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Pre-project management practices, progress control and data application in engineering companies: Basis for project delivery framework

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Abstract

In today's competitive engineering landscape, successful project delivery hinges on a robust framework. This dissertation explores the critical role of pre-project management practices, progress control methods, and data application. By analyzing how these elements function within engineering companies, it aims to establish a foundational framework for optimal project delivery. This framework will equip engineering firms to navigate complex projects efficiently, ensuring successful completion within budget and timeframe. The study evaluated the pre-project management practices， progress control and data application used in engineering companies in China. This dissertation employed descriptive research methods, utilizing questionnaire surveys to gather data from a representative sample. The collected data underwent regression analysis to identify relationships between variables, and analysis of variance (ANOVA) to assess potential differences between groups. The "highly significant" correlations across all pre-project management practices and progress control measures suggest a robust and statistically sound association. This implies a directional relationship, where improvements in pre-project practices tend to lead to better progress control throughout the project lifecycle. Conversely, neglecting these practices might contribute to difficulties in managing project progress. The consistent "highly significant" correlations across all variables suggest a strong, positive association between the quality of pre-project management practices and the level of data application. This implies that robust pre-project planning (encompassing areas like forecasting, construction, quality management, productivity, and dependability) fosters a culture of data-driven decision-making. In other words, companies with well-defined pre-project processes are more likely to leverage data effectively throughout the project lifecycle. The consistent "highly significant" findings from the statistical analysis point towards a robust and statistically reliable association between progress control and data application across various project management domains. These strong positive correlations suggest a synergistic relationship, implying that effective data application is not just beneficial but also potentially essential for achieving better progress control in diverse project management aspects.

Keywords: pre-project management practices, progress control data application, project delivery framework

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1. Introduction

Effective project management is the invisible engine driving a robust economy. In China's case, meticulously planned and executed projects have fueled its remarkable rise. From sprawling urban infrastructure to flourishing industrial capabilities, China's economic trajectory is deeply intertwined with its project management prowess. Before the first construction crane rises, the groundwork for success is laid through meticulous pre-project planning. Feasibility studies, rigorous cost assessments, and comprehensive risk analyses are crucial in ensuring projects are viable, deliver a positive return on investment, and have a clear roadmap to completion. China's emphasis on cost control, particularly in its burgeoning urban infrastructure projects, has been bolstered by economies of scale and a large available workforce.

Equally important is the formation of the project team and the forging of strategic partnerships. Agreements between the owner and stakeholders, often involving joint ventures and collaborations, set the stage for seamless project execution. The meticulous pre-project preparations in China are exemplified by the Belt and Road Initiative, a testament to the importance of laying the groundwork for ambitious endeavors. The success of engineering projects in China hinges on a well-defined and implemented management strategy. Pre-project activities lay the foundation for successful project execution. This includes thorough feasibility studies, comprehensive risk assessments, and meticulous resource planning. These activities ensure that projects are well-defined, potential risks are identified and mitigated, and resources are allocated efficiently. Progress control methods are essential for monitoring and tracking project progress. Earned value management, critical path analysis, and schedule control techniques are crucial tools for ensuring projects stay on track, within budget, and on schedule. By effectively utilizing these methods, engineering companies can identify potential deviations early on and take corrective actions to ensure project success.

Data application plays an increasingly important role in modern project management. Engineering companies are now leveraging data collection, analysis, and utilization to gain valuable insights into project performance. This data can be used to inform decision-making, identify areas for improvement, and ultimately enhance project efficiency and outcomes. The convergence of the aforementioned methodologies forms a comprehensive management strategy framework. The Chinese approach to addressing economic challenges and opportunities is built on a methodical structure that serves as its foundation. This reflects China's strategic planning at the national level, where project management serves not only as an operational requirement but also as a strategic tool aligned with the country's global ambitions. To effectively navigate complex economic ecosystems, it is crucial to possess a comprehensive comprehension of the interrelationships among various facets of project management. This holds particularly true for a prominent global power such as China. Despite the evident project management talents in China, unraveling the intricate network of interdependencies across different management systems remains a challenge. The complexity of the situation emphasizes the importance of conducting further research to enhance our comprehension and ensure the continuous development of project management that will facilitate ongoing growth and innovation in the field of global manufacturing and exporting. This research will contribute to advancing project management practices in the Chinese engineering sector, ultimately leading to improved project outcomes and increased competitiveness.

