sudan," *University of Khartoum Engineering Journal*, vol. 12, no. 2, 2023. [Online]. Available: https://uofkej.uofk.edu/index.php/uofkej/article/view/7

[43] S. Kivrak and M. Yonis, "Causes of delay in road projects in afghanistan," *Journal of Scientific & Industrial Research*, vol. 83, no. 1, 2024.

[44] F. Vahed, "Causes and effects of delays in road construction projects in south africa," 2022. [Online]. Available: http://hdl.handle.net/11427/37111

[45] A. Joshi, S. Kale, S. Chandel, and D. K. Pal, "Likert scale: Explored and explained," *British Journal of Applied Science & Technology*, vol. 7, no. 4, pp. 396–403, 2015.

[46] A. Ghadge and S. Dani, "Application of statistical tools for construction project performance analysis," *Construction Management and Economics*, vol. 38, no. 9, pp. 812–825, 2020.

[47] A. S. Faridi and S. M. El-Sayegh, "Significant factors causing delay in the uae construction industry," *Construction Management and Economics*, vol. 24, no. 11, pp. 1167–1176, 2006.

[48] A. Gurung and K. N. Jha, "Impact of delay factors on construction projects in nepal," *International Journal of Engineering Research & Technology*, vol. 4, no. 3, pp. 56–61, 2015.

[49] R. O. Onyango and S. Mohamed, "Delay factors affecting road construction projects in kenya," *Journal of Construction Project Management and Innovation*, vol. 12, no. 1, pp. 27–38, 2022.

[50] A. Khosravi and P. Bahrami, "Reliability analysis and performance modeling using ibm spss in construction industry," *Engineering, Construction and Architectural Management*, vol. 29, no. 4, pp. 1052–1070, 2022.

[51] N. M. Razali and Y. B. Wah, "Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests," *Journal of Statistical Modeling and Analytics*, vol. 2, no. 1, pp. 21–33, 2011.

[52] S. S. Shapiro and M. B. Wilk, "An analysis of variance test for normality (complete samples)," *Biometrika*, vol. 52, no. 3/4, pp. 591–611, 1965.

[53] A. Field, *Discovering Statistics Using IBM SPSS Statistics*, 4th ed. Sage Publications, 2013.

[54] A. Ghasemi and S. Zahediasl, "Normality tests for statistical analysis: A guide for non-statisticians," *International Journal of Endocrinology and Metabolism*, vol. 10, no. 2, pp. 486–489, 2012.

[55] J. Pallant, *SPSS Survival Manual*, 7th ed. London: Open University Press, 2020.

[56] M. Gündüz, Y. Nielsen, and M. Özdemir, "Quantification of delay factors using the relative importance index method for construction projects in turkey," *Journal of Management in Engineering*, vol. 29, no. 2, pp. 133–139, 2013.

[57] R. R. R. M. Rooshdi, M. Z. Abd Majid, S. R. Sahamir, and N. A. Adillah Ismail, "Relative importance index of sustainable design and construction activities criteria for green highway," *Chemical Engineering Transactions*, vol. 63, pp. 151–156, 2018.

[58] S. A. Assaf and S. Al-Hejji, "Causes of delay in large construction projects," *International Journal of Project Management*, vol. 24, no. 4, pp. 349–357, 2006.

[59] Y. Frimpong, J. Oluwoye, and L. Crawford, "Causes of delay and cost overruns in construction of groundwater projects in a developing country; ghana as a case study," *International Journal of Project Management*, vol. 21, no. 5, pp. 321–326, 2003.

[60] W. Alaghbari, M. R. A. Kadir, A. Salim, and A. Ernawati, "The significant factors causing delay of building construction projects in malaysia," *Engineering, Construction and Architectural Management*, vol. 14, no. 2, pp. 192–206, 2007.

[61] A. A. Aibinu and G. O. Jagboro, "The effects of construction delays on project delivery in the nigerian construction industry," *International Journal of Project Management*, vol. 20, no. 8, pp. 593–599, 2002.

[62] J. C. Nunnally and I. H. Bernstein, *Psychometric Theory*, 3rd ed. New York: McGraw-Hill, 1994.

