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ANALYSIS OF PROJECT DELIVERY SYSTEM

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Abstract: This study has been undertaken to do Analysis of different Project Delivery Systems(PDS) in the construction industry and understanding their relevance through comparison. To conduct a survey to find out which factors affect the selection of PDS in real-time. Lastly, using all the data gathered, testing the reliability and validity using statistical tools.

Keywords **– Project Delivery Systems.**

CHAPTER 1

INTRODUCTION

The phrase "project delivery" refers to the full procedure of beginning, working on, and concluding a project, including, among other things, the structure or facility's construction or renovation. It requires extensive planning, design, and building work from many different parties. A project delivery system defines the structure of the relationships of the parties, the roles and responsibilities of the parties, and the general sequence of activities required to deliver the project.

Project Delivery Systems are one of the crucial elements of successful completion of any project. A specified set of procedures, numerous roles, and standards are necessary for the project delivery system to function. It ensures reduction in cost, enhanced quality, on-time project completion and is also essential for optimum use of available resources. The ideal project delivery method is still up for debate in the design and construction sector. Picking up a trade journal may often yield an article on the decision of project delivery techniques for a design and construction project. Based on specific project needs, owner characteristics and conditions, and the effective formation of the project team, the project delivery system should be chosen. It is essential for the owner to select the right delivery system, which will be influenced by the financial and managerial expertise they possess and accordingly will be helpful in choosing the appropriate party to do the job. The opportunity for design experts and the construction industry is to help owners become aware of the many project delivery options before assisting owners in selecting the best option for their project and circumstances. The owner should always gain from the decision, and it should also encourage winning outcomes for all project participants.

This research aims at studying different PDSs used in the construction industry and understanding their relevance through comparison. Further through PESTEL analysis, risk factors in projects were identified. Prepare a literature review after referring to research papers and listing down all the factors considered by respective researchers. Conduct a survey to find out which factors affect the selection of PDS in real-time. Lastly, using all the data gathered, testing the reliability and validity using statistical tools. To conduct this study, various reports and literature from renowned publications were referred. These documents are mainly focused on models like, DB, DBB, CMR, IPD and PPP models which included BOO, BOT, BOOT, DBFMO, etc. Since, each project has attributes unique to it, it can be concluded that most appropriate delivery model is a must, which will satisfy most of the project needs, standards, economic and ecological conditions.

1.1. Problem statement

CRIP industry is among the core industries of any developed or developing nation, but is also stagnant in terms of R&D. With increasing complexity of projects, there is an ever-growing demand for improvements in project delivery systems, to implement knowledge and techniques as effectively as possible. A PDS takes into account, type of project, construction practices to be used, way of processing information, payment methodology and communication between parties involved. A PDS also represents the relationship and responsibilities of various stakeholders involved.

Factors to be considered while choosing a PDS are, budget, type of project, risks involved, schedule of payments, owner's expertise, etc. Major challenges faced in delivering a project are, unclear goals or objectives, varying scopes, budget and time constraints, inefficient communication, lack of accountability. These challenges can be dealt with, by selecting the most suitable PDS.
The Indian construction industry is being prioritized by the Government of India, in terms of development of beneficial schemes which are supposed to be helpful in delivering a project successfully. Involvement of private players has further improved efficient use of resources and better accountability, thus enabling timely completion of projects. With growing awareness among the developers, their selection criterion for a PDS has seen significant improvements. In order to enhance efficiency, minimize waste, and increase value to the owner throughout all phases of a project, recent methodologies have led to the integration of several PDSs.

1.2. Objective

The objective of our study is to identify the factors that are most crucial when selecting a project delivery method.

1.3. Scope

The scope of this study is to compare various project delivery systems. Conduct a survey to understand which factors affect the selection of a PDS in real-time. With the data obtained, compare the theoretical and practical factors and analyze them using statistical methods.

1.4. Roadmap

F1. Roadmap

1.5. Types of Project Delivery Systems

1. Design–Build (DB)

Design–Build (DB) is a model in which both design and execution phases are covered under a single contract. The client specifies the need of the project, standards and specifications to be followed. The contractor selected for the job, has the capability and resources to take over the project from the initial phase itself. The main benefit of this approach is that it considerably reduces the amount of time needed to complete tasks and permits smooth information flow between stakeholders. DB also encourages innovation, thus delivering better quality projects. On the contrary, the owner has limited say in the methodology of the execution. In addition to this, initial cost of the project is comparatively high, if DB is adopted.

2. Design−Bid–Build (DBB)

It is among the traditional and most commonly adopted methods for delivering infrastructure projects. To implement this model, the client forms two contracts, one with a consultancy and another with a contractor. The consultancy is responsible for preparation of preliminary and detailed design as per general requirement of the client. The owner then carries out a bidding process to nominate a suitable contractor. The contractor is only responsible for execution of the work as per designs provided by the client. This model is beneficial when the contractor has a good track record and is known by the client. This method when adopted properly, reduces the overall cost of the project. Major disadvantage of this model is that, since the contractor in involved in the later part of the project, designs are less optimized and issues may arise due to lack of buildability, eventually leading to time and cost over runs.

