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Al Siyabi, Sulaiman Khamis Khalfan. "Post Evaluation of Project Cost Overrun by U... <1%

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Arshi Shakeel Faridi, Sameh Monir El-Sayegh. "Significant factors causing delay in... <1%

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CHAPTER 1
INTRODUCTION

1.1 Brief Introduction

Delays in the refinery and petrochemical mega projects have significant economic implications, particularly in the developing economies. This research investigates the primary causes of project delays and their correlation with cost overruns through a combination of literature review, expert interviews, and qualitative analysis in the Indian context.

Press Information Bureau (20th April, 2024) published a report that the Public Procurement is estimated between 20% to 22% of the country's GDP. The Indian economy size is around USD 2.7 trillion and annual Public Procurement is approximately USD 500 Billion.

The contribution of "Central Public Sector Enterprises (CPSEs)" to India's Gross Domestic Product (GDP) is approximately 15% to 16%. The government's focus on capital expenditure (CAPEX) has been one of the key drivers of economic growth, particularly in an uncertain and challenging global environment. Investments in sectors like road transport and highways, petroleum, railways, defense services, and telecommunications provide sustained growth by alleviating logistical challenges and expanding productive capacities.

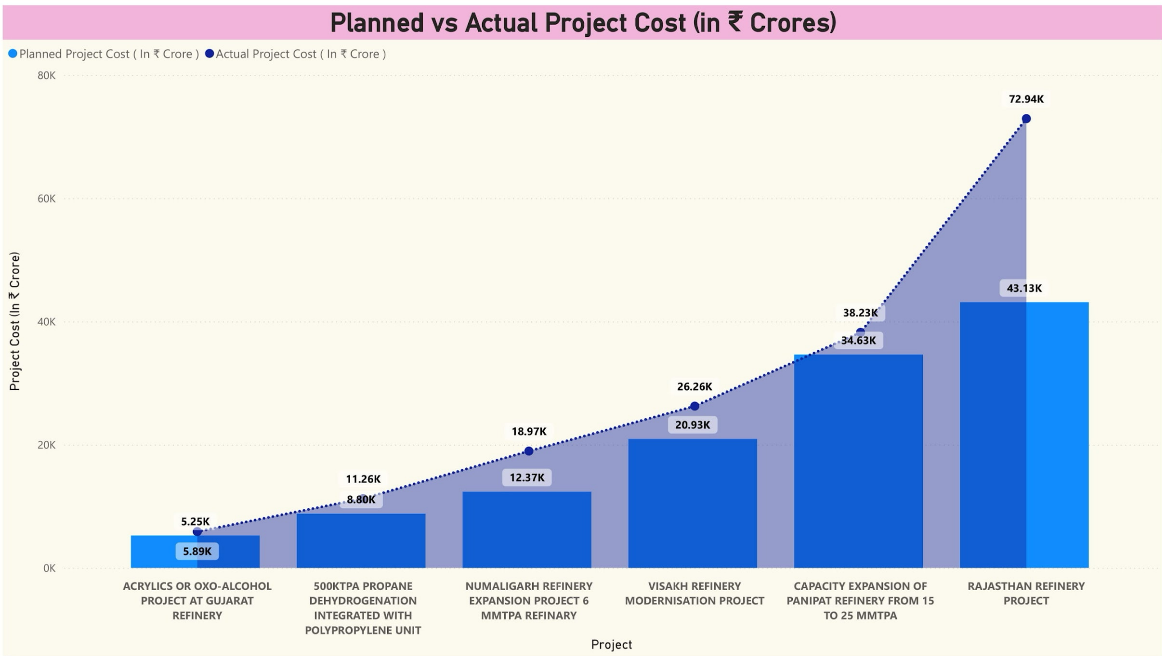
The Economic Survey Report published by E&Y for FY 2023-24 indicates that capital expenditure (CAPEX) is amounting to ₹9.5 lakh crore, marking a 28.2% year-on-year increase and being 2.8 times higher than the FY20 level. The government's focus on CAPEX has played a pivotal role towards driving economic growth, particularly in the face of a challenging and uncertain global environment. Investments in sectors such as road transport and highways, petroleum, railways, defense services, and telecommunications have provided sustained growth by alleviating logistical bottlenecks and expanding productive capacities.

The "Quarterly Project Implementation Status Report (QPISR)" for third quarter of FY 2023-24, published by the "Ministry of Statistics and Programme Implementation, Government of India", highlights that 1,897 projects funded by the central government are currently under execution. The anticipated completion cost of these 1897 projects is reported to be Rs. 31.74 Lakh crore. The total expenditure as on 31st December 2023 was Rs. 16.90 Lakh crore which works out to 53.22% of the total anticipated completion cost and 63.9% of the original cost. For these 1897 projects, a total outlay of Rs 3.71 Lakh crore has been allocated for 2023-24.

Out of 1897 projects, 580 projects are mega projects (Rs.1000 crore and above) and 1317 projects are major projects (Rs.150 crore to Rs.1000 crore).
96 projects out of the 161 projects related to the petroleum sector i.e. refineries & petrochemical projects, LNG terminals & pipeline projects are getting delayed and which are running behind the schedule.

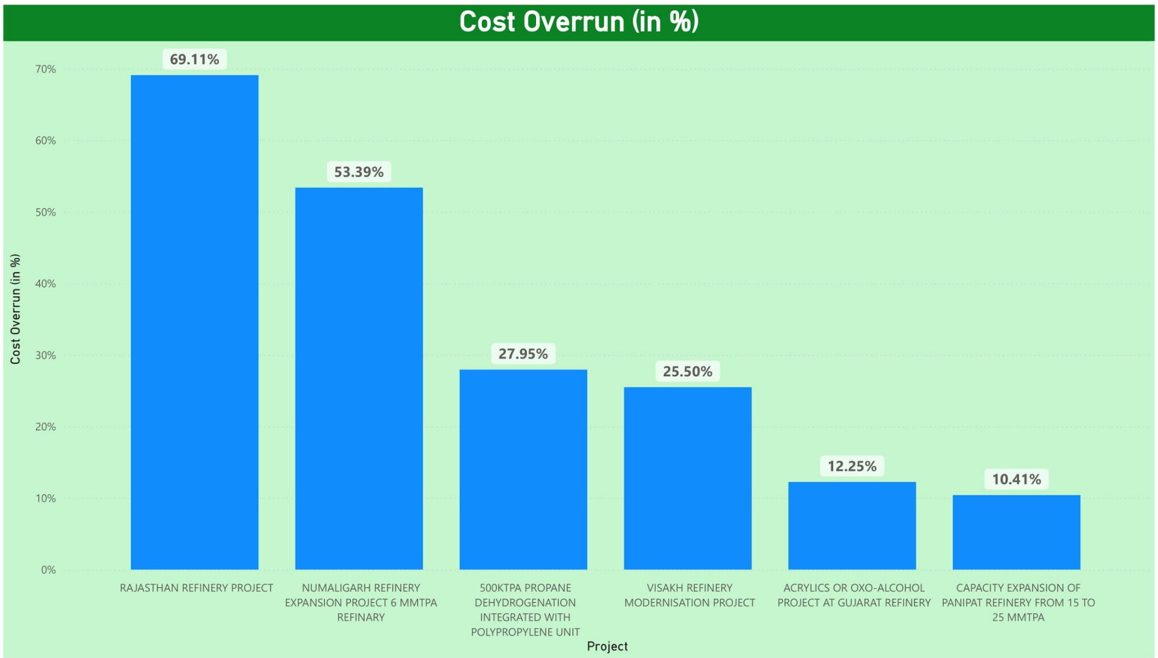
The Figure 1.1 highlights the planned versus actual project costs (in ₹ crores) for six major Indian refinery and petrochemical projects. The Acrylics or Oxo-Alcohol Project at Gujarat Refinery had a planned cost of ₹5.25K crore but was completed at ₹5.89K crore, showing a minor overrun. The 500 KTPA Propane Dehydrogenation Project had a more noticeable increase, with actual costs reaching ₹11.26K crore compared to the planned ₹8.80K crore. A significant spike is seen in the Numaligarh Refinery Expansion, which escalated from ₹12.37K crore to ₹18.97K crore. Similarly, the Visakh Refinery Modernisation Project exceeded its budget by over ₹5K crore, rising from ₹20.93K crore to ₹26.26K crore. The Panipat Refinery Expansion also went over budget, increasing from ₹34.63K crore to ₹38.23K crore. The most substantial cost escalation occurred in the Rajasthan Refinery Project, with actual costs surging to ₹72.94K crore from an initially planned ₹43.13K crore. This analysis underscores the growing concern over cost control and financial planning in large-scale infrastructure and energy projects in India.

Figure 1.1: Planned Vs Actual Project Cost



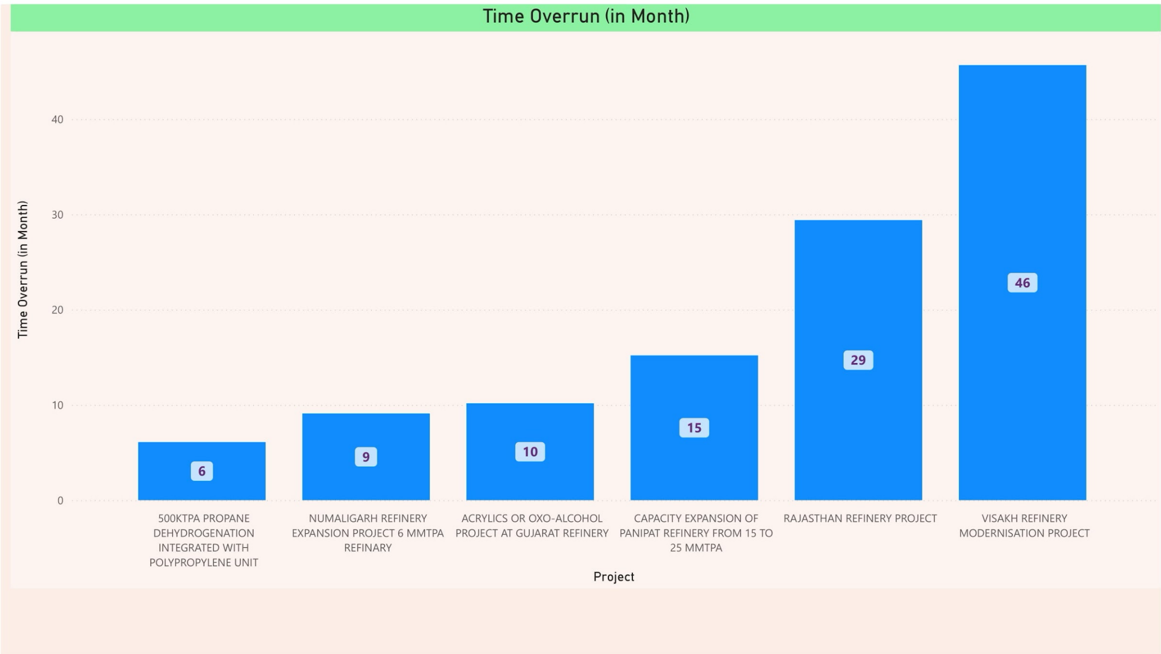
The Figure 1.2 titled as "Cost Overrun (in %)" presents a comparative analysis of percentage cost overruns across six major refinery and petrochemical projects in India. The Rajasthan Refinery Project experienced the highest cost overrun at 69.11%, followed by the Numaligarh Refinery Expansion Project at 53.39%, indicating significant budget miscalculations. The 500 KTPA Propane Dehydrogenation Project and the Visakh Refinery Modernisation Project also show notable overruns of 27.95% and 25.50%, respectively. In contrast, the Acrylics or Oxo-Alcohol Project at Gujarat Refinery and the Panipat Refinery Expansion had relatively lower overruns at 12.25% and 10.41%, respectively. This analysis highlights a concerning trend of substantial cost escalations in larger projects, pointing to the need for more accurate forecasting, risk management, and project control mechanisms.

Figure 1.2: Cost overrun in %



The Figure 1.3 presents the delay durations for six major refinery and petrochemical projects in India, revealing substantial schedule overruns. The Visakh Refinery Modernisation Project experienced the most significant delay at 46 months, followed by the Rajasthan Refinery Project, which faced a 29-month overrun. The Panipat Refinery Expansion was delayed by 15 months, while the Acrylics or Oxo-Alcohol Project at Gujarat Refinery and Numaligarh Refinery Expansion encountered delays of 10 and 9 months, respectively. The 500 KTPA Propane Dehydrogenation Project had the least delay at 6 months. This analysis underscores that in addition to cost overruns, timeline slippages are also a common challenge in large-scale projects, with implications for operational efficiency and financial returns.

Table 1.3: Time Overrun in %



Refineries and petrochemical mega projects are very complex in nature due to complex scope, procurement methods, financing, organization structure, complexity involving stakeholders such as “Owner, Licensor/Technology Providers, Project Management Consultant, Engineering Project and construction Management Consultant, Suppliers, Contactors, Third Party Inspection Agencies (TPIAs), Government Institutions”, external factors like local stakeholders, political institutions and ideological polarising groups and in this way the aforesaid factors results into cascading effect of project delay and thus running behind the schedule project completion time and leads to cost overrun.

Long project cycles are a common problem in projects which leads to inefficiencies, increased costs, and delay in implementations of projects, this is due to the complex nature of rules, regulation, procedure, nature of work and requirement of various stakeholders etc.

Major stakeholders involved in execution of the mega projects refineries and petrochemicals projects are as below:

1) Engineering Project Management Consultant: It provides detailed engineering based on BEDP provided by technology providers, procurement and construction management of the project.

2) Licensor/Technologies Providers: It provides technologies, licencing and basic design engineering package (BEDP) for various block/units involved in refineries and petrochemical projects such as Crude Block, RFCC block, Diesel Block, Polymer Block, Hydrogen Block, Sulphur Block, Captive Plant Unit etc.
3) Owner of the Project
4) Suppliers & Contractors: Suppliers & contractors provide goods & services required at project sites under the supervision of engineering consultants.
5) Other External factors like local stakeholders, political institutions and ideological polarising groups.