Objectives of the Study - The study evaluated the pre-project management practices, progress control and data application used in engineering companies in China. Specifically, the study determined the pre-project management practices as to project planning and forecasting, cost estimation, project team formation and owner negotiations, aassessed the progress control as to design, supply, transportation and installation and commissioning control, aassessed the data application in terms of construction practices, quality management, productivity and project dependability, tested the significant relationship between Pre-Project Management Practices, Progress Control and Data Application in Engineering Companies and developed a project delivery framework to optimize project quality and outcomes in the South Asian power sector.

2. Methods

Research Design - The study employed a descriptive correlational research design to evaluate pre-project management practices, progress control, and data application within engineering companies in China. This design is suitable for systematically describing the state of affairs as it exists and exploring relationships between variables without manipulating them. The correlation analysis is crucial for understanding how these practices are interconnected and can inform the development of a management strategy framework for the South Asian power sector.

Participants of the Study - The participants comprised professionals involved in project management within engineering companies operating in China. These included project managers, engineers, data analysts, quality assurance personnel, and other stakeholders engaged in pre-project planning, execution, and control phases. A stratified random sampling technique was utilized to ensure representation from various departments and to capture a wide range of perspectives on the management practices in question.

Data Gathering Instruments - The research instruments included structured questionnaires and checklists designed to capture quantitative data on the effectiveness of pre-project management practices and the application of data in the specified areas. The questionnaire items were based on a Likert scale to assess agreement levels and were developed in accordance with established project management standards to ensure validity. The checklist served to corroborate the questionnaire responses with actual documentation and practices observed.

Table 1

Reliability Test Result

Variable	Cronbach's Alpha	Remarks
Pre-Project Management Practices		
1A. Project Planning and Forecasting	0.798	Acceptable
1B. Cost Estimation	0.755	Acceptable
1C. Project Team Formation and Owner Negotiation	0.771	Acceptable
Progress Control		
2A. Design Control	0.761	Acceptable
2B. Supply Control	0.817	Good
2C. Transportation Control and Installation Commissioning Control	0.715	Acceptable
Data Applications		
3A. Construction Practices	0.768	Acceptable
3B. Quality Management	0.814	Good
3C. Productivity and Project Dependability	0.827	Good

Legend: George and Mallery (2003) provided the ff rule of thumb: ≥0.90 = Excellent; ≥0.80 = Good; ≥0.70 = Acceptable; ≥0.60 = Questionable; ≥0.50 = Poor; <0.50 = Unacceptable

The reliability result indicates that most variables across the categories fall within the "Acceptable" to "Good" range of Cronbach's Alpha scores, highlighting the overall reliability and internal consistency of the measures used.

Data Gathering Procedure - Data collection was conducted through the distribution of online questionnaires to the selected participants. The participants were briefed on the purpose of the study and the significance of their contributions to ensure informed consent and the reliability of the responses. To supplement questionnaire data, document analysis was carried out by reviewing project reports, management plans, and progress tracking systems. Additionally, interviews with key personnel were conducted to gain deeper insights into the practices and the nuances of their application. The combination of questionnaires, document analysis, and interviews allowed for a comprehensive collection of data, ensuring a robust dataset for subsequent analysis. The use of SPSS version 28 facilitated advanced statistical calculations, including the Shapiro-Wilk Test for normality and Spearman rho for non-parametric correlation analysis, addressing the data's non-normal distribution and fulfilling the study's objectives to inform the development of an optimized management strategy framework.

Data Analysis - Weighted mean and rank were used to determine the pre-project management practices as to project planning and forecasting, cost estimation, project team formation and owner negotiations, to assess the progress control as to design control, supply control, transportation control and installation and commissioning control and to assess the data application in terms of construction practices, quality management, productivity and project dependability. The result of Shapiro-Wilk Test showed that p-values of all variables were less than 0.05 which means that the data set was not normally distributed. Therefore, Spearman rho was used as part of the non-parametric tests to determine the significant relationship. All analyses were performed using SPSS version 28.

Ethical Considerations - Ethical considerations in this study include ensuring the confidentiality and anonymity of the respondents. Participation in the survey was voluntary, with respondents informed about the purpose of the study and assured that their responses will be used solely for research purposes. The data were stored securely, and only aggregate results were reported in the study, ensuring that individual responses cannot be traced back to specific participants. These measures are crucial to uphold the ethical standards of research and ensure the integrity of the study.