3. Construction Manager at Risk (CMAR)

A project delivery method consists of elements like design, planning, construction, and financing. Generally, the owner is responsible for deciding how these elements are to be dealt with. In case if the client lacks the expertise for same, a construction manager (CM) is brought into picture. The CM is hired during the pre-development phases, while finalizing design and specifications and are solely responsible for procurement of resources, subletting of works and delivery of the project. In this model, the CM is responsible to deliver the project within a Guaranteed Maximum Price (GMP), which is decided based on the bids they receive from subcontractors. CMAR is a cost effective and time conscious alternative to the traditional adopted DBB model. CM is hired based on qualifications thus reducing defaulted works, increasing speed and improved cost control. Only risk associated with this model is that, if the CM is inexperienced, problems may arise in both the design and building phases of a project, thus compromising quality.

4. Design−Build−Operate−Maintain (DBOM)

This model holds the contractor responsible for operation and maintenance of the project in addition to design and construction of the same. The contractor incurs all the cost for completion of the project. The contractor receives periodical payments from the employer for the set of completed works when the work is completed. In a similar fashion, maintenance is also funded by the employer at a predetermined cost. When the declared tenure is complete, the project is turned over to the client while the contractor keeps the revenues made during this time. The contract may be renewed at the conclusion of the predetermined maintenance and operation period, or ownership of operation and maintenance may revert to the employer. Less disputes, improved productivity and decision making are few of the merits of this model. These models are generally preferred for large projects only.

5. Build−Own−Operate (BOO)

A BOO model is one in which the government grants a private entity the authority to construct, own, and run a facility for a predetermined period of time. Contrary to BOOT or BOT, the facility is owned by the private party and is not intended to be returned to the government. A specific type of structured financing is used in the BOO projects. These projects are complicated primarily as a result of the numerous parties and contracts that are involved. It guarantees improved quality, a smooth cash flow, and effective project management. When the private party is insufficiently skilled or experienced, this paradigm becomes difficult.

6. Build–Operate–Transfer (BOT)

A BOT model is one in which the private sector constructs, operates, and ultimately hands over the ownership of a project over to the government/client. The government frequently assumes the role of the company's sole client and agrees to buy a specified portion of the project's output. This guarantees that the company will make a reasonable return on its initial investment. The facility will be financed, designed, built, and operated by a private party for a concessionary time before being turned over to the government. This is a private sector participation model. The extended operational durations of this approach make it risky even though it lowers the government's development and infrastructure costs.

7. Build–Own–Operate–Transfer (BOOT)

The main distinction between this model and BOT is that a private entity will own the facility constructed under this model for a predetermined amount of time. The facility is then returned to the government after completion of concession period.

8. Design–Build–Finance–Maintain (DBFM)

A project can be designed, built, and funded by one contractor, who can then perform facilities maintenance tasks as part of a long-term contract, using the project delivery technique known as DBFM. In the maintenance phase, the contractor is held responsible for keeping the facility is running condition. This model creates single point of responsibility and reduces long-term risks. However, financing cost for private parties are much high as compared to government.

9. Design–Build–Finance–Operate–Transfer (DBFOT)

According to this concept, a private entity is in charge of all aspects of design, construction, financing, ownership, operation, and maintenance in exchange for a long-term lease. The infrastructure component is transferred from the private-sector partner to the public-sector partner when the lease expires. Project-specific debt leveraging revenue streams are used to finance DBFOT projects in whole or in part. Tolls are the most typical form of direct user payments. Equity investments from private partners are typically required as well. The project is returned to the original owner after the concession period is expires.

10. Integrated Project Delivery (IPD)

Integrated Project Delivery system is a multiparty contract between client, designer, and contractor, where every party has a share in the project. In IPD these three parties collaborate right from the early stages, to deliver the project. Under this PDS, risk is shared equally by all stakeholders of the project. Profit sharing is based on the contribution of each stakeholder to the project outcome. Because of this approach, the number of requests for information, change of scope, delays, disputes, claims, reduce significantly. The risks are managed by all the project participants, who put projects success overprotecting their bottom line. IPD enables reduction in overall cost of project, improves planning and coordination, reduces wastage and distributes risks more efficiently. All the merits are possible to attain, if there is coordination between each stockholder, which is sometimes difficult to maintain. If the parties involved are not competent enough it hampers innovation and growth of the project in long run.

T1. PDS Comparison (Owner's Perspective)

	DB	**DBB**	**BOT**	**BOOT**	**DBFOT**
Owner's responsibility of project planning	High	High	High	High	Low
Owner's control over project	Moderate	High	Low	Low	Moderate

Owner's administration expenses	High	Moderate	Low	Low	Low
Risks shared by owner	Moderate	High	Low	Low	Low
Complexity of contracts	Moderate	High	Low	Low	Low
Duration of project	Moderate	High	Moderate	Low	Low

Above table compares five mostly used PDSs in India for implementation and execution of construction projects.
As from the table it can be understood that since DBB is the oldest method it, requires maximum client's involvement in the project, this makes it important for the client to be capable for handling the project. Also, client enters into multiple contracts to complete the project and hence it increases the complexity of contract and dependency of each party over other, thus leading to a longer project duration.
To deal with this, DB was introduced. In this model, client enters into contract with only one party which handles the design as well construction processes. This significantly improves coordination and thus reduces project duration. However, client's control over the project reduces when compared to DBB.
Government of India now emphasizes more on privatization, and hence prefer PPP models for delivery of projects. This reduces Government's expenditure and exposure to risk to a great extent. Governments say in the project reduces and it only acts as a governing party. The complexity of project also reduces since the selection of the private party is done based on their merits and experiences of similar projects.