Mega projects very complex in nature and are executed in various project modes such as "Engineering Procurement and Construction (EPC), Engineering Procurement & Construction Management (EPCM) and Open Book Estimate (OBE), Licensing, Engineering, Procurement & Construction (LEPC)", and Public Private Partnership (PPP) etc.

1.2 Brief Background:

Important and critical issues that plague the implementation of refineries and petrochemical projects particularly in the Indian sub-continent. It is perhaps due to modes of project execution methodology, project management challenges, complex public procurement guidelines, construction management, involvement of various stakeholders etc. Projects are getting delayed due to delays in licensor/technology partner selection, detailed design engineering, procurement, construction, commissioning, post guarantee run test of units/blocks and handover to owner.

1.3 Gap in Literature:

61 There is limited research focusing on the specific causes of delays in refinery and petrochemical projects in India, existing literature primarily addresses delays in generic infrastructure/ road and highways projects, but have not been adequately explored in the context of refineries and petrochemical plants.

Project delays in India's refinery and petrochemical sector pose significant challenges, leading to cost overruns, supply chain disruptions, and reduced investor confidence. The literature identifies several key delay factors, including regulatory approvals, land acquisition issues, financial constraints, technical challenges, and logistical bottlenecks and many more.

While existing research provides insights into these causes, there is a literature gap in developing India-specific models for delay prediction and mitigation. Most studies focus on individual factors rather than integrated frameworks that consider financial, regulatory, and technical challenges collectively. Additionally, the impact of geopolitical risks and global supply chain disruptions remains underexplored.

To address these challenges, research suggests improved planning, risk management, stakeholder engagement, and policy reforms. Moreover, while some research has highlighted the economic impact of delays, few studies provide a detailed, quantitative analysis of how delays in Indian refinery projects impact costs, time schedules. Therefore, a significant gap in understanding the causes of delays specific to the Indian Projects.

Further, the timely and successful execution of public procurement is playing a major role for mega refinery and petrochemical projects. The existing literature review outlines the common delays in the public procurement process without going deeply into the root cause of the problem. Some of the studies mentioned that influence of government policies, bureautic approach in the organization delays the public procurement. Further, the involvement of various stakeholders are also overlooked in the delay of public procurement.

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1.4 Objective of the Study:

Objective of this research is to identify the key factors of delay for mega refineries & petrochemical projects in the Indian context. The detailed objectives of this research include as the following:

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1. To find the key causes of delay through literature review, research article and recommendation by researcher. Further, interviews are conducted with the experts dealing with such complex projects.
2. To rank the reasons for delay based on stakeholders i.e. owner, project engineering management consultant, contractors, material, Government & Political, labour, equipment & machinery, force majeure, unforeseen conditions and external factors.
3. To analyse the relationship between delay factors and cost overrun by using linear regression.
4. To analyze the cause of delay in procurement of mega refinery & petrochemical projects.
5. To provide the mitigation of critical delays, recommendation and suggestions.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review

49 Refineries and petrochemical projects are playing a major role towards the development of a nation and their performance measures the economic capability/performance of a nation. Many researchers have studied and investigated the reasons for the project delay for the projects executed in countries like Saudi Arabia, Nigeria, Egypt, Iran, USA and Korea etc., and limited study has been found towards finding the factors which are responsible for the delaying the refineries and petrochemical projects in the India as most of the projects are belong to Central Government/ PSUs.

Y. Frimpong et al. (2003) define project success and failure by measuring the gap between the expected requirements, budgeted costs, and schedule, compared to the actual completion upon delivery. In their research, they identified several key factors that contribute to significant project overruns in many developing countries, including "poor management of the contractor, issue towards payment, challenges in procurement of material, poor performance, and most important there is price escalation of materials required at project site".

Morris, P. W., et al. (1987), suggested the factors which influences the successful project execution, which are as below;

a) Approach to technology selection and detailed design engineering
b) Employees and their management
c) A system related planning & control
d) Organization roles & responsibilities

Trauner, T. J. (2009) notes that the concept of project delay lacks a clear definition, as its interpretation varies across different phases of project execution. Nonetheless, delays experienced in various phases contribute to an overall prolonged project duration.

In 2009, Trauner, T. J., described the term "critical delays" as a crucial task or route that, if postponed, will extend the deadline for completion. Activities that control the project completion of the project depend on time schedule, project execution strategy, procurement strategy, contractor/supplier selection, adequate resource mobilisation.

Flyvbjerg et al. (2003) found that nearly 90% of projects experience cost overruns, with actual costs exceeding the estimated costs by an average of 28%. Additionally, in the majority of cases, there is a considerable disparity between the anticipated outcomes of large capital expenditure (CAPEX) investments and the actual returns realized from mega project investments.

J. R. Park et al. (2005) identified five main reasons for project delays: "lack of proper planning, challenges in acquiring necessary land, inefficiency in project management, weak monitoring systems, conflicts between organizations, and strong public opposition".

Abdul-Rahman et al. (2009) reported that reasons for delay of the project i.e. "poor cash flow management, late payments, insufficient financial resources, and instability in financial markets". Further, these four factors were found to be "contractors' unstable financial backgrounds, clients' inadequate financial and business management, challenges in securing loans from financiers, and market inflation".

According to Cobb, A. T. (2011), the organisation must review the project's timeline, evaluate it critically, and create a detailed plan for putting them into action. It should be emphasised that at this stage, project tasks throughout the project life cycle will be mapped onto a schedule of the project. Further, they explained that starting a project is very crucial; it requires that leaders devote a lot of their focus and time on project and procurement planning.

Tadelis, S. (2012), identified that the most significant element that is decision-specific is contract complexity. Complex contracts have aspects that are hard to define or impossible to determine could raise more questions about quality. Complex contract design takes more time and effort to complete. Higher contract complexity and quality concerns encourage negotiation, which has an impact on award speed and ultimately causes delay in procurement.

Merrow (2012) found in their study of over 100 oil and gas projects with capital investments over USD1 billion that 80% of these projects had an average cost overrun of 25% and a schedule delay of about 22%.

15 E&Y (2014), published a report and highlighted that more than 60% of large oil and gas projects are having significant cost overrun, based on research conducted for more than 250 projects.

Rui et al. (2017), explained in their article that time and cost overruns are the key factors for failure of the oil and gas projects. Further, he also explained that average cost overrun in refineries is about 18%.

Nguyen et al. (2013), have explained the failure indicators in construction projects are 1) Cost overrun 2) Time overrun 3) Defect in quality of product and services 4) Negligence on HSE.

Suppramanium et al. (2018), categories the 47 causes of project delay for oil and gas projects in Malaysia into six major groups i.e. “Owner, Contractor, Engineering Consultant, Project, External, and Resources”.

Sweis et al. (2019), used the process of root cause analysis (RCA) in construction projects in oil & gas refineries to define the category and rank of the source of the delay. The 24 causes of delay were divided into five main groups i.e. Operational, Human & Equipment, External, Project site conditions & Financial arrangements of project. Further, they ranked the cause of the delay and the most significant causes are poor planning and scheduling, cash flow and financial management issues among the owner, contractor and subcontractor and Political situations in the country.

Ruqaishi et al. (2015), conducted a survey from 54 project managers and based analysis they defined five causes which lead to the failure of the project i.e. “poor site management, sub-contractors issues at site, inadequate planning and scheduling, poor management at site and delay of materials at site”.

R. Aziz et al. (2016), public procurement system states that, a contractor with lowest price wins the project, this significantly caused the poor performance by the contractor and delay of the projects.

Hatmoko et al. (2019), found in their research work that “long lead items are very critical and require a long manufacturing time schedule, scopes changes, detailed engineering design delay, and the lack of experience of contractors” are the common reasons for project delays in oil and gas projects.

The reasons for project delays and cost overruns of the project are summarized in Table 2.1 after reviewing the literature review, research articles, books and recommendation from researchers. During the review process, relevant studies were identified and selected from reputed journals and SCOPUS using combinations of keywords related to project failure, such as 'project failure,' 'failure in construction projects,' 'failure factors,' 'cost overrun,' and 'time overrun.', delays in oil & gas projects’".

Table 2.1: Major causes of delay in the reviewed articles & research papers

Sr.	Major delay causes	Researchers
1.	Slow decision making an approval process	Kammer A, Azour J, Selassie AA (2022). Mbah RE, Wasum DF (2022) Z˙ uk P, Z˙ uk P. (2022) Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK. (2022) Tadelis, S. (2012)
2.	Financial difficulties (i.e. shortfall in funds) and delays in payments by client	Kammer A, Azour J, Selassie AA, Goldfajn I, Rhee C. (2022). Mbah RE, Wasum DF (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M at. al. (2023) Rawat A, Gupta S, Rao TJ. (2023) Y. Frimpong et al. (2003)
3.	Change orders by client and large quantities of extra work	Kammer A at. al. (2022). Xie M at. al. (2023) Rawat A, Gupta S, Rao TJ. (2023)
4.	Frequent technical and executive interventions during execution of the project	Kammer A at. al. (2022). Mbah RE, Wasum DF (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M at. al. (2023) Rawat A, Gupta S, Rao (2023)
5.	Delay in award of the projects and suspension of the work	Rawat A, Gupta S, Rao TJ. (2023) Sharma J at. al.(2022)
6.	Improper project pre-feasibility study, detailed feasibility study and design basic	Kammer A, Azour J, Selassie AA, Goldfajn I, Rhee C. (2022). Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)

		Tollefson J. (2022)
7.	Unrealistic contract duration and cost estimation	Kammer A, Azour J, Selassie AA, Goldfajn I, Rhee C. (2022). Mbah RE, Wasum DF (2022) Tollefson J. (2022)
8.	Improper bidding process and award mechanism (negotiation of prices and contract terms & conditions, lowest bidder)	Kammer A at. al.(2022). Z˙ uk P, Z˙ uk P. (2022) Xie M at. al. (2023) Rawat A, Gupta S, Rao TJ. (2023) Ma X. (2017) Tadelis, S. (2012)
9.	Inadequately vague scope of work	Tollefson J. (2022) Z˙ uk P, Z˙ uk P. (2022) Gupta S K (2019)
10.	Lack of effective project control management system	Mbah RE, Wasum DF (2022) Sharma J at. al.(2022) Ma X. (2017) Gupta SK at. al.(2019) J. R. Park et al. (2005)
11.	Poor communication and coordination among the stakeholders	Mbah RE, Wasum DF (2022) Tollefson J. (2022) Sharma J at. al.(2022) Ma X. (2017) Gupta SK, Gunasekaran A, Antony J, Gupta S, Bag S, Roubaud D. (2019) Z˙ uk P, Z˙ uk P. (2023) Y. Frimpong et al. (2003)

12.	Administrative procedures and bureaucratic organization	Mbah RE, Wasum DF (2022) Tollefson J. (2022) Sharma J (2022) Ma X. (2017) Gupta SK, Gunasekaran A, Antony J, Gupta S, Bag S, Roubaud D.(2019) Z˙ uk P, Z˙ uk P. (2023) Tadelis, S. (2012)
13.	Inaccurate quality assurance, quality assurance and inspection process	Mbah RE, Wasum DF (2022) Tollefson J. (2022) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022). Ma X. (2017) Gupta SK, Gunasekaran A, Antony J, Gupta S, Bag S, Roubaud D. (2019) Z˙ uk P, Z˙ uk P. (2023)
14.	Insufficient contract clauses and ineffective delay penalties	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2023) Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)
15.	Major legal disputes	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023)
16.	Poor Human Resource Management and low motivation	Mbah RE, Wasum DF.(2022) Tollefson J. What the war in (2022) Y. Frimpong et al. (2003)

17.	Inadequate design experience while executing the project (design changes and frequent errors)	Kammer A, Azour J, Selassie AA, (2022) Mbah RE, Wasum DF. (2022). Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)
18.	Delay in the document preparation for procurement and construction	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023)
19.	Delay in approving manufacturing drawings and test reports	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023) Ma X. (2017)
20.	Frequent changes in specifications and manufacturing drawings	Mbah RE, Wasum DF. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. 2023
21.	Technology restrictions and poor use of advanced design software	Mbah RE, Wasum DF. (2022) Tollefson J. (2022) Rawat A, Gupta S, Rao TJ. (2023) Gupta SK, Gunasekaran A, Antony J, Gupta S, Bag S, Roubaud D. (2019)
22.	Shortage of knowledgeable designers and experienced experts in the organization	Mbah RE, Wasum DF. (2022) Ma X. (2017) J. R. Park et al. (2005)

23.	Poor management and supervision of work during site construction	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022) Gupta SK, Gunasekaran A, Antony J, Gupta S, Bag S, Roubaud D. (2019) Y. Frimpong et al. (2003)
24.	Employing unqualified subcontractors and frequent changes	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022). Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)
25.	Cash flow problems	Mbah RE, Wasum DF. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Ma X. (2017) Y. Frimpong et al. (2003)
26.	Inappropriate construction methods	Mbah RE, Wasum DF. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)

27.	Rework due to frequent error in site activities	Kammer A, Azour J, Selassie AA, Goldfajn I, Rhee C. (2022) Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023) Ma X. (2017)
28.	Incompetent engineer at site and technical staff	Mbah RE, Wasum DF. (2022) Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)
29.	Shortage of skilled manpower and critical equipment operators required at site.	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023) Y. Frimpong et al. (2003)
30.	Labor productivity	Kammer A, Azour J, Selassie AA, Goldfajn I, Rhee C. (2022) Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Rawat A, Gupta S, Rao TJ. (2023)
31.	Labor disputes and strikes, injuries, and tough shifts at project site	Xie M at. al.(2023) Rawat A, Gupta S, Rao TJ.(2023)
32.	Shortage of supply material and late deliveries of supply materials and delay in imported critical materials	Mbah RE, Wasum DF. (2022) Tollefson J. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M at. al.(2023) Rawat A, Gupta S, Rao TJ. (2023) Ma X. (2017)