3. Results and discussion

Table 2

Summary Table on Pre-project Management Practices

Key Result Areas	Composite Mean	VI	Rank
Project Planning and Forecasting	2.91	Agree	1
Cost Estimation	2.88	Agree	3
Project Team Formation and Owner Negotiations	2.89	Agree	2
Grand Composite Mean	**2.89**	**Agree**	

Legend:3.50-4.00=Strongly Agree;2.50-3.49=Agree;1.50-.249=Disagree;1.00-1.49=Strongly Disagree

Table 2 shows summary on Pre-project Management Practices. It shows that all the domains in assessing technological upgrading are agreed with the grand composite mean of 2.89. All items were assessed by the respondents and among the indicators project planning and forecasting got the highest composite mean of 2.91.

Morris et al. (2019) emphasize the crucial role of well-defined project plans in achieving project goals. Effective planning provides a roadmap and allows for proactive risk management. This high ranking aligns with research by Chin et. al., (2020) who conducted a meta-analysis highlighting the connection between strong team formation practices and project success. Diverse and well-formed teams are essential for effective project execution. Additionally, Chan et al. (2020) in their review on "Project Briefing and Early Collaboration" found that establishing a collaborative relationship with owners early on is a critical success factor. Owner buy-in and clear communication contribute significantly to project goals. While cost estimation might be ranked lower, it remains a vital pre-project practice. Belout et. al.,(2019) discuss the importance of trust within project teams.

Accurate cost estimates foster trust between team members and the owner by setting realistic expectations. The prioritization of planning and forecasting might be due to the specific industry or project type. In highly dynamic environments, flexibility in planning might be more crucial. While ranked separately, these practices are interconnected. Effective project planning considers team capabilities and cost estimates. Communication with the owner ensures alignment between plans and budget realities. The presented ranking highlights a balanced approach to pre-project management. While planning is crucial, building a strong team and fostering collaboration with the owner are equally important for project success. Further research can provide deeper insights into the optimal balance of these practices for different project scenarios.

Table 3

Summary Table on Progress Control

Key Result Areas	Composite Mean	VI	Rank
Design Control	2.89	Agree	1
Supply Control	2.88	Agree	2
Transportation Control and Installation and Commissioning Control	2.87	Agree	3
Grand Composite Mean	**2.88**	**Agree**	

Legend:3.50-4.00=Strongly Agree;2.50-3.49=Agree;1.50-.249=Disagree;1.00-1.49=Strongly Disagree

Table 3 provides a consolidated view of progress control across three key result areas within an organization: Design Control, Supply Control, and Transportation Control and Installation and Commissioning Control. The Composite Mean is at 2.88, ranging from 2.87-2.89, thereby showing a tight clustering of scoring. It suggests that there is relatively consistent perception of effectiveness across the areas.

In terms of ranking, Design Control is rated highest, followed by Supply Control, and lastly, Transportation Control and Installation and Commissioning Control. The grand composite mean, all areas with 2.88, meant all items were agreed. This overall score reflects a uniform agreement on the effectiveness of the practices across the board. The summary table indicates that while there is a general agreement on the adequacy of progress control measures across various management practices, none excel to the point of strong agreement. Design Control is perceived as slightly more effective than the others, while Transportation Control and Installation and Commissioning Control lag slightly behind. The close proximity of the composite mean scores suggests that while there are no significant deficiencies, there is also no area of exceptional performance. This consistency in scoring may point to an opportunity for the organization to make holistic improvements across all areas of progress control.

Table 4

Summary Table on Data Application

Key Result Areas	Composite Mean	VI	Rank
Construction Practices	2.88	Agree	2
Quality Management	2.87	Agree	3
Productivity and Project Dependability	2.89	Agree	1
Grand Composite Mean	**2.88**	**Agree**	

Legend:3.50-4.00=Strongly Agree;2.50-3.49=Agree;1.50-.249=Disagree;1.00-1.49=Strongly Disagree

Table 4 provides a summary of data application the weighted means (WM) being very close (between 2.87 and 2.89) indicating that respondents see data application as equally important for Productivity and Project Dependability, Construction Practices, and Quality Management. This agreement suggests a significant shift towards acknowledging the value of data application across various aspects of construction projects. The close

WMs imply that respondents view data application not as isolated areas but as a holistic approach that improves both project outcomes (productivity, dependability) and construction processes (practices, quality management). Agreement might not directly translate to successful implementation. Further research could explore barriers like data skills gap, integration challenges, or data security concerns that might hinder effective data application. Overall, the close weighted means for all dimensions highlight the perceived importance of data application across various aspects of construction projects. However, further analysis of specific indicators and potential implementation challenges is recommended for a more comprehensive understanding.