T2. PDS Comparison (Stakeholder's Responsibilities)

	Feasibility Studies	Designing	Financing	Construction	Operation	Maintenance	Ownership
DB		■		■			
DBB		■		■			
DBOM		■		■	■	■	
BOO				■	■	■	■
BOT				■	■	■	
BOOT				■	■	■	■
DBFM		■	■	■		■	
DBFOT		■	■	■		■	

Public Party	
Private Party	■

1.6. PESTEL Analysis

PESTEL analysis is a methodology that helps strategists assess and analyses the external environment that has an impact on an industry, business, or project. Threats and vulnerabilities are identified using the PESTEL analysis. It can also be used to determine the benefits and drawbacks of the project and to plan corporate strategy. The framework is an adjunct to the PEST strategic framework which also assesses additional environmental and legal factors that can impact a project. It's crucial to comprehend the framework that encapsulates the fundamental tenets of strategic management for a project to be completed successfully. It not only outlines how a project should proceed in terms of planning, carrying it out, and marketing, but it also takes into account the environment in which it will operate. While the significance of each PESTEL element may vary depending on the industry, it is crucial for an organization's operational efficiency and improved strategy formulation.
PESTEL analysis considers the following variables, which are briefly stated below: political, economic, social, technological, environmental, and legal.

1. Political factors

The policies of the government affect the project in numerous ways. Under political umbrella we analyze how different government policies affect the project. Change in leadership of government can bring some significant affects either positive or negative. Political outfits have diverging views and strategies for policy on the different projects.
It includes the following,

- Tax Policy
- Trade Restrictions
- Foreign relations
- Political trend
- Internal politics
- Bureaucracy

2. Economic factors

Economic factor focuses on the economy of an area and how it can impact the project. These economic indicators are published by various financial institutes.
It includes the following,

- Economic growth
- Inflation
- Interest rate
- Disposable income
- Employment
- Globalization

3. Social factors

The cultural and demographic patterns of society are examined in social factors. Along with sociocultural changes, ethnic and religious tendencies, and living standards are also included in this aspect.
It includes the following,

- Population growth rate
- Demography (age, sex, race, language etc.)
- Attitude of people
- Cultural barriers

4. Technological factors

PESTEL analysis also includes the innovation in the industry and the economy. Technological advancement makes production, communication and distribution easy. No development in technology or innovation may hamper project operations and growth.
It includes the following,

- Research and development activities
- Technology change
- Automation
- Support to innovation

5. Environment factors

Environment factor focuses on ecological impact of project. There is an ever-growing concern about nature. Businesses are now more focused on lowering their carbon footprint and increasing their dependency on sources of renewable energy to conserve nature.
It includes the following,