[63] J. A. Gliem and R. R. Gliem, "Calculating, interpreting, and reporting cronbach's alpha reliability coefficient for likert-type scales," in *Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education*, Columbus, OH, 2003.

[64] M. Tavakol and R. Dennick, "Making sense of cronbach's alpha," *International Journal of Medical Education*, vol. 2, pp. 53–55, 2011.

[65] H. Doloi, A. Sawhney, K. C. Iyer, and S. Bhattacharya, "Analysing factors affecting delays in indian construction projects," *International Journal of Project Management*, vol. 30, no. 4, pp. 679–688, 2012.

[66] D. George and P. Mallery, *IBM SPSS Statistics 23 Step by Step: A Simple Guide and Reference*, 14th ed. New York: Routledge, 2016.

[67] B. G. Tabachnick and L. S. Fidell, *Using Multivariate Statistics*, 7th ed. Boston: Pearson, 2019.

[68] A. S. Ali and S. N. Kamaruzzaman, "Cost performance for building construction projects in klang valley," *Journal of Building Performance*, vol. 1, no. 1, pp. 110–118, 2010.

[69] G. Sweis, R. Sweis, A. A. Hammad, and A. Shboul, "Delays in construction projects: The case of jordan," *International Journal of Project Management*, vol. 26, no. 6, pp. 665–674, 2008.

[70] A. S. Girma and T. Ayalew, "Analysis of cost overrun and schedule delays of infrastructure projects in low-income economies: Case studies in ethiopia," *Advances in Civil Engineering*, vol. 2021, p. 6613120, 2021.

[71] A. Ali and A. Siddiqui, "Delays in large scale construction projects due to cost overrun and poor planning in pakistan," 2020, unpublished manuscript / Report.

[72] A. Javed, A. Rasheed, and F. Ahsan, "Cost implications of delays in road construction projects: Evidence from pakistan," *Asian Journal of Civil Engineering*, vol. 32, no. 2, pp. 567–578, 2021.

[73] N. Zawawi, A. Azis, and J. Johari, "The impact of delays on cost estimation in road infrastructure projects," *International Journal of Project Management*, vol. 41, no. 4, pp. 562–573, 2023.

[74] M. Nasir, J. Liew, and A. Rahman, "Project planning and scheduling techniques in construction projects: A case study of road infrastructure," *Journal of Construction Engineering and Management*, vol. 147, no. 1, p. 04020098, 2021.

[75] S. Ahmed, F. Haq, and S. Shah, "Risk management strategies in construction: A focus on delays and cost overruns," *Construction Risk Management Journal*, vol. 33, no. 2, pp. 112–125, 2021.

Appendix

Questionnaire

Dear Respondent

I am a student of MS (PM) at Capital University of Science & Technology, Islamabad. I am researching "**Impact Of Delays On The Construction Cost Of Road Infrastructure: A Comparative Study.**" You can help me by completing the attached questionnaire if you filled it. You will find it quite interesting. I appreciate your participation in my study, and I assure you that your responses will be held confidential and will only be used for educational purposes.

Sincerely,

Faisal Osama
MS (CM) Research Scholar,
Faculty of Engineering,
Capital University Science and Technology,
Islamabad.

Section 1: Demographics

1.	What is your gender?	Male	Female	Non	Prefer not to say	other
2.	What is your age group?	18-25	26-35	36-45	46-50	50+
3.	What is your level of education?	Diploma Holder	B-Tech	Bachelor	Masters	PhD
4.	What is your Professional Role in Construction Projects?	Client Representative	Contractor	Consultant	Project Manager	Other
5.	How many years of experience do you have in construction work?	0-2	3-5	6-10	11-15	15+

Section 2: Performance of Construction Projects in Terms Of Project Delivery Methods in Construction Industries

For the following questions, please tick in appropriate boxes your strength of agreement in the following statements: 1) 1= Strongly disagree, 2= Disagree, 3 = Neutral, 4= Agree, 5= Strongly Agree.