33. Poor quality of material	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M at. al.(2023) Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)
34. Material breakdown at the time of installation and improper/ preservation	Mbah RE, Wasum DF. (2022) Tollefson J. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023)
35. Difficulties in critical imported material and their transportation	Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Ma X.(2017)
36. Shortage of equipment required for installation and frequent equipment breakdown	Mbah RE, Wasum DF. (2022). Tollefson J. (2022) Z˙ uk P, Z˙ uk P. (2022) Rawat A, Gupta S, Rao TJ. (2023). Ma X. (2017)
37. Lack of modern machineries, equipment and special tools & tackles	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022)
38. Slow permit by government body	Xie M at.al(2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)
39. Changes in government rules, regulations and laws	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ.(2023)

40.	Frequent political interference and unstable government	Kammer A, Azour J, Selassie AA, Goldfajn I, Rhee C. (2022) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)
41.	Delayed service of utilities (electricity, water, etc.)	Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023)
42.	Recruitment of local peoples at site	Z˙ uk P, Z˙ uk P. (2022)
43.	Social, religious events, and disputes with local people	Z˙ uk P, Z˙ uk P. (2022) Sharma J at. al.(2022)
44.	Extreme weather conditions at construction site	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ.(2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022) Ma X. (2017)
45.	Natural disasters (floods, landslides, etc.)	Mbah RE, Wasum DF. (2022) Z˙ uk P, Z˙ uk P. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023)
46.	Accidents during construction	Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023)

47.	Global unexpected crises	Kammer A, Azour J, Selassie AA, Goldfajn I, Rhee C. (2022) Rawat A, Gupta S, Rao TJ. (2023) Sharma J at. al.(2022) Gupta SK, Gunasekaran A, Antony J, Gupta S, Bag S, Roubaud D. (2019)
48.	Price fluctuations and inflation & Global unexpected crises	Mbah RE, Wasum DF. (2022) Tollefson J. (2022) Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Rawat A, Gupta S, Rao TJ. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022) Ma X. (2017)
49.	Security issues (vandalism etc.)	Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Sharma J, Soni S, Paliwal P, Saboor S, Chaurasiya PK, Sharifpur M, Afzal A. (2022)
50.	Corruption and bribery	Xie M, Yi X, Liu K, Sun C, Kong Q. (2023) Sharma J at.al.(2022)
51.	Sanction imposed by Government	Mbah RE, Wasum DF. (2022). Xie M at. al.(2023)

Procurement of Goods & Services is playing a major role for successful implementation of mega projects. Milne, A., et al. (2023), suggest that delays in procurement are increasing the project cost. Low competition creates options for bidders to charge more price. Further, delay in refineries & petrochemical projects lead to substantial increase in cost. This study examines various factors that cause delays in public procurement contracts award. It is highlighting that decision specific factors such as contract complexity, bureaucratic process and negotiation mechanism also causes delay in public procurement.

Hazarika, B. et al. (2017) explained in the report of "National Institute of Public Finance and Policy, New Delhi" (WP No. 204, 2017), "An active public procurement system is necessary in India to get the required results. Public procurement is delayed due to ineffective standard procurement procedures, low awareness, organisational cultures and procurement practices. The main issues that have arisen in the Indian public procurement system are "a) The absence of a comprehensive procurement Act, b) Lack of standard bid documents, c) Delays in activities in procurement cycle, d) Unfair practices and corruption, e) Presence of anti-competitive elements & f) Competency and skill of the Procurement Officials."

Further, Hazarika, B. et al. (2017) find that public procurement procedure in India is complex in nature because of the federal structure for the provision of public services as per the "National Institute of Public Finance and Policy, New Delhi" (WP No. 204, 2017). In order to comply with the constitutional framework, Public Sector Undertakings (PSUs), autonomous and statutory entities, the Union and State governments must meet a wide range of conditions for providing public services. Due to non availability of comprehensive public procurement law that oversees the procurement process, public procurement has become more complex. In the lack of comprehensive legislation, government bodies are granted the authority to conduct procurement processes through the use of General Financial Rules (GFRs). The public procurement environment in the country has become more diverse despite the system maintaining the principles of the practice. Many companies have their own procurement manuals, including those in the fields of public works, railroads, defence, and some oil and gas as well.

OECD-Organization for Economic Co-operation & Development (2024), it is explained how standardisation is required, notably for the procedures, tender documents, and contract terms & conditions. Tender documents must be extremely transparent, as general as feasible, and non-discriminatory in nature.

India's performance in the Corruption Perceptions Index (CPI), published annually by Transparency International, has shown a slight decline in recent years. In the 2024 CPI, India ranked 96th out of 180 countries, with a score of 38 out of 100, down from 93rd place in 2023, when it scored 39 points.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Design:

A research design outlines the methods and procedures for gathering and analyzing the necessary data. It serves as a comprehensive framework for the study, ensuring that the objectives set at the beginning of the research are achieved. The purpose of this research is to identify the key causes of project delays impacting Indian refineries and petrochemical projects, from the perspectives of stakeholders such as owners, project engineering management consultants, contractors, materials, labor, equipment and machinery, force majeure, unforeseen conditions, and external factors. This study will employ both qualitative and descriptive research designs, with a particular focus on quantitative research.

3.2 Interview & Data Collection:

Interviews were conducted with the managers from project, procurement, contract, finance, and construction for finalising and confirming the list of delay causes & cost overrun, and after discussion some of the causes were added, revised, or removed. The finalised list is now containing 44 delay factors categorised into 07 major groups, which is presented in Table 3.1. Further, the 07 cause of cost overrun is also presented in Table 3.2. Gupta et al (2019) has adopted similar methodologies in their research work.

Table 3.1: Major causes for delay finalised after interview with Experts

Sr.	Group	Categories	Code	Major Causes of Delays
1.	G01	Client (Owner of the Project)	CL01	Delays in making of decision and approval processes
2.			CL02	Financial difficulties, including shortfalls in funds and delays in payments
3.			CL03	Frequent technical and executive intervention
4.			CL04	Project award delay and suspension of the work

5.			CL05	Non availability of physical fronts, Right of Way permission
6.			CL06	Delay due to Land Acquisition issues, Transfer of Government Land & Diversion of forest land.
7.			CL07	Improper pre-feasibility study, detailed feasibility study of the project
8.	G02	Project Management & Engineering Consultancy	PME01	Improper bidding process and award mechanism (price/contract negotiations and lowest bidder)
9.			PME02	Inadequately described or vague scope of work *"Specific tasks, deliverables, responsibilities, and objectives of a project or job are not clearly defined"*
10.			PME03	Lack of effective project control in place *"Inability to monitor, manage, and guide a project adequately to ensure it stays on track, within budget, and meets its objectives"*
11.			PME04	Poor communication and coordination between various stakeholder
12.			PME05	Administrative procedures and bureaucratic organization
13.			PME06	Inaccurate quality assurance, quality control and inspection process at site

14.			PME07	Ambiguous and conflicting contract clauses in contract and ineffective delay penalties, legal disputes
15.			PME08	Unrealistic contract duration *"Leads to penalizing contractors during execution of the contract which may result in delays"*
16.			PME09	Variations in cost estimate may lead to delay in awarding the contracts
17.			PME10	Inadequate design experience (design changes and errors)
18.			PME11	Frequent revisions in scope of work and issuance of amendments.
19.			PME12	Delay in preparation of the documents for procurement and construction
20.			PME13	Delay in approving the manufacturing drawings and test reports during inspection
21.			PME14	Shortage of knowledgeable and experienced project team
22.	G03	Contractor	C01	Delay in mobilisation of manpower and equipment & machineries at project site
23.			C02	Poor management & supervision of work by contractor during construction at site
24.			C03	Deployment of unqualified subcontractors and frequent changes

25.			C04	Cash flow problems with contractors
26.			C05	Modifications and rework at construction site
27.			C06	Incompetent site engineer and technical staff
28.	G04	Material	M01	Shortage of supply material, late deliveries, delay in imported materials
29.			M02	Poor quality of material
30.			M03	Improper storage of material and their breakdown during installation
31.	G05	Labour, Equipment & Machinery	LEM01	Shortage of skilled staff and also high turnover of skilled staff
32.			LEM02	Labor disputes, injuries, strikes, sickness, workload, and tough shifts of work.
33.			LEM03	Lack of modern machineries, equipment, and special tools & tackles required at construction site
34.	G06	Government & Political	GP01	Slow permit processing by government agencies & Ministries involved in execution
35.			GP02	Changes in government rules & regulations
36.			GP03	Political interference and unstable government
37.			GP04	Delay in delivery of utilities provided by the government (electricity, water, etc.)
38.			GP05	Recruitment of localised people

39.	G07	Force majeure, unforeseen condition and external factors	F01	Extreme weather conditions at construction sites (rainy, high summer season etc.)
40.			F02	Natural disasters (floods, landslides, etc.)
41.			F03	Accidents at construction site
42.			F04	Price fluctuations and inflation & global unexpected crises (due to war, political crisis etc.)
43.			F05	Corruption and bribery
44.			F06	Religious & social events, disputes with local people, theft and vandalism

Table 3.2: key causes of cost overrun finalised after interviews with experts

Sr.	Group	Categories	Code	Major causes for Cost Overrun
1.	G08	Cost Overrun	CO1	Cost overrun due to delay in projects schedule
2.			CO2	Cost overruns due to policy related issues i.e. ((i) foreign exchange rate, (ii) Statutory duties & Taxes, (iii) Price rise & inflation)
3.			CO3	Cost overruns due to under-estimation of original cost
4.			CO4	Cost overruns due to monopolistic pricing by suppliers for critical equipment
5.			CO5	Cost overrun due to delay in tendering, ordering & supply of equipment

6.	CO6	Cost overrun due to changes in scope/design of projects
7.	CO7	Escalating expenses for land acquisition

3.3 Sampling:

Buckley, P. J. (2016), emphasised the importance of selecting experts for interviews in narrative strategy that relies on historical analysis techniques. It is essential that the chosen interviewees are involved throughout the entire process to ensure researchers are gathering the accurate data. Additionally, Fei and Khan (2015) outlined the criteria for expert selection used in this research, which include:

1) A minimum experience of 10 years in project execution for refinery and petrochemical;

2) Having either a bachelor's degree or above.

According to Kothari, C.R. (2004), the study's population focused on data readily obtainable from various stakeholders involved in the project execution cycle. In this study total 93 individuals have responded to the questionnaire issued, which was basically designed to identify the causes of project delays & cost overrun due to this for the refineries & petrochemical projects in the Indian contest. Survey was distributed to individuals of various parties involved in project execution especially who have vast experience. Various parties are as below:

1) Owner
2) Suppliers
3) Contractors
4) Engineering, Procurement & Construction Management Consultant (Various specialists like: Procurement, Project, Planning & Cost Control, Engineering & Finance).
5) Technology Providers & Licensor

3.4 Questionnaire Survey:

The questionnaires have three Parts: Part I (Demographic Information like personal details, experience and organisational details of the respondents), Part II (Time Overrun: listing the causes of time overruns), and Part III (Cost Overrun: listing the causes of cost overruns). The online survey was created and distributed to participants actively engaged in various roles & responsibilities and phases of refinery and petrochemical projects execution. After respondents completed their survey, their answers were collected, and the data was analysed in relation to the study's overall objective findings. Participants were assured that their responses would remain confidential.

3.5 Reliability and Validity of Data:

The current study establishes validity and reliability using four methods outlined by Koch et al. (1994) and Riege et al. (2003). To ensure both validity and reliability, three key criteria were considered i.e. "developing the initial interview framework based on the theoretical background; clarifying key concepts related to the research topic prior to the interview; and posing questions aligned with the expertise of the project practitioners during the interview process".

3.6 Measurement Scale:

The type of Questionnaires defined based on likert scale as indicated below:
"Strongly Agree: SA,
Agree: A
Neutral: N
Disagree: D
Strongly Disagree: SD"

Table 3.3: Likert scale

	SA	A	N	D	SD
Ranking Order	**5**	**4**	**3**	**2**	**1**

3.7 Public Procurement Delay:

Sponsors for most mega refinery and petrochemical projects are PSUs & Government due to high CAPEx and their procurement of goods & services are guided by public procurement guidelines. Mega projects are very complex in nature due to complex scope, procurement methods, financing, organization structure, complexity involving stakeholders, Government Institutions & external factors like local stakeholders, political institutions and ideological polarising groups. Accordingly a separate study has also been conducted by way of questionnaire with approximately 67 individuals. Questionnaire was designed to identify the primary causes of procurement delays.

3.7.1 Independent Variable:

1) Complex technical specifications commercial terms and conditions (complexity, scale & scope)
2) Frequent extension of Bid Due date on account of Poor response from bidder/Pre-bid Clarification/Amendments.
3) Involvement of complex Procedure/Guideline.
4) Slow decision-making Process.
5) Unfair Practice and Corruption causes a delay in public procurement.
6) Inadequate Competency and skill of the procurement officials.
7) Negotiation process (negotiation over Contract Terms & conditions, contract specification and Price).

3.7.2 Dependent Variable:

1) Procurement Delay.

3.7.3 Conceptual Framework of the Study:

The conceptual framework serves to guide the identification of research problems and outline the variables along with their indicators for the study's objectives. It establishes the relationships between the variables to be examined, aligning with the study's objectives. This research explores the associations and interrelations among independent and dependent variables, focusing on their cause and effects.

3.7.4 Data Analysis Technique:

57 The objective of the study is to find out the key factors which are contributing towards the delay of the public procurement for projects. The independent variables that cause the effect on dependent variables were taken, as they might have some significant impact on the
54 dependent variables. while investigating it is required to find out the key factors that caused the delay in the public procurement. The primary data were collected through questionnaires for the study. SPSS-IBM was used for analysing the demographic data through descriptive analysis and regression analysis. Regression analysis assessed reliability and significance levels between respondent groups using Beta coefficients and Significance Value of P.
6 Additionally, linear regression analysis was done to find the relationship between dependent and independent variables.

CHAPTER 4

ANALYSIS, DISCUSSION AND RECOMMENDATIONS

4.1 Results of the Study:

A careful study of the identified problem that was conducted through the analysis, with the collected data through questionnaire. Consequently, the responses from the participants provided insight into the key reasons for the organisation's public procurement delay.