- Climate change
- Environment policies
- Pollution
- Natural disaster

6. Legal factors

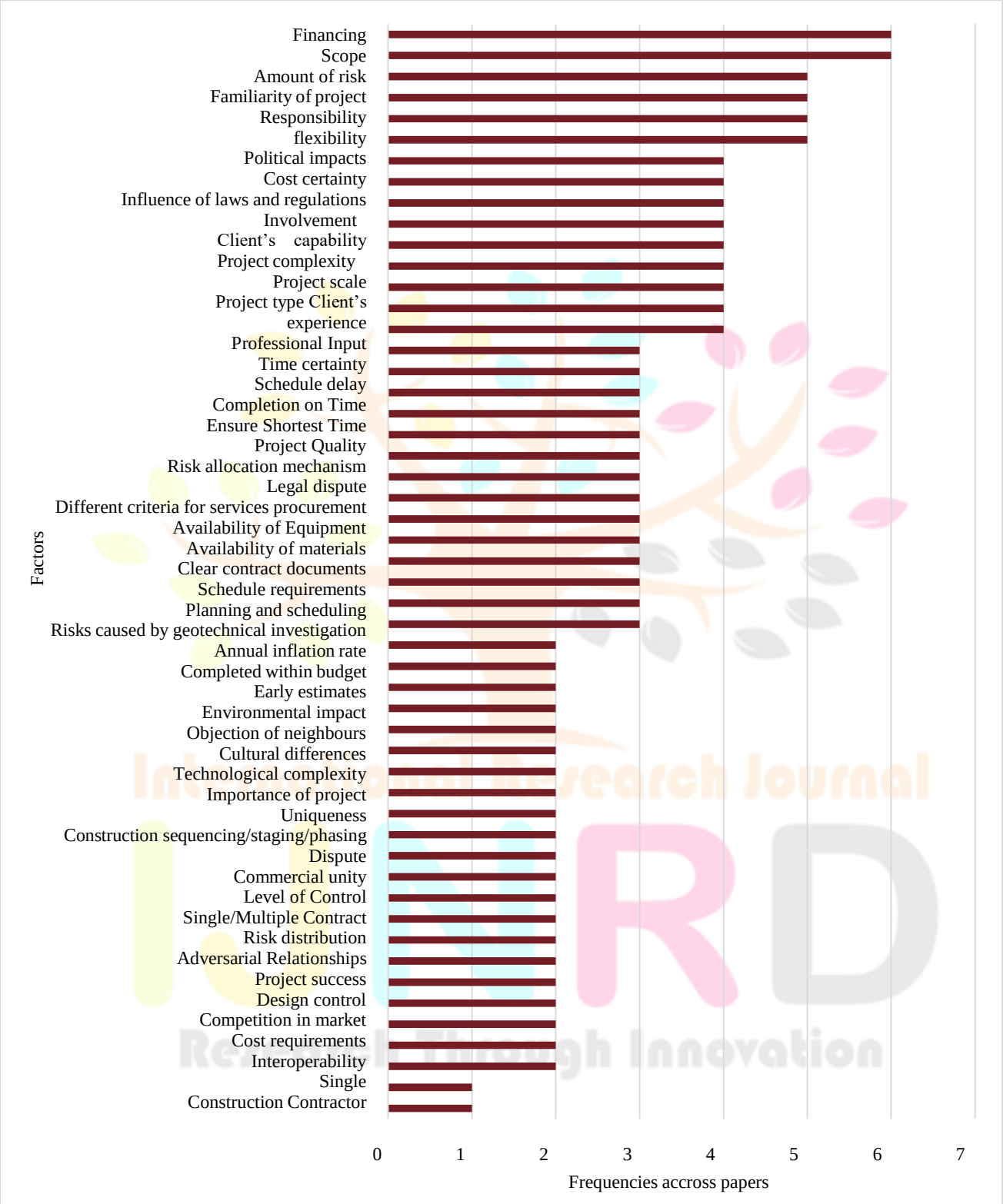
Legal factors are somewhat different from government policies. Legal factors are the base of the relationship between the government and project stakeholders. Legal factors can change the way a project is executed.
It includes the following,

- Industry regulation
- Labor law
- Patent right
- Health and safety law

CHAPTER 2

RESEARCH METHODOLOGY

Some of the research publications we cited are summarized in the preceding section. After conducting a literature review, we learned more about the elements that influence the choice of a certain PDS. This was a step in the procedure we used to gather secondary data. The following graph illustrates the factors we discovered. These factors are referred to as theoretical factors.



F2. Theoretical Factors

For primary data collection we prepared a questionnaire, which consisted of 20 factors that we considered to be the most important and floated the form for collecting responses. **Our questionnaire consisted of factors which were repeated frequently across**

papers we referred to, for example, Financing Options, Scope of project, etc. Additionally, some factors which were not repeated very often but in our opinion are crucial in PDS selection process, e.g., Risk distribution mechanism, were also added in the questionnaire. The list of most repeated factors is expressed graphically above.

A 5-point Likert scale was used to collect the data, with 1 denoting "Not Important," 2 denoting "Least Important," 3 denoting "Moderately Important," 4 denoting "Important," and 5 denoting "Most Important." We also collected information regarding the age and profession of the respondents, which are expressed below graphically. The questionnaire consisted of following factors.

1. Client's Experience	2. Client's Capability
3. Client's Involvement	4. Risk Distribution Mechanism
5. Schedule Requirements	6. Cost Requirements
7. Level of Control	8. Professional Input
9. Project Type	10. Project Scale
11. Project Scope	12. Project Flexibility (Number of variations allowed)
13. Uniqueness of Project	14. Project Complexity
15. Familiarity with Project (Experience of similar projects)	16. Influence of Laws and Regulations
17. Legal Dispute	18. Political Impacts
19. Availability of Funding (Sources/Methods)	20. Mode of Recovery (Toll, Annuity, etc.)