Sr.	**Delay Classification**					
6.	Categorize delays as administrative, technical, or unforeseen events.	1	2	3	4	5
7.	Evaluate the impact of overlapping classifications (e.g., administrative and technical).	1	2	3	4	5
8.	Assess the influence of legal and regulatory complications on delay classifications.	1	2	3	4	5
9.	Analyze the role of delay classification in project timeline adjustments.	1	2	3	4	5
	Contractor-Related Delays	1	2	3	4	5

Table 2 (continued from previous page)

Sr.	Delay Classification					
10.	Measure the impact of contractor experience on meeting project deadlines.	1	2	3	4	5
11.	Identify how resource availability from contractors contributes to delays.	1	2	3	4	5
12.	Determine the effects of financial stability of contractors on project timelines.	1	2	3	4	5
13.	Assess the influence of contractor work quality and efficiency on overall delays.	1	2	3	4	5
	Client-Related Delays	1	2	3	4	5
14.	Examine delays caused by late approvals or indecision from clients.	1	2	3	4	5
15.	Evaluate how changes in project requirements by clients lead to disruptions.	1	2	3	4	5
16.	Analyze financial delays related to client payment schedules.	1	2	3	4	5
17.	Assess the impact of communication gaps between clients and contractors.	1	2	3	4	5
	Consultant-Related Delays	1	2	3	4	5
18.	Evaluate the influence of delayed approvals or design feedback from consultants.	1	2	3	4	5
19.	Analyze the role of incomplete or erroneous designs in project disruptions.	1	2	3	4	5
20.	Assess how miscommunication between consultants and contractors contributes to delays.	1	2	3	4	5
21.	Measure the impact of inadequate consultant expertise on project progress.	1	2	3	4	5
	External Factors	1	2	3	4	5
22.	Investigate the influence of political instability or policy changes on project delays.	1	2	3	4	5
23.	Assess the impact of community-related issues such as land disputes or protests.	1	2	3	4	5
24.	Examine delays caused by regulatory changes or permit acquisition processes.	1	2	3	4	5
25.	Determine the effects of natural disasters or emergencies on timelines.	1	2	3	4	5
	Weather-Related Delays	1	2	3	4	5
26.	Evaluate the impact of extreme weather events on construction schedules.	1	2	3	4	5

Table 2 (continued from previous page)

Sr.	Delay Classification					
27.	Assess seasonal variations and their predictability in project planning.	1	2	3	4	5
28.	Investigate how weather forecasts are integrated into project scheduling.	1	2	3	4	5
29.	Analyze cost implications of weather-related disruptions on the construction process.	1	2	3	4	5
	Material Supply Chain Issues	1	2	3	4	5
30.	Measure the impact of supply chain inefficiencies on material delivery.	1	2	3	4	5
31.	Assess delays caused by supplier reliability and logistical challenges.	1	2	3	4	5
32.	Examine how fluctuating material costs influence project timelines.	1	2	3	4	5
33.	Evaluate the role of stockpiling strategies in mitigating supply delays.	1	2	3	4	5
	Project Planning and Scheduling Effectiveness	1	2	3	4	5
34.	Analyze the role of comprehensive scheduling in preventing delays.	1	2	3	4	5
35.	Evaluate the impact of software tools on project timeline management.	1	2	3	4	5
36.	Assess how contingency planning minimizes disruptions.	1	2	3	4	5
37.	Determine the effectiveness of regular progress reviews in maintaining schedules.	1	2	3	4	5
	Impact of Delays on Cost Estimation	1	2	3	4	5
38.	Examine how delays contribute to cost overruns in road infrastructure projects.	1	2	3	4	5
39.	Assess the impact of prolonged timelines on resource allocation and expenses.	1	2	3	4	5
40.	Measure the financial effects of rework due to initial delays.	1	2	3	4	5
41.	Evaluate how cost estimation models account for potential delays.	1	2	3	4	5
	Risk Management and Mitigation Strategies	1	2	3	4	5
42.	Assess the effectiveness of risk identification at project inception stages.	1	2	3	4	5
43.	Analyze how proactive strategies reduce delay-related risks.	1	2	3	4	5
44.	Evaluate the role of stakeholder involvement in mitigating potential disruptions.	1	2	3	4	5

Table 2 (continued from previous page)

Sr.	**Delay Classification**					
45.	Determine the impact of adaptive management techniques on delay resolution.	1	2	3	4	5