4.2 Demographic Characteristics:

Below demographic details were collected from the respondents.

a) Age
b) Occupation
c) Educational Qualification
d) Stakeholder involved in project execution
e) Specialised Professionals
f) Work Experiences

4.2.1 Age of the Respondent:

Table 4.1 explains the age distribution of the sample shows with the largest group (54.84%) falling within the 31-40 years age range. The 41-60 years group comprises 38.71% of the sample, while only 5.38% are aged 21-30 years. Individuals aged above 60 years represent a very small proportion, making up just 1.08% of the total sample. Overall, the sample is predominantly composed of those experienced in the age group.

4.2.3 Occupation of the Respondent

Table 4.1 explains the sample is predominantly employed in Government Organizations & PSUs operating under MoPNG, which account for 74.19% of the total respondents. In contrast, Private Organizations make up 25.81% of the sample. This indicates a strong representation of individuals from the public sector.

4.2.4 Educational Qualification of the Respondent

In Table 4.1, The sample is evenly distributed between individuals with Graduate (B.Tech) qualifications, who make up 50.54% of the total respondents, and those with PostGraduate qualifications, comprising 49.46%.

4.2.5 Stakeholder involved in project execution

Table 4.1 explains that the majority of stakeholders are from the Project Management & Engineering Consultant category, comprising 77.4% of the total participants (72 out of 93), reflecting the significant role these professionals play in overseeing project execution. The Supplier group follows at 10.8% (10 out of 93), highlighting the essential role of suppliers in providing resources and materials. A smaller proportion of Contractors (6.5%, or 6 participants) and Owners (5.4%, or 5 participants), were identified, demonstrating the collaborative yet specialized nature of the project environment.

4.2.6 Specialised professionals involved in project

Table 4.1 provides the information that the sample includes a diverse range of specialized professionals involved in the project, with Procurement (25.81%) and Engineering (24.73%) being the largest groups. Other notable areas of involvement include Project Management (17.20%) and Construction & Commissioning (16.13%). Smaller representations are seen in Business Development (2.15%), Finance (1.08%), Human Resource (1.08%), Inspection (1.08%), Marketing (1.08%), and Sales & Marketing (1.08%). This distribution reflects a strong focus on technical, project management, and procurement roles within the sample.

Table 4.1: Demographic Details of the Respondent

Parametre	**Frequency**	**Percent**
	Age	
21-30 Years	5	5.38
31-40 Years	51	54.84
41-60 Years	36	38.71
Above 60 Years	1	1.08
Total	93	100.00
	Occupation	
Government Organizations & PSUs Operating under MoPNG	69	74.19

Private Organization	24	25.81
Total	93	100.00
Educational Qualification		
Graduate (B.Tech)	47	50.54
Post Graduate	46	49.46
Total	93	100.00
Stakeholder involved in Project Execution		
Contractor	6	6.45
Owner	5	5.38
Project Management & Engineering Consultant	72	77.42
Supplier	10	10.75
Total	93	100.00
Specialised professionals involved in project		
Business Development	2	2.15
Construction & Commissioning	15	16.13
Engineering	23	24.73
Finance	1	1.08
Human Resource	1	1.08
Inspection	1	1.08
Marketing	1	1.08

Planning, Control & Cost Estimation	8	8.60
Procurement	24	25.81
Project	16	17.20
Sales & Marketing	1	1.08
Total	93	100.00

4.2.7 Work Experience of the Respondent

Table 4.2 represents the distribution of professional experience across 93 individuals, with the range of experience spanning from 2 years to 35 years. The data indicates a varied distribution of years of experience, with certain levels being more prevalent than others.

The most common experience level among the participants is 17 years, containing 12.90% of the total sample size. Other experience levels that show relatively higher frequencies include 15 years (10.75%), 18 years (9.68%), 12 years, and 13 years, each contributing 6.45% to the total distribution. These five levels (15, 17, 18, 12, and 13 years) represent the central cluster of experience, encompassing nearly half of the respondents.

In conclusion, the data demonstrates a predominant cluster of individuals with 15 to 18 years of experience, with other levels showing a more scattered, yet still noticeable, presence across the full spectrum of years in the study.

Table 4.2: Work Experience of the Respondent

Experience in Years	**Frequency**	**Percent**
2	1	1.08
3	3	3.23
4	1	1.08
5	1	1.08
8	2	2.15

Experience in Years	Frequency	Percent
10	3	3.23
11	1	1.08
12	6	6.45
13	6	6.45
14	7	7.53
15	10	10.75
16	5	5.38
17	12	12.90
18	9	9.68
19	5	5.38
20	4	4.30
21	3	3.23
22	3	3.23
23	1	1.08
24	1	1.08
25	1	1.08
26	1	1.08
28	3	3.23
29	1	1.08
31	1	1.08

Experience in Years	Frequency	Percent
33	1	1.08
35	1	1.08
Total	93	100.00

4.3 Reliability Analysis:

Cronbach's Alpha is 0.879 for Project Management & Engineering Consultancy, this variable has very good reliability and is a strong aspect of your research. for Contractor its (0.770) and Government & Political (0.788), this is also good, with reliable measurement. Cronbach's Alpha for Force majeure, Unforeseen Conditions, External Factors is (0.739) and for Cost Overrun its (0.768) its moderate reliability. Cronbach's Alpha for Owner is (0.673) and for Material its (0.680). This is slightly below the acceptable threshold, and it may be worth revisiting the items for clarity or relevance.

Table 4.3: Variability & Reliability Analysis

Sr.	Name of Variable	Cronbach Alpha	No. of Items
1	Owner (Client)	0.673	7
2	Project Management & Engineering Consultancy	0.879	14
3	Contractor	0.77	6
4	Material	0.680	3
5	Labour, Equipment & Machinery	0.754	3
6	Government & Political	0.788	5
7	Force majeure, Unforeseen Condition, External Factors	0.739	6

8	Cost OverRun	0.768	7

Cronbach Alpha = Reliability

4.4 Normality Test (Descriptive Analysis):

The data summary of computed variables presents the mean value, standard deviation, skewness, and kurtosis values for various variables related to project delays in refinery and petrochemical projects.

45 4 4.4.1 Owner: Owner has a mean of 4.026, with a relatively low standard deviation (0.467), indicating consistent responses. The skewness (0.048) and kurtosis (-0.438) suggest a near-normal distribution.

51 4.4.2 Project Management & Engineering Consultancy(PMEC): PMEC shows a mean of 3.782 and a higher standard deviation (0.543), implying greater variability in responses. The skewness is slightly negative (-0.067), and the kurtosis is positive (0.210), indicating a slight peak in the distribution.

4.4.3 Contractor: Contractor mean score is 4.065, and standard deviation is 0.486, reflecting moderate consistency. The skewness (0.099) is positive, while the kurtosis (-0.259) indicates a slight flatness in the distribution.

4.4.4 Material: Material mean score is 3.742, with standard deviation of (0.680), which shows significant variability. The skewness (-0.173) and kurtosis (-0.547) suggest a fairly normal distribution with a slight negative skew.

27 4 4.4.5 Labour, Equipment & Machinery: Labour, Equipment and Machineries have a mean of 3.935 and a standard deviation of 0.667, indicating variability in responses. The negative skewness (-0.268) and the negative kurtosis (-0.371) suggest a distribution that is slightly skewed to the left with some flatness.

4 4.4.6 Government & Political: Government & Political shows a mean of 3.791, with a standard deviation of 0.641. The skewness (-0.256) and kurtosis (-0.020) indicate a near-normal distribution with slight left skewness and a relatively flat distribution.

37 The factors of Force Majeure, Unforeseen Conditions, and External Factors have an average score of 3.704 and a standard deviation of 0.576, showing some variation. The skewness of -0.312 and kurtosis of -0.304 indicate that the distribution is slightly left-skewed and flatter than a normal distribution. 34

4 **4.4.7 Cost Overrun:** Cost overrun shows a mean of 3.948 and a standard deviation of 0.458, with positive skewness (0.191) and positive kurtosis (0.326), suggesting a distribution with a slight peak and a skew towards higher values.

Table 4.4: Normality Test (Descriptive Statistics)

Variable	Mean	Std. Deviation	Skewness	Kurtosis
Owner (Client)	4.026	0.467	0.048	-0.438
Project Management & Engineering Consultancy	3.782	0.543	-0.067	0.210
Contractor	4.065	0.486	0.099	-0.259
Material	3.742	0.680	-0.173	-0.547
Labour, Equipment & Machinery	3.935	0.667	-0.268	-0.371
Government & Political	3.791	0.641	-0.256	-0.020
Force majeure, Unforeseen Condition, External Factors	3.704	0.576	-0.312	-0.304
Cost Overrun	3.948	0.458	0.191	0.326

N=93

Table 4.1: Normality curve for delay attributable to Owner

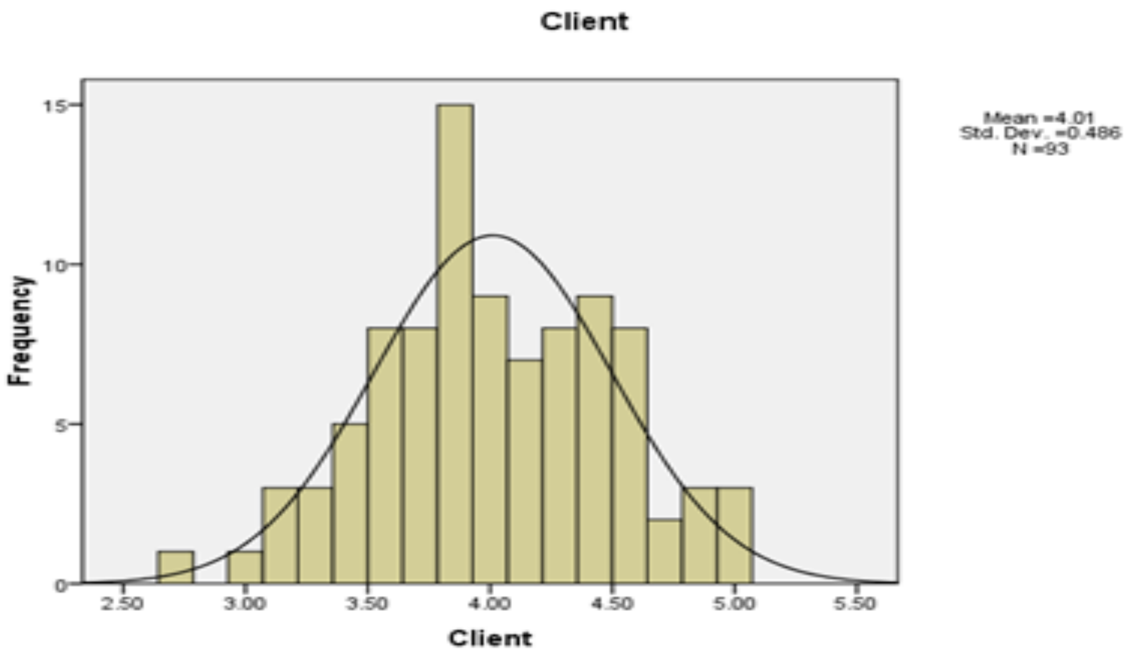

Figure 4.2: Normality Curve for Project Management & Engineering Consultancy Contractor

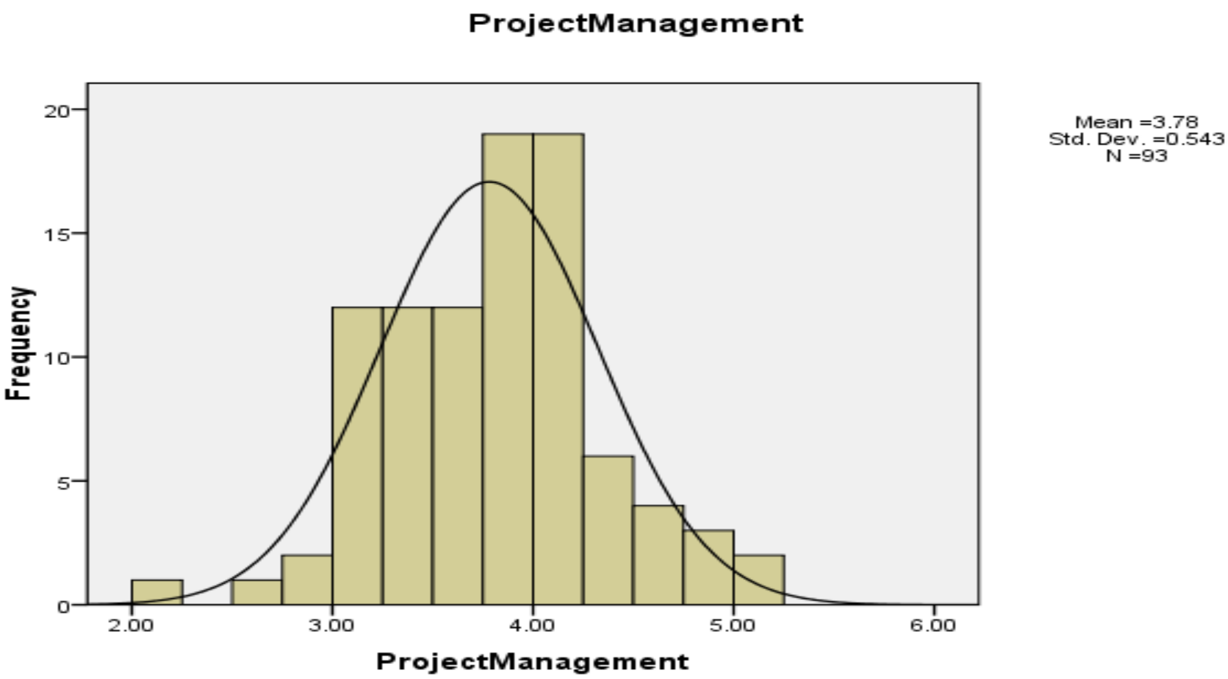

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Figure 4.3: Normality Curve for Contractor