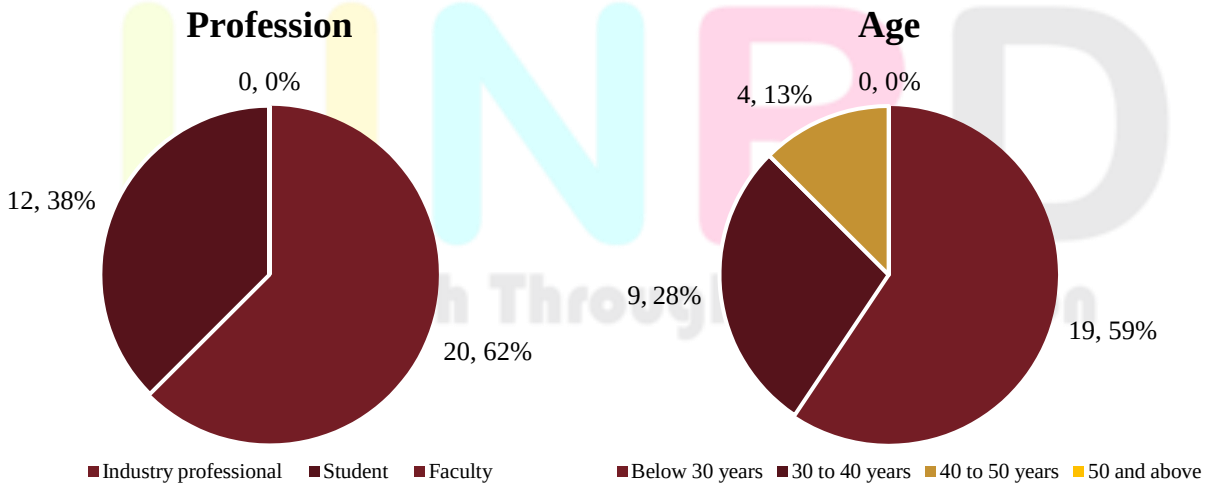
CHAPTER 3

DATA ANALYSIS AND FINDINGS

The questionnaire's results were reviewed and analyzed. To ensure that the data were statistically relevant, various tests were run.

3.1. Age and Profession data representation

Through the responses obtained it can be understood that about 62% of the total respondents were industry professionals and the second major group was of students, which comprised about 38%. Regarding age group, the major respondents were between 30 to 40 years. Additionally, around 13% of the respondents, which accounted to 4, were in the age group of 40 to 50 years, which had maximum work experience among all the respondents.