A deeper comprehension of the interests of international organizations, suppliers, governments, and the Internet of Things is necessary for the circular economy to transition inside Industry 4.0. The summary table shows a uniform perception of the data application's effectiveness in key areas of the organization's operations, with Productivity and Project Dependability slightly leading the way. The tight range of the scores suggests that while there are no significant issues with data application, there may be no particular area of excellence either. Quality Management is seen as the area with the most room for improvement, although the difference is marginal. Overall, the organization's data application practices are seen as adequate, but the close scores across the areas suggest that there is an opportunity for improvement that could lead to higher levels of performance and satisfaction.

As seen in table 5, the computed rho-values ranging from 0.861 to 0.898 indicate a very strong direct relationship among the sub variables of pre-project management practices and progress control. There was a statistically significant relationship between pre-project management practices and progress control because the obtained p-values were less than 0.01. Table 5 displays the statistical relationship between various pre-project management practices and progress control, using Spearman's rho correlation coefficient and associated p-values for significance testing. All listed pre-project management practices have high rho values close to 1, which suggests a strong positive correlation with progress control. For project planning and forecasting, rho values are in the high 800s, which point to a very high degree of relationship. Consequently, p-values are also shown to be highly significant ($p<0.001$). Further, for Cost Estimation and Project Team Formation and Owner Negotiations, it is generally the same, with high 800s in coefficient of correlation, and p-value <0.001 demonstrating a very high degree of relationship and a highly significant one at that.

Table 5

Relationship Between Pre-project Management Practices and Progress Control

Variables	Rho	p-value	Interpretation
Project Planning and Forecasting			
Design Control	0.884**	<.001	Highly Significant
Supply Control	0.898**	<.001	Highly Significant
Transportation Control and Installation and Commissioning Control	0.885**	<.001	Highly Significant
Cost Estimation			
Design Control	0.864**	<.001	Highly Significant
Supply Control	0.881**	<.001	Highly Significant
Transportation Control and Installation and Commissioning Control	0.872**	<.001	Highly Significant
Project Team Formation and Owner Negotiations			
Design Control	0.862**	<.001	Highly Significant
Supply Control	0.872**	<.001	Highly Significant
Transportation Control and Installation and Commissioning Control	0.861**	<.001	Highly Significant

***. Correlation is significant at the 0.01 level*

For those indicators that correlate highest for each variable, there is “Supply Control” for all variables: Project Planning and Forecasting (r=0.898, p<0.001), Cost Estimation (r=0.881, p<0.001), and Project Team Formation and Owner Negotiations (r=0.872, p<0.001). The "Highly Significant" interpretation given for all correlations suggests that there is a strong and statistically significant relationship between and among each of the pre-project management practices and the control of progress within the projects. This implies that as these pre-project practices improve, progress control within the project also tends to improve, and vice versa. As such, there is a highly significant positive correlation between pre-project management practices—specifically in project planning and forecasting, design control, supply control, transportation control, installation and commissioning control—and progress control. This indicates that effective management practices are closely linked with the successful control of progress in projects. The relationship between risk management and project performance is favorably moderated in a positive way by management expertise. Project-based firms can use this study to raise the bar and give employees the tools and resources they need to complete their projects successfully.

Table 6

Relationship Between Pre-project Management Practices and Data Application

Variables	Rho	p-value	Interpretation
Project Planning and Forecasting			
Construction Practices	0.872**	<.001	Highly Significant
Quality Management	0.880**	<.001	Highly Significant
Productivity and Project Dependability	0.886**	<.001	Highly Significant
Cost Estimation			
Construction Practices	0.880**	<.001	Highly Significant
Quality Management	0.865**	<.001	Highly Significant
Productivity and Project Dependability	0.883**	<.001	Highly Significant
Project Team Formation and Owner Negotiations			
Construction Practices	0.878**	<.001	Highly Significant
Quality Management	0.859**	<.001	Highly Significant
Productivity and Project Dependability	0.873**	<.001	Highly Significant