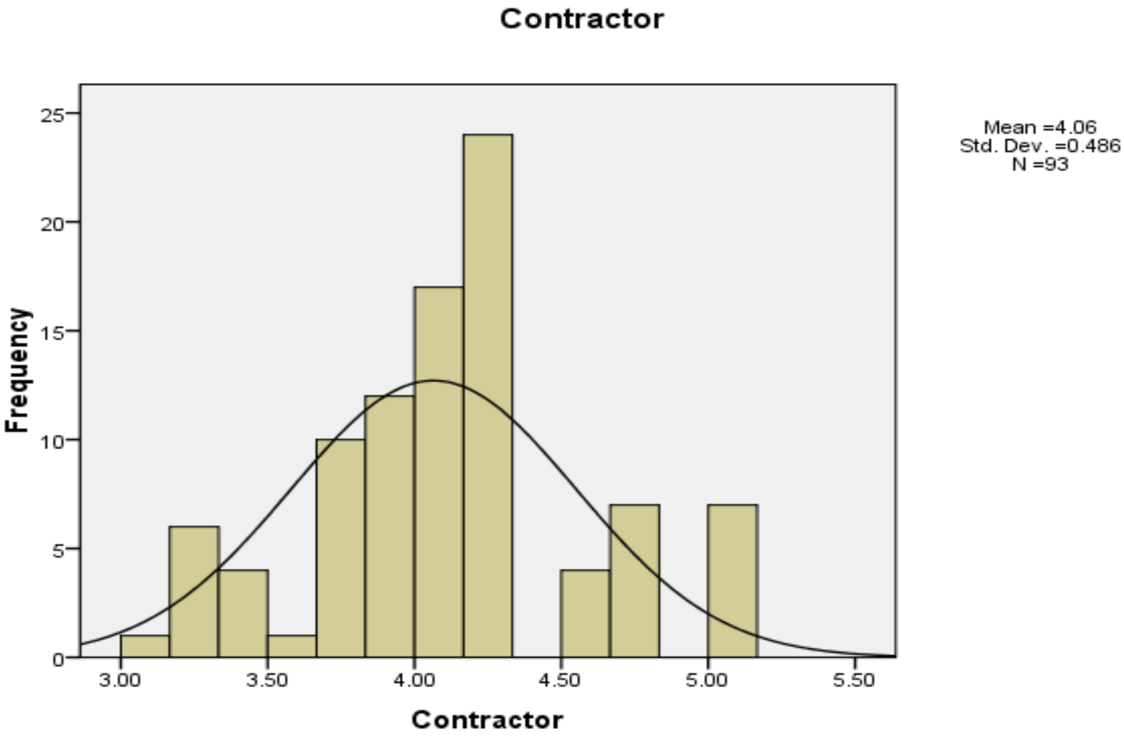


Figure 4.4: Normality Curve for Material

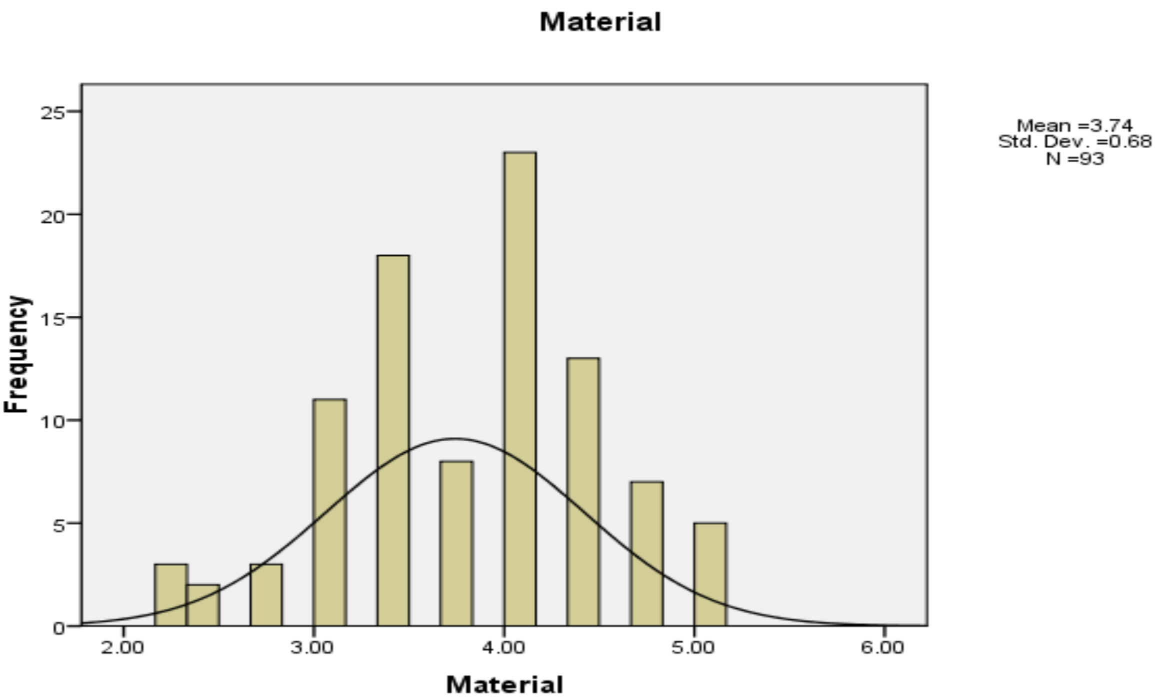


Figure 4.5: Normality curve for Labour, Equipment & Machinery

Table 4.6: Normality curve for Government & Political

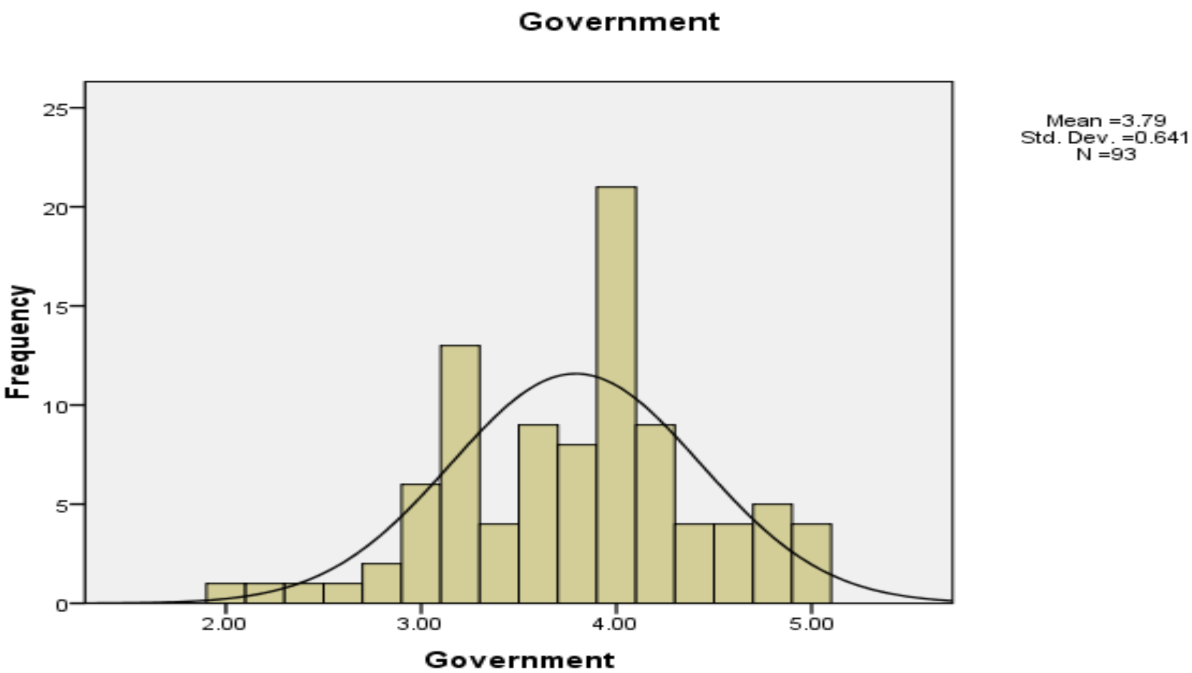


Table 4.7: Normality curve for Force Majeure, Unforeseen Conditions, External Factors

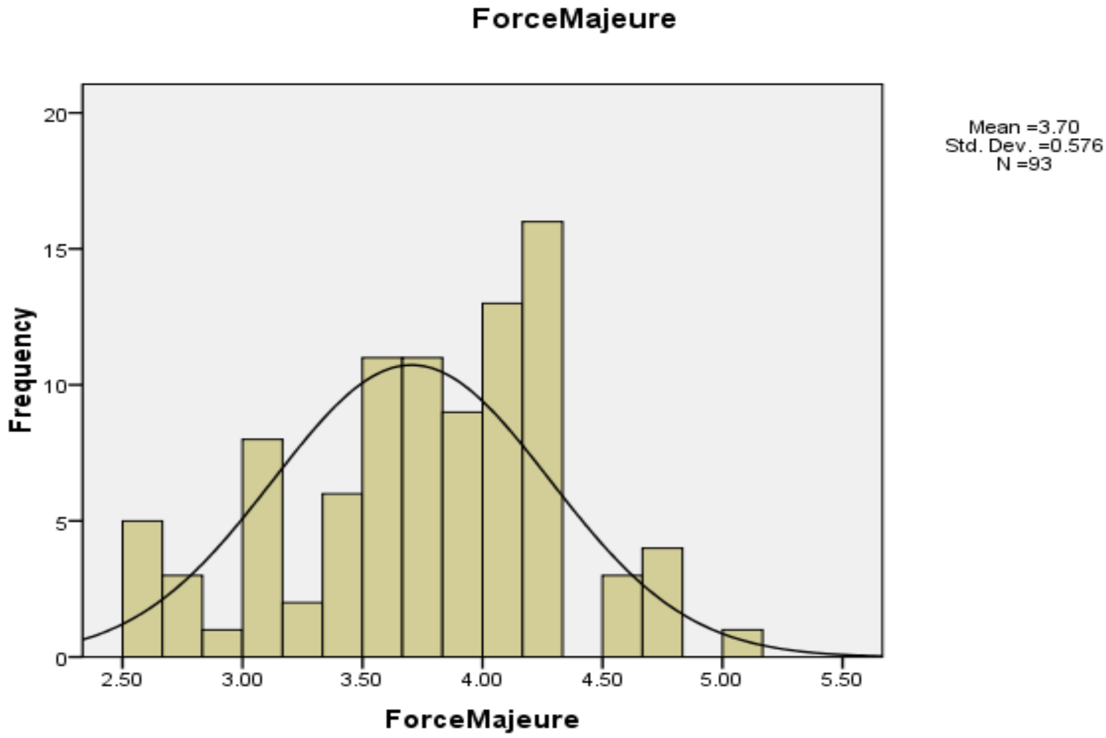
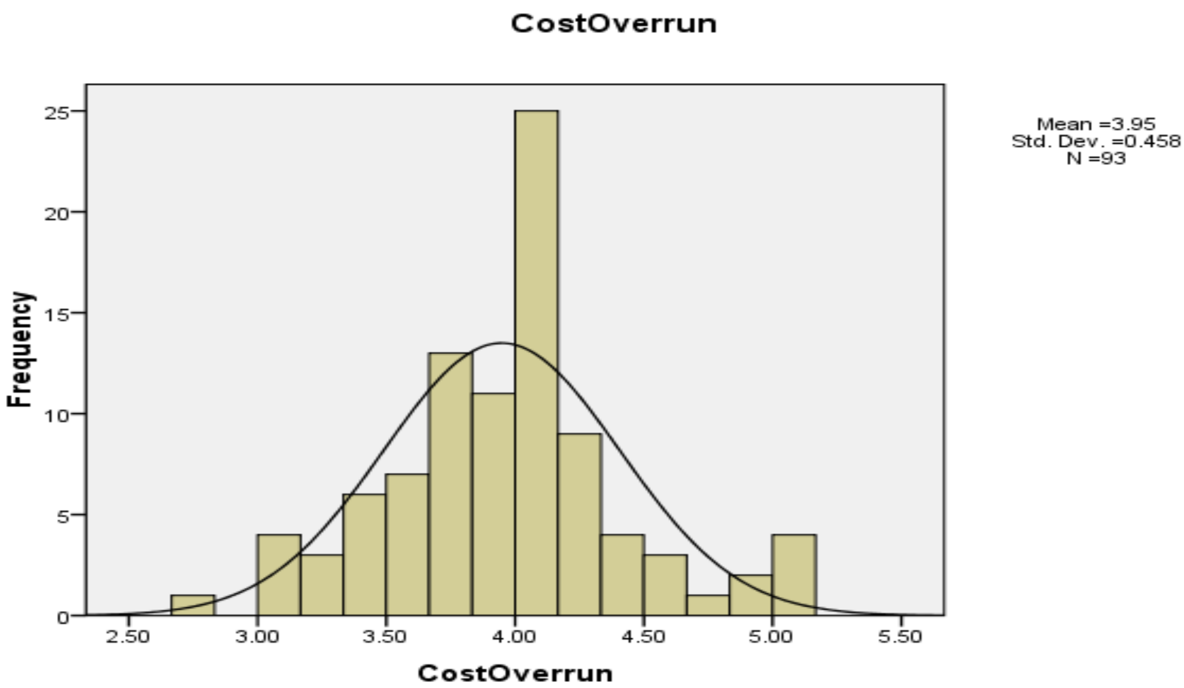


Figure 4.8: Normality curve for Figure Cost Overrun



4.5 Correlation Analysis:

The data represents correlations between various factors, including Owner (O), Project Management & Engineering Consultancy (PMEC), Contractor (C), Material (M), Labour, Equipment & Machinery (LEM), Government & Political (GP), Force Majeure/Unforeseen Conditions/External Factors (F), and Cost Overrun (CO).

Project Management & Engineering Consultancy shows strong positive correlations with Contractor (.470), Material (.503), and Labour, Equipment & Machinery (.364), indicating that the Project Management & Engineering Consultancy is strongly related to these factors.

Contractor and Material also exhibit a moderate positive correlation (.423), while Material is linked to Labour, Equipment & Machinery (.384).

The Government & Political factor correlates moderately with Project Management & Engineering Consultancy (.584) and weakly with Cost Overrun (.378).

Cost Overrun has a notable positive correlation with Contractor (.563) and Material (.345), indicating that cost overruns are often associated with both the contractor's and material-related factors.