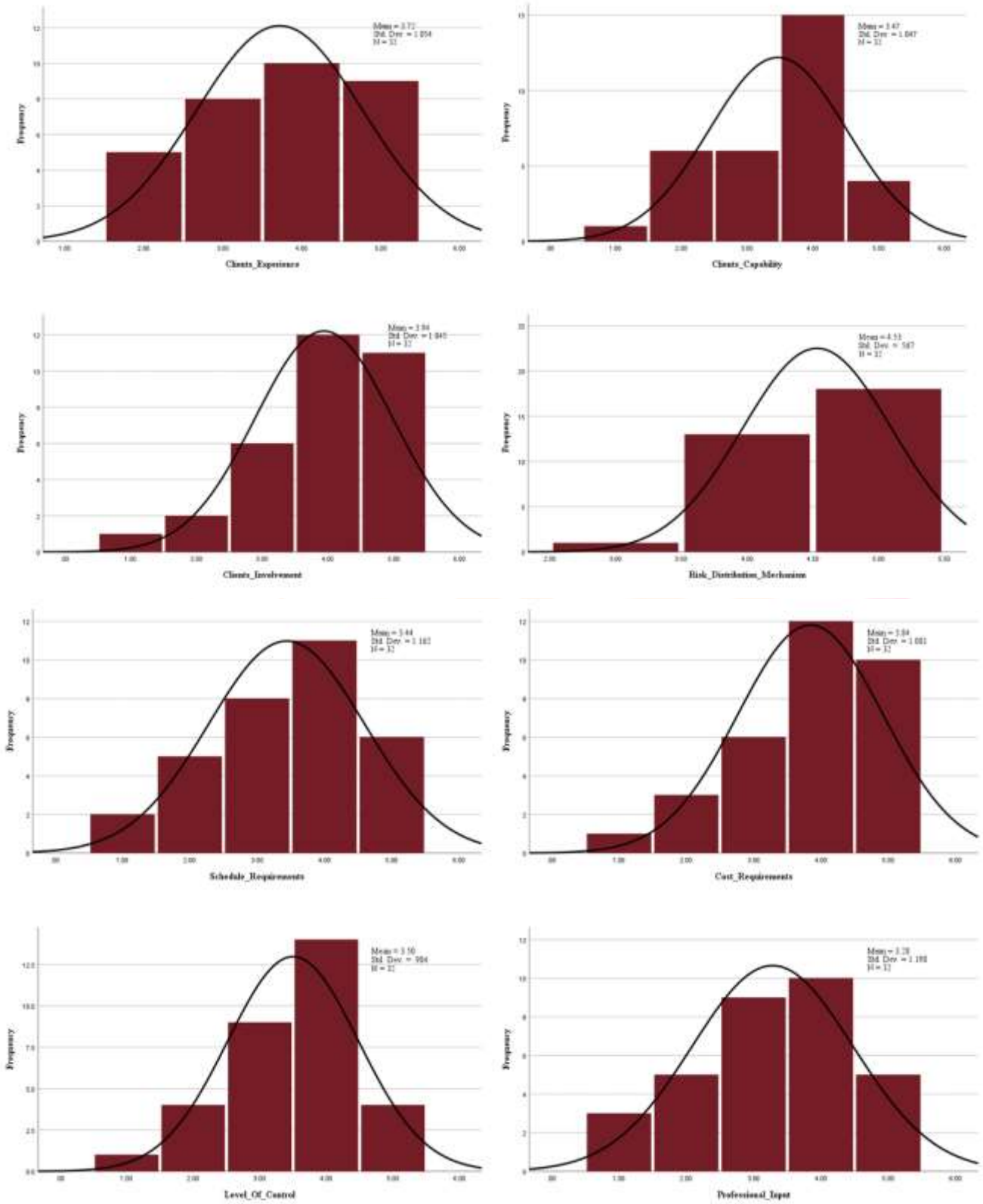
F3. Profession and Age data

3.2. Data distribution as per SPSS

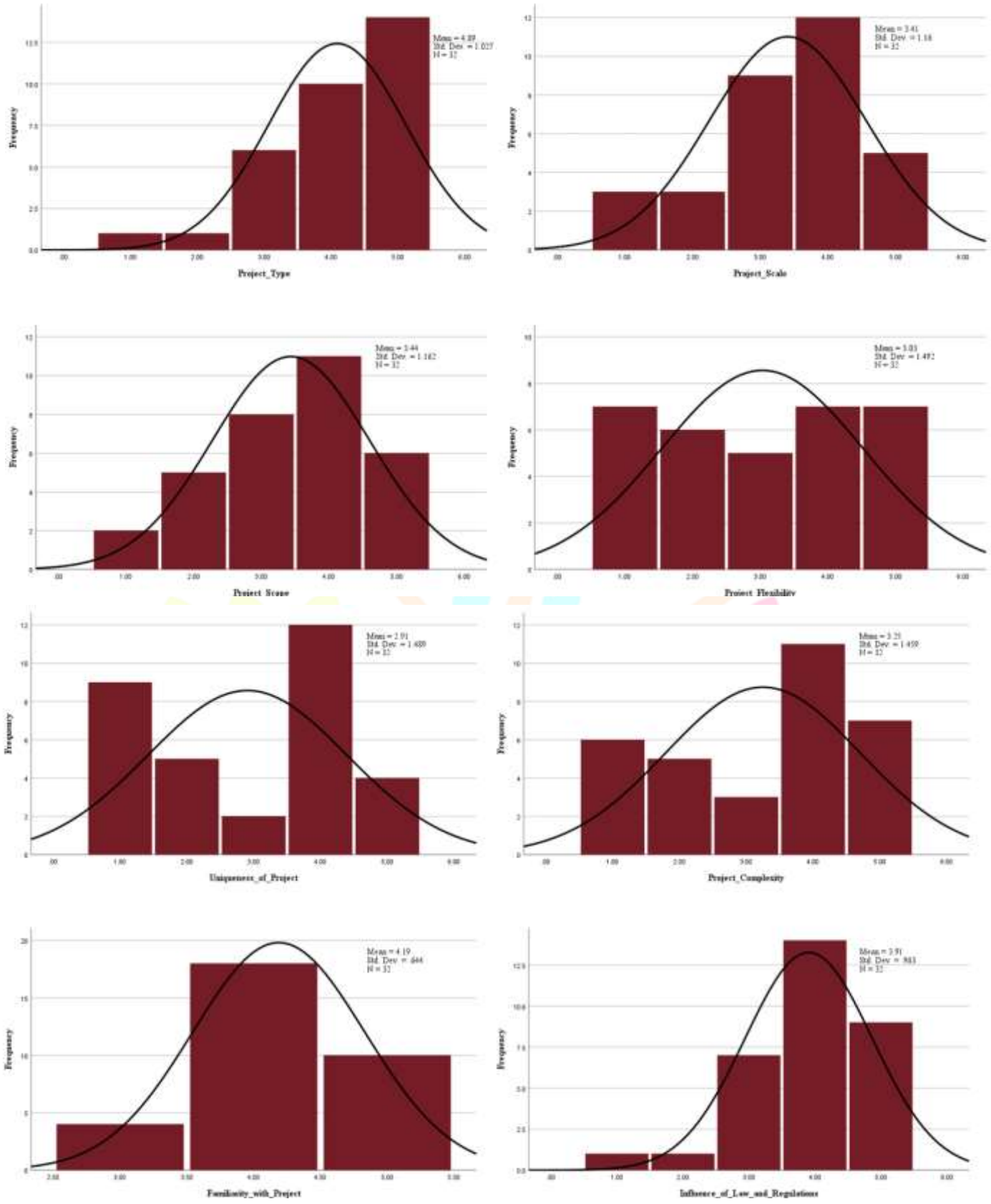
Below is the graphical representation of the responses received through the questionnaire. It represents the trends we have observed after the survey, with frequency on the y axis and the score on the x axis. It can be observed that every graph shows the mean, standard deviation and normal distribution lines of a particular factor along with the distribution according to the Likert scale.

This distribution when compared with the respective mean, gives us an idea of the opinion of respondents. In most cases, the distribution is skewed, which implies the level of importance of a factor. In some cases, the distribution is somewhat uniform, so we