***. Correlation is significant at the 0.01 level*

As seen in the table 6, the computed rho-values ranging from 0.859 to 0.886 indicate a very strong direct relationship among the sub variables of pre-project management practices and data application. There was a statistically significant relationship between pre-project management practices and data application because the obtained p-values were less than 0.01. Table 6 outlines the relationship between various pre-project management practices and data application, as indicated by Spearman's rho correlation coefficients and p-values. For Project Planning and Forecasting and Cost Estimation, “Productivity and Project Dependability” correlates the most (r=0.886, and r=0.883 respectively). Both are highly significant, with p<0.001 as well, demonstrating a highly significant association between the indicator and the two variables mentioned. Meanwhile, for Project Team Formation and Owner Negotiations, “Construction Practices” got the highest relationship at r=0.878 p<0.001. Still, for all purposes of calculations, these indicators are statistically tied with each other. Since all p-values are less than .001, this indicates a highly significant correlation between the pre-project management practices and data application.

The "Highly Significant" interpretation across all variables suggests that as the quality of pre-project management practices increases (in planning and forecasting, construction, quality management, and productivity and project dependability), the level of data application also increases. This implies that effective pre-project management is strongly linked to the effective application of data. The strong and highly significant positive correlations shown underscore the pivotal role of data application in enhancing various aspects of pre-project management practices. Effective data application is integral to the success of these management practices, suggesting that data-driven approaches are key to improving project outcomes. Therefore, it was determined that property businesses' ability to effectively plan and incentivize performance will contribute to the success of the projects.

Table 7

Relationship Between Progress Control and Data Application

Variables	rho	p-value	Interpretation
Design Control			
Construction Practices	0.874**	<.001	Highly Significant
Quality Management	0.863**	<.001	Highly Significant
Productivity and Project Dependability	0.855**	<.001	Highly Significant
Supply Control			
Construction Practices	0.865**	<.001	Highly Significant
Quality Management	0.873**	<.001	Highly Significant
Productivity and Project Dependability	0.875**	<.001	Highly Significant
Transportation Control and Installation and Commissioning Control			
Construction Practices	0.862**	<.001	Highly Significant
Quality Management	0.871**	<.001	Highly Significant
Productivity and Project Dependability	0.889**	<.001	Highly Significant

***. Correlation is significant at the 0.01 level*

As seen in the table 7, the computed rho-values ranging from 0.855 to 0.889 indicate a very strong direct relationship among the sub variables of progress control and data application. There was a statistically significant relationship between progress control and data application because the obtained p-values were less than 0.01. Table 7 provides an analysis of the relationship between progress control and data application in various areas of project management, utilizing Spearman's rho (ρ) correlation coefficients and p-values for statistical significance. Similar with the last two tables on relationships, we have a similar high 800s rho value (ranging from 0.855 to 0.889) of correlation here for all indicators against the variables. All of them naturally have highly significant association ($p<0.001$), showing that there is indeed significant relationship between progress control and data application, and that these correlation coefficients are not due to random chance but are indeed, statistically significant.

For individual indicators, we have “Construction Practices” correlating highest ($r=0.874$, $p<0.001$) with Design Control. For Supply Control, it is “Productivity and Project Dependability” that has highest correlation coefficient ($r=0.875$, $p<0.001$). The same goes for Transportation Control and Installation and Commissioning ($r=0.889$, $p<0.001$) for “Productivity and Project Dependability”.

The "Highly Significant" label for all the correlations means that the relationship between progress control and data application in these domains is both strong and statistically reliable. With the strong positive correlations seen across the board, this suggests that effective data application is closely tied to better progress control in various project management aspects. The highest correlation is with Productivity and Project Dependability in the context of Transportation Control and Installation and Commissioning Control, highlighting the critical role of data in managing complex logistics and commissioning tasks efficiently. As such, Table 7 reveals that there is a highly significant and strong positive correlation between the application of data and progress control within project management domains, underscoring the importance of data-driven approaches to enhancing project control mechanisms.