This suggests that the factors affecting project execution like Contractor, Material, and Labour & Equipment are interconnected, and project management plays a key role in mitigating or influencing these relationships. Cost Overrun is largely influenced by the contractor and material aspects, alongside government and political factors.

Table 4.5: Spearman Correlations

	O	PEMC	C	M	LEM	GP	F	CO
O	1							
PEMC	.647**	1						
C	.380**	.470**	1					
M	.363**	.503**	.423**	1				

LEM	.421**	.364**	.515**	.384**	1			
GP	.584**	.390**	.312**	.340**	.328**	1		
FFM	.371**	.410**	.360**	.336**	.424**	.506**	1	
CO	.352**	.530**	.563**	.345**	.360**	.378**	.344**	1

**. *Correlation is significant at the 0.01 level (2-tailed).*

O: Owner (Client), PMEC: Project Management & Engineering Consultancy, C: Contractor, M: Material, LEM: Labour, Equipment & Machinery, GP: Government & Political, F: Force majeure, Unforeseen Condition, External Factors, CO: Cost Overrun.

4.6 Ranking of the Delay Causes:

This study identifies and ranks the main causes of project delays in the refinery and petrochemical sectors in India. The factors contributing to delays are ranked in ascending order based on their mean score value, as shown in Table 4.6.

Table 4.6: Final Ranking of cause of the project delay including all stakeholders

Ranking	Code	Description	Mean Score
1	CL01	Decision-making and approval processes	4.35
2	CL06	Land Acquisition issues, Transfer of Government Land & Diversion of forest land	4.34
3	C04	Cash flow problems with contractors	4.31
4	CL05	Non availability of physical fronts, Right of Way permission	4.28
5	C01	Delay in mobilisation of manpower and equipment & machineries at project site	4.20
6	M01	Shortage of supply material, late deliveries, delay in imported materials	4.20
7	GP01	Slow permit processing by government agencies & Ministries involved in execution	4.14
8	C03	Deployment of subcontractors and frequent changes	4.12

9	CL04	Awarding delay of the projects and suspension of the work	4.11
10	PME11	Frequent revisions in scope of work and issuance of amendments	4.08
11	C02	Poor management & supervision of work by contractor during construction at site	4.08
12	LEM01	Shortage of skilled staff and also high turnover of skilled staff	4.04
13	PME09	Variations in cost estimate may lead to delay in awarding the contracts	3.95
14	F02	Natural disasters (floods, landslides, etc.)	3.92
15	PME08	Unrealistic contract duration	3.91
16	F01	Extreme weather conditions at construction sites (rainy, high summer season etc.)	3.91
17	PME05	Administrative procedures and bureaucratic organization	3.90
18	C05	Modifications and rework at construction site	3.90
19	F04	Price fluctuations and inflation & global unexpected crises (due to war, political crisis etc.)	3.90
20	LEM03	Lack of modern machineries, equipment and tools required at construction site	3.89
21	GP03	Political interference and unstable government	3.87
22	LEM02	Labor disputes, strikes, sickness, injuries, workload, and tough shifts at construction sites.	3.87
23	PME03	Lack of effective project control during execution of the project	3.86
24	PME13	Delay in approving manufacturing drawings and test reports	3.81
25	CL03	Frequent technical and executive intervention	3.78
26	PME04	Poor communication and coordination among the stakeholders	3.78
27	PME02	Inadequately vague scope of work defined in contract	3.77

28	PME12	Delay in preparation of the documents for procurement and construction	3.76
29	C06	Incompetent site engineer and site technical staff provided by contractor	3.75
30	GP02	Changes in government rules & regulations	3.74
31	CL02	Financial difficulties, including shortfalls in funds and delays in payments	3.73
32	PME10	Design experience (design changes and frequent errors)	3.72
33	M03	Improper storage of material and their breakdown during installation	3.72
34	PME07	Ambiguous/ conflicting contract clauses and ineffective delay penalties & legal disputes	3.71
35	GP05	Recruitment of localised people	3.68
36	CL07	Improper feasibility study of the project	3.66
37	PME14	Shortage of knowledgeable and experienced project team	3.59
38	F03	Accidents at construction site	3.59
39	PME01	Improper bidding process and award mechanism (price/contract negotiations and lowest bidder)	3.58
40	GP04	Delay in delivery of utilities provided by the government (electricity, water, etc.)	3.54
41	F06	Religious and social events, disputes with local people, theft and vandalism	3.45
42	F05	Corruption and bribery	3.44
43	PME06	Inaccurate quality assurance/quality control and inspection process	3.41
44	M02	Poor quality of material	3.32

N=93

4.7 Hypothesis wise Analysis:

The hypothesis analysis for this research investigates the relationships between various factors influencing delays in refinery and petrochemical projects in India. The primary goal of the analysis was to test the validity of several hypotheses related to project delays and their associated causes, as derived from the data collected during the study.

4.7.1 Linear Regression Test

A linear regression analysis was conducted to understand the relationship between the various computed independent variables like stakeholders of cause of delay with cost overrun. Assuming the below hypothesis.

H1o (Null Hypothesis): There is no significant association between delay due to the owner and the Cost overrun.

H1a (Alternate Hypothesis): There is significant association between delay due to the owner and the Cost overrun.

H2o (Null Hypothesis): There is no significant association between delay due to the Project Management & Engineering Consultancy and the Cost overrun.

H2a (Alternate Hypothesis): There is significant association between delay due to the Project Management & Engineering Consultancy and the Cost overrun.

H3o (Null Hypothesis): There is no significant association between delay due to the contractor and the Cost overrun.

H3a (Alternate Hypothesis): There is significant association between delay due to the contractor and the Cost overrun.

H4o (Null Hypothesis): There is no significant association between delay due to the material and the Cost overrun.

H4a (Alternate Hypothesis): There is significant association between delay due to the material and the Cost overrun.

H5o (Null Hypothesis): There is no significant association between delay due to the Labour, Equipment & Machinery and the Cost overrun.

H5a (Alternate Hypothesis): There is significant association between delay due to the Labour, Equipment & Machinery and the Cost overrun.

H6o (Null Hypothesis): There is no significant association between delay due to the Government & Political and the Cost overrun.

H6a (Alternate Hypothesis): There is significant association between delay due to the Government & Political and the Cost overrun.

H7o (Null Hypothesis): There is no significant association between delay due to the Force Majeure, Unforeseen Conditions, External Factors and the Cost overrun.

H7a (Alternate Hypothesis): There is significant association between delay due to the Force Majeure, Unforeseen Conditions, External Factors and the Cost overrun.

4.7.2 Overall Interpretation of linear regression:

Table 4.7 presents the results of hypothesis testing for the factors influencing Cost Overrun in refinery and petrochemical projects. Each hypothesis is tested by examining the relationship between independent variables (factors such as Owner, Project Management, Contractor, etc.) and the dependent variable, Cost Overrun. The key statistical measures include R^2, F-statistic, beta, t-test, and significance level (sig/p).

H1: Owner (Client)→ Cost Overrun: The R^2 value of 0.114 suggests a weak but significant relationship. The beta value of 0.345 and t-test value of 3.583 indicate that the Owner's influence on cost overruns is statistically significant with a p-value of 0.001, supporting the hypothesis.

H2: Project Management & Engineering Consultancy → Cost Overrun: With an R^2 of 0.281, this relationship is stronger. The beta of 0.447 and t-test of 5.966 confirm the significant impact of project management and consultancy on cost overruns, with a highly significant p-value of 0.000.

H3: Contractor → Cost Overrun: The R^2 of 0.317 shows a moderately strong relationship. The beta value of 0.530 and t-test of 6.499 further indicate a significant influence of the contractor on cost overruns, with a p-value of 0.000, strongly supporting this hypothesis.

H4: Material → Cost Overrun: The R^2 value of 0.119, beta of 0.233, and t-test of 3.508 suggest a weaker but statistically significant relationship, with a p-value of 0.001. This shows that material-related issues do contribute to cost overruns, though to a lesser extent.

H5: Labour, Equipment & Machinery → Cost Overrun: The R^2 of 0.129, beta of 0.247, and t-test of 3.678 show a statistically significant contribution of labour, equipment, and machinery to cost overruns, with a p-value of 0.000, supporting the hypothesis.

H6: Government & Political → Cost Overrun: With an R^2 of 0.143, a beta of 0.270, and a t-test of 3.897, this relationship is statistically significant. The p-value of 0.000 suggests that government and political factors play a significant role in cost overruns.

H7: Force Majeure, Unforeseen Conditions, External Factors → Cost Overrun: The R^2 value of 0.119, beta of 0.274, and t-test of 0.344 indicate that while external factors have some influence on cost overruns, the relationship is weaker compared to other variables. However, the p-value of 0.001 still indicates statistical significance.

All above hypotheses except for H7 show statistically significant relationships between the independent variables and Cost Overrun, with Contractor and Project Management & Engineering Consultancy having the strongest impacts. The analysis underscores the importance of factors such as the Owner, Material, Labour, and Government & Political influences on cost overruns in refinery and petrochemical projects. While Force Majeure, Unforeseen Conditions, External Factors are statistically significant, their impact is weaker compared to other variables.

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Table 4.7: Hypothesis Testing

Hypothesis	**Independent Variable**	**Dependent Variable**	**R2**	**F**	**beta**	**t-test**	**sig/p**
H1	Owner (Client)	Cost Over Run	0.114	12.840	0.345	3.583	0.001
H2	Project Management & Engineering Consultancy	Cost Over Run	0.281	35.589	0.447	5.966	0.000
H3	Contractor	Cost Over Run	0.317	42.239	0.530	6.499	0.000
H4	Material	Cost Over Run	0.119	12.309	0.233	3.508	0.001

H5	Labour, Equipment & Machinery	Cost Over Run	0.129	13.529	0.247	3.678	0.000
H6	Government & Political	Cost Over Run	0.143	15.188	0.270	3.897	0.000
H7	Force majeure, Unforeseen Condition, External Factors	Cost Over Run	0.119	12.239	0.274	0.344	0.001

4.8 Analysis of the Pareto Chart on Project Delay Causes

The Pareto chart has been prepared for the cause of delay as in Figure: 4.9 which represents the relative impact of different causes of project delays, based on their mean scores derived from various stakeholders. Applying the 80/20 rule, it focuses on the few critical causes that account for the majority of the impact. The chart reveals that the top 10 Contributors (Vital Few) which is shown in Table: 4.9 below, contribute a disproportionately large portion of the total impact. These 10 causes alone account for nearly 50–60% of the cumulative impact (based on cumulative percentage in the chart). Delays stem largely from institutional bottlenecks (decision-making, approvals, permits), contractor-side issues (cash flow, mobilisation), and project front availability. Mitigation of these major delays have been explained in chapter 4.11.

The lower-ranked causes (bottom 20–25 items) show mean scores below 3.8 and have a much smaller cumulative effect on delays. These issues are still important but are less frequent or less severe compared to the top causes. The Pareto analysis helps isolate the most influential causes of delay. By strategically addressing the top issues, stakeholders can potentially eliminate a large portion of overall delays, improving both project timelines and cost efficiency.

Figure: 4.9 Pareto Chart of project delays

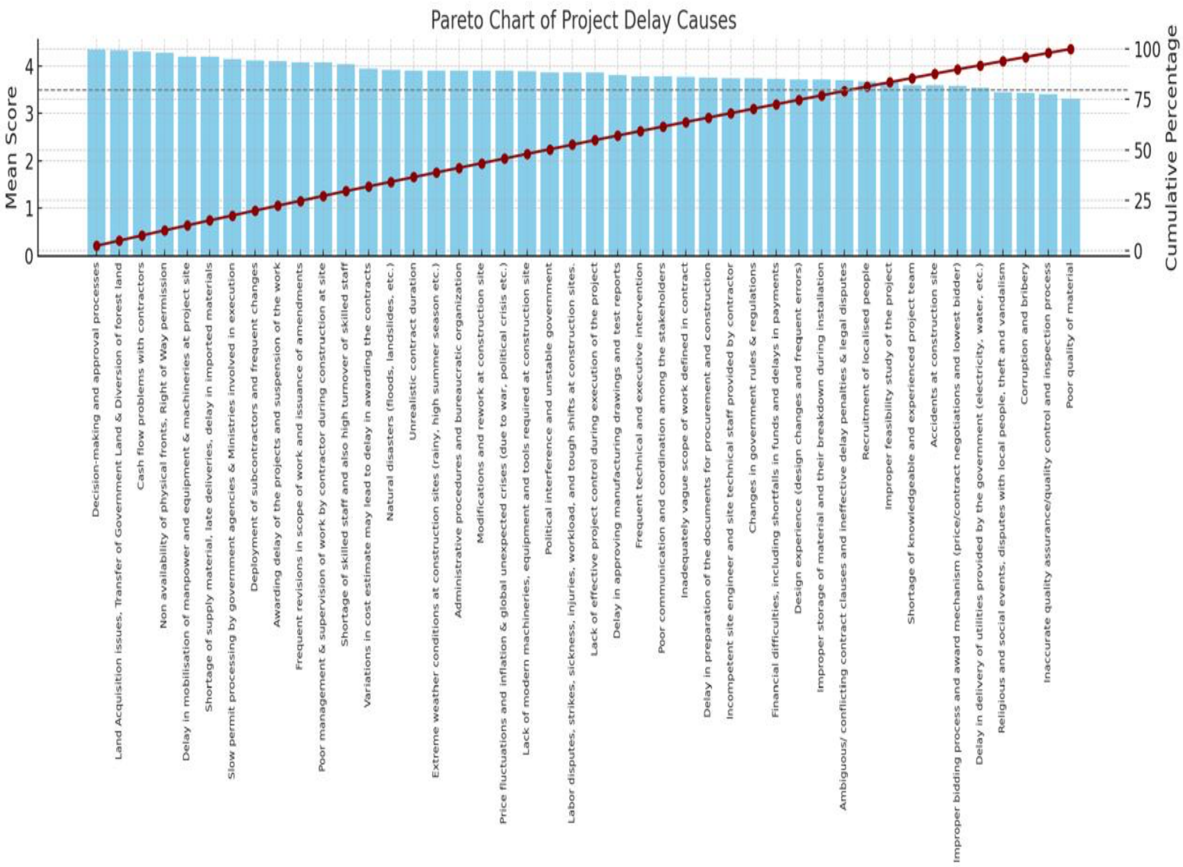

Table 4.8: Top 10 Contributors (Vital Few) delays causes

Rank	Code	Description	Mean Score
1	CL01	Decision-making and approval processes	4.35
2	CL06	Land Acquisition, Transfer of Govt Land, Forest Diversion	4.34
3	C04	Cash flow problems with contractors	4.31
4	CL05	Non-availability of physical fronts, Right of Way	4.28

5	C01	Delay in mobilisation of manpower and equipment	4.20
6	M01	Shortage or delay of materials (incl. imported ones)	4.20
7	GP01	Slow government permit processing	4.14
8	C03	Subcontractor deployment and frequent changes	4.12
9	CL04	Delay in project award and suspension of work	4.11
10	PME11	Frequent revisions and amendments in scope of work	4.08

4.9 Delay Causes in Procurement for Mega Refineries and Petrochemicals Projects in Indian Context:

Public procurement delays in mega projects in India are a common challenge and have significant implications for the overall growth and development of the petroleum sector. The delay of procurement processes in the projects can result in cost overruns, missed timelines, regulatory challenges, and reduced competitiveness and economic growth of the nation. This issue is compounded by several factors specific to the Indian context. Below is an analysis of the key causes of delay, and their impact on schedule overrun.