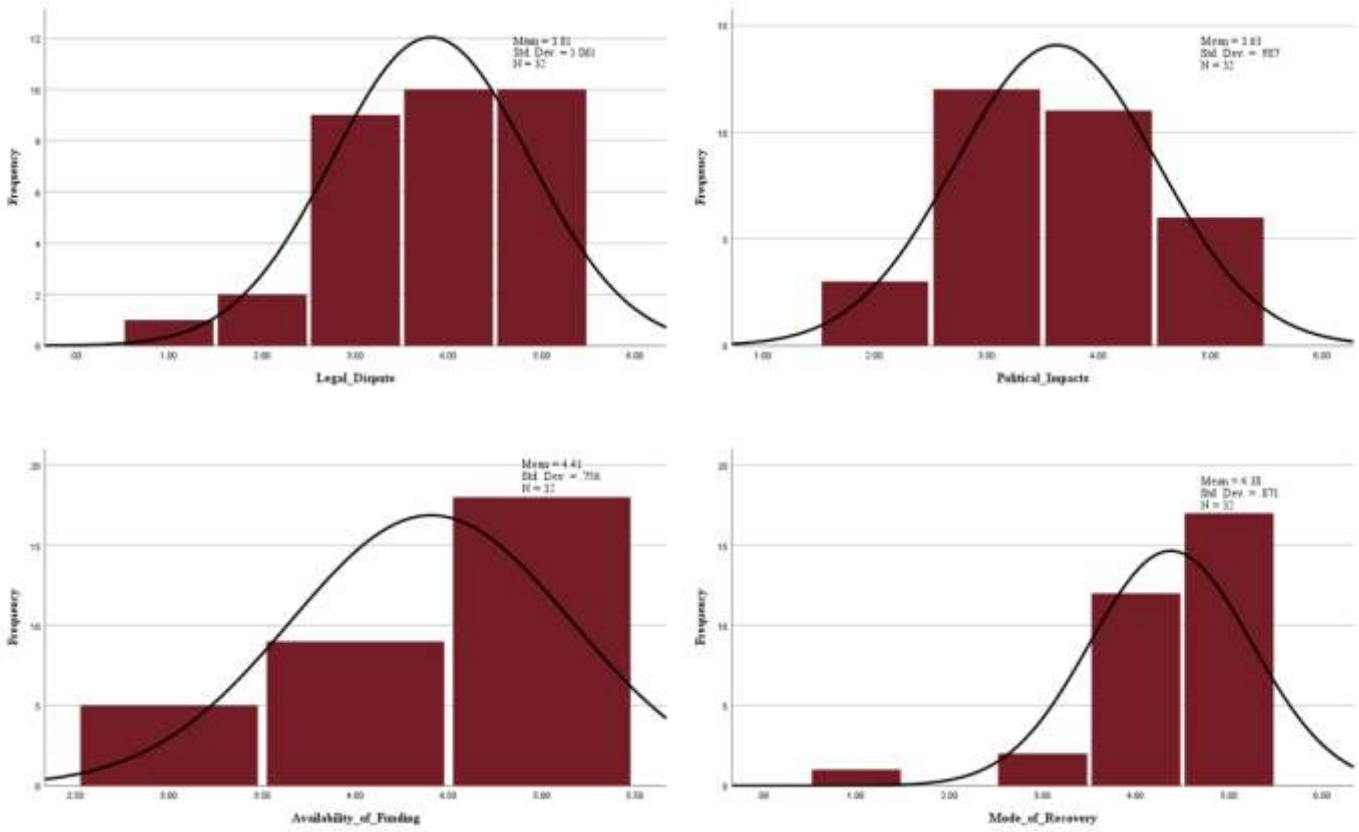
can conclude that these factors are not the most significant ones as the respondents have mixed opinions about the same. It is to be noted that this data is based on respondents' opinions and may change with a different audience. The data collected was later studied and analyzed using SPSS and inferences were drawn.



F4. Survey Data Trends (1-8)



F5. Survey Data Trends (9-16)



F6. Survey Data Trends (17-20)

3.3. Tests Conducted

In order to understand the relevancy of data collected through questionnaire, following tests were conducted and results were interpreted accordingly.

3.3.1. Reliability Test

Cronbach's alpha is the most popular r measure of internal consistency ("reliability"). When a Likert scale made up of numerous questions in a survey or questionnaire needs to be assessed for reliability, this method is generally used.

- Cronbach's alpha reliability coefficient typically falls between 0 and 1.
- The degree of internal consistency of the scale's components (variables) increases as the coefficient approaches 1.0.
- Cronbach's alpha rises with either an increase in the number of items (variables) or an increase in the average inter-item correlations (i.e., when the number of items is held constant).

T3. Reliability Test

Case Processing Summary			
		N	%
Cases	Valid	32	100.0
	Excluded	0	.0
	Total	32	100.0
a. Listwise deletion based on all variables in the procedure.			

Reliability Statistics

Cronbach's Alpha	N of Items	Cronbach's Alpha
0.895	20	0.895

From the above table it can be interpreted that the reliability of our data is excellent, as the Cronbach's Alpha's value is close to 1.0.

3.3.2. t-Test

The t-test compares the alternative hypothesis, which claims that the means are not equal (2-tail), or that the mean for one of the groups is greater than the mean for the other group, with the null hypothesis, which claims that the means for both groups are equal (1-tail).
The p-value for the test is all that is required to be located on the output in order to comprehend the t- test findings. Simply compare the output's p-value (labelled as a "Sig." value on the SPSS output) to the selected alpha level to perform a hypothesis test at a certain alpha (significance) level. As an alternative, you might just state the p-value without stating whether the result is statistically significant or not at an appropriate level.

Assumption:

For a factor to be considered important, it should have a mean value of greater than 4.

Hypothesis:

Null Hypothesis (Ho): The factor considered is not important (mean <= 4) Alternate Hypothesis (Ha): The factor considered is important, (mean > 4)
We accept the alternative hypothesis and reject the null hypothesis if t computed > than t tabulated.

Results:

T tabulated corresponding to 95% confidence interval and degree of freedom=31 will give the value t=1.699519. Additionally, the t score for each factor is calculated using SPSS and the table is shown below.