<u>4.9.1 Demographic Characteristics</u>

Below demographic details were collected from the 67 respondents related to the similar industries.

a) Gender
b) Occupation
c) Educational
d) Work Experiences

<u>4.9.2 Age of the Respondent</u>

Table 4.8 shows that 44 respondents i.e. 65.7% are 31 to 40 years old, 12 respondents 17.9% are 21 to 30 years old and 11 respondents i.e. 16.4% are between 41 to 60 years old.

<u>4.9.3 Gender of the Respondent</u>

Table 4.8, illustrated that out of 67 respondents, 58 (86.6%) are male and 9 (13.4%) are female.

4.9.4 Occupation of the Respondent:

Table 4.8 shows that the 43 participants i.e. 64.2% are working in the Government/Public Sector Unit (Individuals of Engineering, Procurement & Construction Consultant) and 24 participants i.e. 35.8% are working in Private Organization (includes Suppliers & Contractors).

4.9.5 Educational Qualification of the Respondent:

Table 4.8 explained that out of 67 participants, 46 (68.7%) are graduates, 18 (26.9%) are postgraduates, and 3 (4.5%) hold doctorates.

4.9.6 Work Experience of the Respondent:

Table 4.8 shows that the largest portion of respondents have work experience ranging from 11 to 15 years. Specifically, 10 participants (14.9%) have 1 to 5 years of experience, 11 participants (16.4%) have 6 to 10 years, 29 participants (43.3%) have 11 to 15 years, 14 participants (20.9%) have 16 to 20 years, and 4 participants (6%) have over 20 years of experience. This suggests that the majority of participants possess a strong understanding of the study's subject matter.

Table 4.9: Demographic Details of Public Procurement Analysis

Parameter	Frequency	Percent
	Age	
21-30 Years	12	17.9
31-40 Years	44	65.7
41-60 Years	11	16.4
Total	67	100.0
	Gender	
Female	9	13.4
Male	58	86.6
Total	**67**	**100.0**
	Occupation	
Government Organization/PSU	43	64.2
Private Organization	24	35.8

Total	**67**	**100.0**
Educational Qualification		
Doctorate	3	4.5
Graduate	46	68.7
Post Graduate	18	26.9
Total	**67**	**100.0**
Work Experience		
01-05 Years	10	14.9
06-10 Years	11	16.4
11-15 Years	28	41.8
16-20 Years	14	20.9
Above 20 Years	4	6.0
Total	67	100.0

N=67

4.9.7 Descriptive Statistics:

Table 4.9 illustrates the number of participants involved alongside their scores (N), presenting the mean and standard deviation.

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Table: 4.10: Descriptive Statistics

Variable	**Mean**	**Std. Deviation**
Complex Technical Specifications and Commercial Terms & Conditions.	3.82	.777
Ineffective Procurement Planning and Scheduling.	3.94	.833
Repeated bid deadline extensions caused by the bidder's poor response, pre-bid clarifications, or bid amendments.	4.09	.900
Involvement of complex procedures/guidelines/policies.	4.19	.892
Slow decision-making and delayed approval.	4.31	.743

Unfair practices and corruption are involved.	3.48	1.092
Inadequate competency and skill of the procurement officials.	3.70	1.045
Negotiating Process over contract terms and conditions, specification and price.	3.72	.884

N=67

4.9.8 Linear Regression Test:

41 A linear regression has been conducted to understand the relationship between the respondents overall the perception about the Procurement Delay as a dependent variable and "1) Complex Technical Specifications and Commercial Terms & Conditions, 2) Ineffective Procurement Planning and Scheduling, 3) Repeated bid deadline extensions caused by the bidder's poor response, pre-bid clarifications, or bid amendments, 4) involvement of complex procedure/guidelines/policies, 5) Slow decision-making and delayed approval, 6) Unfair practices and corruption are involved, 7) inadequate competency and skill of the procurement officials and 8) Negotiating process (discussion over contract terms and conditions, contract specification, and price)" as Independent variables.

4.9.9 Hypothesis:

3 Ho (Null Hypothesis): There is no significant association between the 1) Complex Technical Specifications and Commercial Terms & Conditions, 2) Ineffective Procurement Planning and Scheduling, 3) Repeated bid deadline extensions caused by the bidder's poor response, pre-bid clarifications, or bid amendments, 4) involvement of complex procedure/guidelines/policies, 5) Slow decision-making and delayed approval, 6) Unfair practices and corruption are involved, 7) inadequate competency and skill of the procurement officials and 8) Negotiating process (discussion over contract terms and conditions, contract specification, and price) towards the delay in Public Procurement.

Ha (Alternate Hypothesis): There is significant association between the 1) Complex Technical Specifications and Commercial Terms & Conditions, 2) Ineffective Procurement Planning and Scheduling, 3) Repeated bid deadline extensions caused by the bidder's poor response, pre-bid clarifications, or bid amendments, 4) involvement of complex procedure/guidelines/policies, 5) Slow decision-making and delayed approval, 6) Unfair practices and corruption are involved, 7) inadequate competency and skill of the procurement officials and 8) Negotiating process (discussion over contract terms and conditions, contract specification, and price) towards the Delay in Public Procurement.

Table 4.10 presents the summary of the regression analysis model, Table 4.11 provides ANOVA results of the Regression Analysis and Table 4.12 provides the coefficient details of the regression analysis, including their corresponding significance values.

Table 4.11: Model Summary of Regression Analysis

Model Summary of Regression Analysis		
Model	R	R Square
Linear Regression	.609	.371

a. Independent Variable:

Public procurement is delayed by the negotiating process (discussion over contract terms and conditions, contract specification, and price)

Public Procurement is delayed due to ineffective Procurement Planning and Scheduling.

Public Procurement delayed due to repeated bid deadline extensions caused by the bidder's poor response, pre-bid clarifications, or bid amendments.

Public Procurement is delayed due to involvement of complex procedures / guidelines / policies.

Public Procurement is delayed due to inadequate competency and skill of the procurement officials.

Public Procurement is delayed when unfair practices and corruption are involved.

Public Procurement delayed Complex Technical Specifications and Commercial Terms & Conditions.

Public Procurement is delayed as a result of slow decision-making and delayed approval.

b. Dependent Variable:

Procurement Delay

N=67

Table 4.12: The ANOVA results of the Regression Analysis

ANOVA[b]

Model	Mean Square	F	Sig./p
Linear Regression	2.891	4.268	.000[a]

a. Independent Variable:

Public procurement is delayed by the negotiating process (discussion over contract terms and conditions, contract specification, and price)

Public Procurement is delayed due to ineffective Procurement Planning and Scheduling.

Public Procurement delayed due to repeated bid deadline extensions caused by the bidder's poor response, pre-bid clarifications, or bid amendments.

Public Procurement is delayed due to involvement of complex procedures / guidelines / policies.

Public Procurement is delayed due to inadequate competency and skill of the procurement officials.

Public Procurement is delayed when unfair practices and corruption are involved.

Public Procurement delayed Complex Technical Specifications and Commercial Terms & Conditions.

Public Procurement is delayed as a result of slow decision-making and delayed approval.

b. Dependent Variable:

Procurement Delay

N=67

Table 4.13: The Coefficients of the Regression Analysis

Variable	**beta**	**t-test**	**Sig/p**
Public Procurement delayed Complex Technical Specifications and Commercial Terms & Conditions.	.138	1.130	.263
Public Procurement is delayed due to ineffective Procurement Planning and Scheduling.	.127	1.093	.279
Public Procurement delayed due to repeated bid deadline extensions caused by the bidder's poor response, pre-bid clarifications, or bid amendments.	.103	.902	.371

Public Procurement is delayed due to involvement of complex procedures/guidelines/policies.	-.168	-1.431	.158
Public Procurement is delayed as a result of slow decision-making and delayed approval.	.037	.292	.771
Public Procurement is delayed when unfair practices and corruption are involved.	**.266**	**2.153**	**.036**
Public Procurement is delayed due to inadequate competency and skill of the procurement officials.	**.289**	**2.448**	**.017**
Public procurement is delayed by the negotiating process (discussion over contract terms and conditions, contract specification, and price).	.037	.319	.751

N=67

4.9.10 Interpretation on Public Procurement:

Significance value for the Complex Technical Specifications and Commercial Terms & Conditions is .263 which is >.05, Ineffective Procurement Planning and Scheduling is .279 which is >.0, Repeated bid deadline extensions (caused by the bidder's poor response, pre-bid clarifications, or bid amendments) is .371 which is >.05, Involvement of complex procedure/guidelines/policies is .158 which is >.15, Slow decision-making and delayed approval is .771 which is >.05 and Negotiating process (discussion over contract terms and conditions, contract specification, and price is .715 which is >.05. Hence null hypothesis is accepted and there is no significant association between these toward Delay in Public Procurement.

However, as the significance value of the Unfair practices and corruption are involved is .036 which is <.05 and Inadequate competency and skill of the procurement officials is .017 which is also <.05. Hence, alternate hypotheses are accepted and these independent variables have a significant impact on delay in public procurement.

4.10 Findings and Recommendations on Projects Delays:

Identifying the causes of delays and arresting them is the most important step to ensuring projects are going to be completed within the time frame. Key causes of 44 Nos. which are delaying the project were derived from a review of relevant literature, research papers. It was finalized after interviews with project execution experts. Questionnaire was designed and responses were received and analysed. After ranking analysis top most significant delay causes are identified as "decision-making and approval processes, land acquisition issues, transfer of government land and diversion of forest land, cash flow problems with contractors, non-availability of physical fronts and right of way permission, delays in mobilizing manpower, equipment, and machinery at the project site, material shortages, late deliveries, and delays in imported materials, slow permit processing by government agencies and ministries, deployment of unqualified subcontractors and frequent changes, and delays in awarding projects or suspending work. Further, to focus on investigating individual factors or groups of related factors to find their root causes and develop mitigation strategies to either eliminate or minimize their impact on the project on the entire project life cycle.

Linear regression has been conducted between independent variables (various stakeholders) and dependent variable (cost overrun) and found that there are statistically significant relationships between the independent variables and Cost Overrun, with Contractor and Project Management & Engineering Consultancy having the strongest impacts. The analysis underscores the importance of factors such as the Owner, Material, Labour, and Government & Political influences on cost overruns in refinery and petrochemical projects. While "Force Majeure, Unforeseen Conditions, External Factors" are statistically significant, their impact is weaker compared to other variables.

4.11 Mitigation of the critical causes of delay which are delaying the refinery and petrochemical project

Mitigating the challenges related to major delays identified in the pareto chart have been explained as below:

4.11.1 Decision-making and Approval Processes

Mitigating the challenges related to decision-making and approval processes in mega refinery and petrochemical projects is critical for ensuring that these complex, high CAPEx projects are completed on time and within budget. Delays in decision-making and inefficiencies in the approval process can result in cost overruns, schedule delays, and even project failure. A study by Aithal et al. (2021) discusses the critical role of policy clarity in enhancing project timelines. They argue that streamlining the regulatory process ensures faster approval, reduces ambiguities, and facilitates the effective implementation of large infrastructure projects in India, including refineries and petrochemical plants. Implementing advanced decision-making tools such as Artificial Intelligence (AI) and Machine Learning (ML), alongside sophisticated data analytics, can provide real-time insights, predictive capabilities, and support more accurate and timely decision-making. Digital tools that allow for scenario modeling and decision simulations can help identify potential bottlenecks early. Jain et al. (2020), highlight the integration of AI and IoT in refinery operations for real-time monitoring and predictive maintenance, which can also be extended to the decision-making and approval process. The ability to simulate different outcomes can expedite decision-making by offering clear data-driven choices. According to Rao (2020), effective project management frameworks and governance structures play a significant role in mitigating delays in decision-making and approvals. Poor communication between various stakeholders (e.g., government bodies, private companies, contractors) can lead to delays in approvals and misalignment of project goals. Patel et al. (2021), emphasize the role of stakeholder management in the timely delivery of mega projects. They argue that proper engagement through structured communication reduces approval bottlenecks, as it ensures that all parties are informed and their concerns addressed promptly.

Mitigating the challenges associated with decision-making and approval processes in mega refinery and petrochemical projects requires a combination of regulatory clarity, technological advancements, effective governance, stakeholder management, and risk mitigation strategies. The integration of modern decision-making tools such as AI, improved communication frameworks, and enhanced project management methodologies can streamline the entire process.

4.11.2 Land Acquisition issues, Transfer of Government Land & Diversion of forest land:

Addressing challenges related to land acquisition, transfer of government land, and diversion of forest land is critical for the successful implementation of infrastructure projects. Mangioni (2018) evaluates the land acquisition phase in megaprojects and underscores the importance of transparent processes and equitable treatment of property owners to reduce disputes and delays.