T4. t-Test

One-Sample Statistics				
Test Value = 4 (4 = Important & 5 = Most Important)				
Factors	**t**	**df**	**Significance One-Sided p**	**Mean Difference**
Client's Experience	-1.509	31	0.071	-0.28125
Client's Capability	-2.871	31	0.004	-0.53125
Client's Involvement	-.338	31	0.369	-0.06250
Risk Distribution Mechanism	**5.299**	**31**	**<0.001**	**0.53125**
Schedule Requirements	-2.738	31	0.005	-0.56250
Cost Requirements	-.818	31	0.210	-0.15625
Level of Control	-2.875	31	0.004	-0.50000
Professional Input	-3.395	31	<0.001	-0.71875
Project Type	.516	31	0.305	0.09375
Project Scale	-2.895	31	0.003	-0.59375
Project Scope	-2.738	31	0.005	-0.56250
Project Flexibility	-3.674	31	<0.001	-0.96875
Uniqueness of Project	-4.156	31	<0.001	-1.09375
Project Complexity	-2.908	31	0.003	-0.75000

Familiarity with Project	1.646	31	0.055	0.18750
Influence of Law & Regulations	-.551	31	0.293	-0.09375
Legal Dispute	-1.000	31	0.163	-0.18750
Political Impacts	-2.339	31	0.013	-0.37500
Availability of Funding	**3.040**	**31**	**0.002**	**0.40625**
Mode of Recovery	**2.436**	**31**	**0.010**	**0.37500**

All the factors having t value greater than 1.699519, are critical. Hence, As per the above given explanation and the (SPSS) table included, it can be concluded that Risk Distribution Mechanism, Availability of Funding and Mode of Recovery are the most significant factors.

3.3.3. Relative Importance Index (RII)

The Relative Relevance Index (RII) is highly significant since its value indicates the ranked degree of importance. It is especially useful for questionnaires that use a Likert scale.
The formula used is as follows.

$$RII = \sum W/AN = (5n5 + 4n4 + 3n3 + 2n2 + 1n1)/AN$$

n1 – Frequency of Not Important
n 2 – Frequency of Least Important
n 3 – Frequency of Moderately Important n 4 – Frequency of Important
n 5 – Frequency of Most Important W – Weight of each factor
A – Highest Weight
N – Total number of responses

T5. Relative Importance Index

Factors	n1	n 2	n 3	n 4	n 5	Score	RII	Rank
Client's Experience	0	5	8	10	9	119	0.74	10
Client's Capability	1	6	6	15	4	111	0.69	13
Client's Involvement	1	2	6	12	11	126	0.79	6
Risk Distribution Mechanism	**0**	**0**	**1**	**13**	**18**	**145**	**0.91**	**1**
Schedule Requirements	2	5	8	11	6	110	0.69	14
Cost Requirements	1	3	6	12	10	123	0.77	8
Level of Control	1	4	9	14	4	112	0.70	12
Professional Input	3	5	9	10	5	105	0.66	17
Project Type	1	2	5	10	14	130	0.81	5
Project Scale	3	3	9	12	5	109	0.68	16
Project Scope	2	5	8	11	6	110	0.69	14
Project Flexibility	7	6	5	7	7	97	0.61	19
Uniqueness of Project	9	5	2	12	4	93	0.58	20
Project Complexity	6	5	3	11	7	104	0.65	18
Familiarity with Project	0	0	4	18	10	134	0.84	4
Influence of Law & Regulations	1	1	7	14	9	125	0.78	7
Legal Dispute	1	2	9	10	10	122	0.76	9
Political Impacts	0	3	12	11	6	116	0.73	11
Availability of Funding	**0**	**0**	**5**	**9**	**18**	**141**	**0.88**	**2**
Mode of Recovery	**1**	**0**	**2**	**12**	**17**	**140**	**0.88**	**3**

The factors are ranked according to the Relative Importance Index (RII) in order to comprehend their importance. Hence, From the table above, it can be inferred that the most significant factor which affects the selection of a PDM is Risk Distribution Mechanism, since its ranked first and has the RII of 0.91, highest among all factors. Availability of Funding & Mode of Recovery are also among the most important factors with RIIs 0.88 each and are ranked at 2 and 3 respectively.

CHAPTER 4

CONCLUSION

Project Delivery Systems (PDS) are a collection of phases that are necessary for organizing, implementing, and finishing any project. These phases include planning, designing, execution, and other ancillary services. There are multiple options to opt for when selecting a PDS. But the final selection depends on various factors, one of them is clients' capabilities and involvement. Since the final selection of the PDS is done by client, this factor is must to be considered. The selection process can also involve participation of other stakeholders like contractor and consultants, to make it easy for the client to reach a conclusion.
Based on our findings, we learned that the factors which matter the most while selecting a PDS are risk distribution mechanism, availability of funding and modes of recovery. The reason behind this, could be the involvement of private players which has seen a significant rise due to governments initiatives in privatizing the public projects. The aforementioned factors make the most sense because private individuals won't be able to participate unless there are sufficient prospects for monetary gain and risks are fairly distributed.

CHAPTER 5

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