4.11.3 Cash flow problems with contractors:

Mitigating cash flow problems with contractors requires a combination of proactive financial management practices, including clear contractual agreements, accurate cost estimates, contingency funds, effective project monitoring, and improved payment systems. The integration of risk-sharing mechanisms and financial oversight also plays a crucial role in ensuring that contractors do not face liquidity challenges during project execution. Implementing clear and fair payment schedules aligned with project milestones ensures that contractors receive timely payments, aiding in maintaining healthy cash flow. Koopman et al. (2021) emphasizes the importance of such schedules in preventing financial strain on contractors. Providing contractors with advance payments or mobilization advances enables them to cover initial project costs, reducing financial strain during the project's early stages. Mukherjee et al. (2024) highlight that such financial arrangements can significantly enhance contractors' liquidity, facilitating smoother project execution.

Establishing a transparent and efficient process for handling change orders helps prevent disputes and ensures contractors are compensated promptly for additional work, thereby maintaining cash flow stability. Gupta et al. (2021) discusses the significance of clear change order mechanisms in managing financial risks in oil refinery construction projects in India.

Conducting thorough financial risk assessments during the project planning phase allows for the identification of potential cash flow issues. Implementing risk mitigation strategies, such as contingency funds, can address unforeseen financial challenges. Ajmera et al. (2022) identify cost overruns and time overruns as significant factors affecting cash flow, emphasizing the need for proactive risk management.

Cash flow problems often occur when initial cost estimates are inaccurate, leading to unexpected costs that are not accounted for in the project budget. Jain et al. (2020) argue that accurate cost estimation techniques that incorporate detailed project planning and historical data help reduce the likelihood of cost overruns and, therefore, reduce cash flow stress for contractors. Their research suggests that using advanced cost management software and tools can improve the accuracy of these estimations, leading to better cash flow control. Unforeseen events, such as material shortages, labor strikes, or environmental issues, can lead to additional costs and cash flow challenges for contractors. Nayak et al. (2021) emphasize that setting aside a contingency fund reduces the likelihood of payment delays caused by unforeseen project costs. Their study highlights that this approach not only protects contractors' cash flow but also enhances the overall financial health of large-scale projects.

Delayed payments from project owners or contractors' clients can create significant cash flow stress. Establishing automated invoicing systems that ensure invoices are processed promptly and payments are made on time is crucial. Ensuring a streamlined payment process minimizes delays and provides contractors with the liquidity necessary to continue operations without interruption. Additionally, setting up clear processes for dispute resolution over payments can prevent delays caused by disagreements or misunderstandings. According to Patel et al. (2021), improving payment systems and reducing administrative bottlenecks leads to smoother cash flow and greater financial stability for contractors. The research stresses that establishing clear communication between project owners and contractors about payment schedules is essential for managing cash flow.

4.11.4 Non availability of physical fronts, Right of Way permission:

Mitigating the non-availability of physical fronts and Right of Way (RoW) permission issues in mega refinery and petrochemical projects is a significant challenge. These issues often cause delays in project timelines, increased costs, and project scope adjustments. The process of obtaining RoW permissions and land for refinery projects is often hindered by complex legal and bureaucratic hurdles, especially in densely populated or environmentally sensitive areas. Rao (2020) discusses how policy reforms in land acquisition processes in India have helped accelerate the pace of large infrastructure projects. The study advocates for the introduction of reforms such as transparent land compensation schemes and simplified regulatory frameworks to reduce delays in RoW permissions and land acquisition. One of the major obstacles in acquiring land or securing RoW permissions is the reluctance of landowners or local communities to sell or lease land. Aithal et al. (2021) examine how land pooling and joint development agreements have been used successfully in other large infrastructure projects in India. They suggest that such approaches can address land ownership complexities and help mitigate resistance to land acquisition by creating mutually beneficial agreements between project developers and landowners. Legal disputes and compensation issues can significantly delay land acquisition and RoW permissions. To mitigate this, project developers should establish clear dispute resolution mechanisms and fair compensation policies to address landowners' concerns. Nayak et al. (2021) emphasize the importance of dispute resolution mechanisms in resolving conflicts between landowners and developers. They found that fair and transparent compensation practices, coupled with clear legal frameworks for dispute resolution, significantly reduce project delays due to land-related challenges.

4.11.5 Delay in mobilisation of manpower and equipment & machineries at project site

33 Delays in the mobilisation of manpower, equipment, and machinery can severely hinder the progress and timely completion of the refinery and petrochemical sectors. To effectively

mitigate these delays, various strategies must be implemented at both the project planning and execution stages. Key mitigation strategies include improved project planning and scheduling, which involves using advanced project management techniques like Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) to identify potential bottlenecks early in the process. Mahamid and Bruland (2013) stress the importance of proactive planning to avoid delays during mobilisation and ensure the timely availability of resources. The management of skilled labor is equally important. Labor shortages can significantly delay mobilisation, especially in specialized sectors like refinery and petrochemical projects. Sweis et al. (2008) suggest that investing in training and skill development programs, coupled with early recruitment strategies, can mitigate labor-related delays. Effective communication and coordination among all stakeholders i.e. contractors, subcontractors, suppliers, and clients are very critical. Olaniran et al. (2020) highlight that using communication platforms and project management tools can streamline coordination, ensuring that all parties are aligned and delays due to miscommunication are minimized.

4.11.6 Shortage of supply material, late deliveries, delay in imported materials

In refinery and petrochemical mega projects, the timely availability of materials is crucial for maintaining the project schedules. Delays caused by shortages of supply materials, late deliveries, and delays in imported materials can significantly disrupt project timelines, escalate costs, and hinder overall project success. One key strategy is improved procurement planning. Early identification of critical materials, coupled with accurate demand forecasting and detailed procurement schedules, can prevent shortages and delays. Chan et al. (2002) highlight that an efficient procurement process, including robust supplier relationships and advanced ordering systems, can reduce the risk of delays related to material shortages and deliveries. Another essential approach is to diversify sourcing options. Relying solely on a single supplier or geographic region for critical materials exposes projects to risks such as geopolitical instability, natural disasters, or transportation disruptions. Zhang and Li (2006) recommend broadening the supply base and establishing secondary suppliers in different regions to ensure continuity of material supply and reduce the likelihood of delays due to supply chain disruptions.

The implementation of just-in-time (JIT) inventory management is also a proven strategy for minimizing material shortages and delays. According to Sweis et al. (2008), JIT systems help maintain optimal inventory levels and ensure that materials are delivered as needed, avoiding overstocking and minimizing storage costs while also preventing material shortages that may result from late deliveries.

Advanced logistics and transportation management are also critical to mitigate delays in material deliveries, especially for imported materials. Effective coordination with international logistics providers, as well as utilizing real-time tracking systems, can help monitor material shipments and reduce delays due to customs clearance or transportation issues. Olaniran et al.(2020) argue that leveraging technology to streamline logistics and track shipments in real time can significantly improve material delivery times. Additionally, risk management and contingency planning are vital to address unexpected disruptions in the material supply chain. Sweis et al. (2008) suggest that contingency plans, including maintaining buffer stock and having backup suppliers in place, can minimize the impact of unforeseen delays in material deliveries.

4.11.7 Slow permit processing by government agencies & Ministries involved in execution

Slow permit processing by government agencies and ministries is a significant challenge in the execution of refinery and petrochemical mega projects in India. One essential strategy is to streamline the regulatory and approval process. Governments can introduce more efficient mechanisms for fast-tracking approvals for critical permits related to land acquisition, environmental clearances, and construction licenses. According to Mahamid and Bruland (2013), creating a centralized, digital platform for permit applications and approvals can significantly reduce bureaucratic delays and enhance transparency. This can also allow stakeholders to track the status of their permits in real time, reducing idle waiting periods. Advocacy and policy reform play a crucial role as well. Olaniran and Olayiwola (2020) suggest that actively engaging with policymakers to advocate for the reduction of procedural delays and unnecessary bureaucratic processes can lead to faster permit processing. Over time, such advocacy could lead to policy reforms that streamline regulatory processes for large-scale projects, particularly in sectors critical to national development, such as refinery and petrochemical industries. Moreover, technology integration can help expedite the permitting process. E-governance initiatives, such as digitized application submissions, automated approval workflows, and online permit tracking systems, can speed up processing times and minimize human errors. Zhang et al. (2006) stress that adopting digital tools for permit management can enhance the efficiency of government agencies and ministries, thus reducing delays that typically occur due to manual handling of paperwork.

4.11.8 Awarding Delays and Work Suspension

Awarding delays and work suspensions are persistent challenges in the successful execution of refinery and petrochemical mega projects in India. These issues often lead to cost overruns, schedule slippages, and project failures. Key Mitigation Strategies are below. Enhanced Project Planning and Scheduling: Improper planning is one of the leading causes of project delays. Using advanced project scheduling tools and incorporating buffer time into project timelines can minimize uncertainties as explained by Sambasivan et al. (2007). Detailed work breakdown structures and early procurement planning are also recommended. Transparent and continuous communication among all project participants including contractors, clients, regulatory bodies, and suppliers prevents misunderstandings and accelerates decision-making. Aljohani et al. (2017) found that weak stakeholder collaboration is a primary contributor to project delays. Project-specific risks, such as supply chain disruptions, land acquisition issues, or legal disputes, need to be identified early. Risk registers and mitigation frameworks can be implemented to manage unforeseen events (Alaghbari et al., 2007). Insufficient technical expertise within project teams contributes to inefficiencies. Continuous professional development and training programs improve project team competency and responsiveness to challenges (Kumar & Mukherjee, 2019). Regulatory Streamlining: Cumbersome approval processes delay contract awards and work commencement. Policy reforms aimed at simplifying environmental clearances, land acquisition, and tendering processes are crucial (Tayal & Saha, 2021). Digital platforms for approvals and better inter-agency coordination can significantly improve timelines. To mitigate awarding delays and work suspensions in India’s refinery and petrochemical mega projects, a holistic approach is needed. Project management best practices, supported by institutional reforms and capacity enhancement, offer a pathway to improved efficiency and on-time delivery. These strategies, when implemented in an integrated manner, have the potential to transform project execution standards in India’s energy infrastructure sector.

4.12 Public Procurement Management in mega refinery & petrochemical project:

As per data analysis towards procurement delay in refinery and petrochemical projects, the “Unfair practices and corruption” and “inadequate competency and skill of procurement officials” have a significant impact on delays in public procurement. The significance values (p-values) of these two variables are both less than 0.05 (0.036 and 0.017), which indicates that the null hypothesis is rejected in both cases, and the alternative hypotheses are accepted.

4.12.1 Unfair Practices and Corruption

A p-value of 0.036 means there is strong statistical evidence to reject the null hypothesis, suggesting that unfair practices and corruption significantly contribute to delays in public procurement. Since the p-value is less than 0.05, this variable has a notable impact on procurement efficiency.
Strengthen oversight mechanisms: Implement robust anti-corruption measures, such as independent audits, transparency initiatives, and strict penalties for unethical practices, to minimize the impact of corruption. Encourage employees and stakeholders to report unethical behavior by offering anonymous reporting systems and protection for whistleblowers. Create clear accountability structures within procurement processes to ensure that those involved in corruption or unfair practices are held responsible. Conduct regular workshops and training for procurement officials on ethical standards and how to recognize and avoid corruption. Work with anti-corruption organizations or government agencies that specialize in preventing corruption in procurement.

4.12.2 Inadequate Competency and Skill of Procurement Officials

With a p-value of 0.017, this result also shows that inadequate competency and skill of procurement officials are statistically significant factors contributing to delays in public procurement. Since the p-value is below the threshold of 0.05, this suggests that improving the skills and competencies of procurement personnel could positively affect the efficiency of procurement processes.

Develop and implement comprehensive training programs focused on procurement best practices, contract management, project planning, and negotiation skills for procurement officers. Promote professional certifications for procurement officials (such as Certified Professional in Supply Management - CPSM) to ensure that they are equipped with the necessary skills and knowledge to handle complex procurement activities effectively. Establish mentorship or peer-to-peer learning systems where less experienced procurement officials can learn from more seasoned professionals. Implement continuous performance reviews for procurement officials to identify skill gaps early and provide opportunities for further development.

A well-trained workforce is necessary for the effective design, construction, and operation of mega refinery projects. Training programs, vocational education, and international partnerships are essential to build a pool of skilled workers. Effective project management ensures the refinery project is completed on time, within budget, and meets quality standards. This includes managing timelines, resources, and coordination between different project teams. Kumar et al. (2021) found that skilled labor and expert project management practices are essential to mitigate the risks associated with large-scale refinery projects. Their study demonstrates how the lack of skilled workers leads to inefficiencies and delays.

4.12.3 Recommendations for addressing delays in Public Procurement

Process improvement: Since both of these variables (unfair practices and inadequate skills) contribute significantly to delays, focus on streamlining and improving the overall procurement process. Establish clear guidelines and timelines, and ensure that these processes are followed consistently.
Use of technology: Implement digital procurement platforms to improve efficiency, transparency, and accountability. These systems can automate much of the procurement process, reducing human error and increasing the speed of decision-making. Strengthen legal frameworks: Advocate for stronger legal frameworks to deal with procurement inefficiencies and unethical behavior, ensuring that delays caused by unfair practices or lack of competency are penalized appropriately. Collaboration with experts: Engage procurement experts and consultants to assess and provide recommendations on optimizing procurement processes. This can bring fresh perspectives and introduce industry best practices to the organization.

The results suggest that both corruption/unfair practices and lack of competency in procurement officials significantly contribute to delays in public procurement. Addressing these issues requires a multi-pronged approach, focusing on increasing transparency, improving training, and strengthening accountability mechanisms. By doing so, procurement efficiency can be improved, leading to more timely and cost-effective public procurement processes.

4.13 Limitations and future work:

Several difficulties have been found while conducting analysis on finding key parameters which are delaying the mega refinery & petrochemical projects in India. The inability to collect actual executed project data and their scrutiny. Further, the difficulties in getting the accurate information were also the limitations in this study as most of the individuals belong to the Government Officials. Further, no major research work has been conducted on the key delay factors for mega refineries & petrochemical projects in India due to these projects belonging to the PSUs/ Government having high CAPEx investment.

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