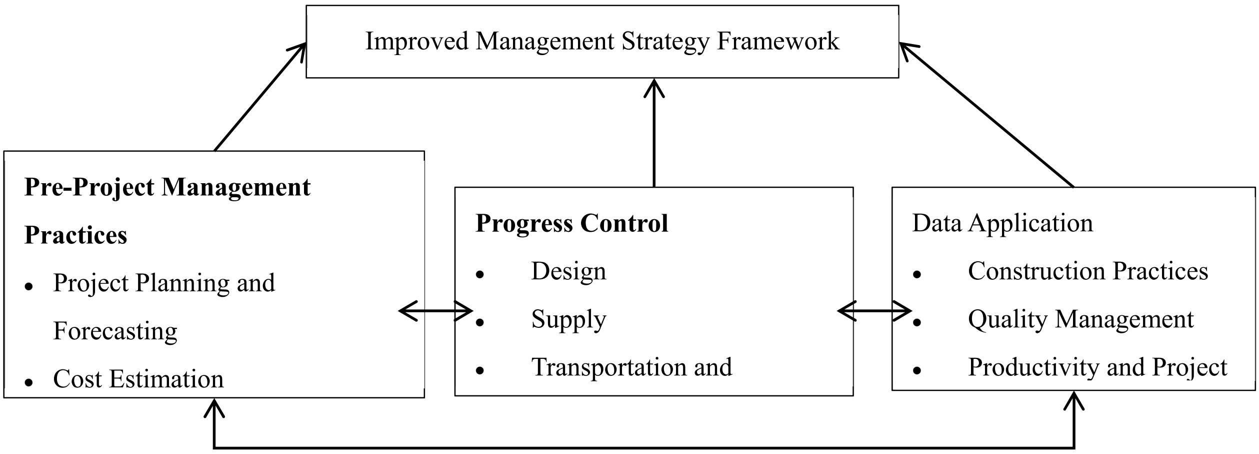

Figure 1. Framework for Improve Management Strategy

The framework outlines a series of steps that can be used to improve the overall management of a project. This highlights the importance of setting a strong foundation before the project officially begins. It includes activities like Project planning and forecasting, Defining project goals, scope, schedule, and budget. Cost estimation, Developing a realistic estimate of project costs. Project team formation, Building a competent and collaborative team to execute the project. Owner negotiations mean establishing clear communication and expectations with the project owner, monitoring the project's progress and ensuring it aligns with the plan. It includes Project planning and tracking, continuously monitoring progress against the initial plan and making adjustments as needed. Data application construction practices include leveraging data to inform decision-making throughout construction. Quality management is implementing processes to ensure the project meets the required quality standards.

Other important elements are supply and transportation, that is, efficient management of material procurement and delivery to the construction site. Installation means executing the construction activities according to the plan. Commissioning control is about ensuring that the completed project functions as intended before handover. Project dependability includes factors influencing the reliability and predictability of project outcomes. Overall, the framework emphasizes the importance of planning, communication, data application, and continuous monitoring to achieve successful project outcomes. The arrows in the diagram suggest an iterative process, where information from progress control can inform adjustments to pre-project plans. The success of the framework relies on effective communication and collaboration among all stakeholders involved in the project.

To optimize project quality and outcomes in the South Asian power sector, a management strategy framework is proposed, focusing on enhancing pre-project management practices, cost estimation, team formation, and owner negotiations, alongside improving design control, supply management, and progress control mechanisms. Key recommendations include refining initial planning and risk assessment processes, leveraging strong forecasting and resource management as benchmarks, continuously refining cost estimation methods, and improving coordination and negotiation success with project owners. Additionally, focusing on timely design modifications, strengthening supply chain resilience, and fortifying installation and debugging practices, especially concerning safety and quality assurance, are crucial. The framework advocates for a strategic focus on data-driven decision-making to enhance project management practices across planning, construction, quality management, and productivity, ensuring comprehensive coverage and flexibility to accommodate external changes. Organizations are encouraged to prioritize data analytics integration, particularly in transportation, installation, and commissioning phases, to significantly enhance overall project progress control and outcomes. The development of a comprehensive management strategy framework tailored to the Chinese context is crucial for optimizing project management practices in the country. This framework will provide engineering companies with practical guidance on implementing effective pre-project activities, robust progress control methods, and data-driven decision-making.

4. Conclusions and recommendations

The respondents moderately agreed that the engineering companies observed pre-project management practices as to planning and forecasting, cost estimation, project team formation and owner negotiations. The respondents moderately agreed that there is progress control as to design, supply, transportation and installation and commissioning. The respondents moderately agreed that there is data application in terms of construction practices, quality management, productivity and project dependability. There is highly significant relationship between pre-engineering management, progress control and data application used in engineering companies. Project delivery framework has been developed to optimize project quality and outcomes in the South Asian power sector.

The company may implement more robust demand forecasting methods to improve project scope definition and resource allocation. The company may consider using digital tools like Building Information Modeling (BIM) for improved design coordination and progress visualization. The company may adopt the framework for improve project quality and outcomes. Future researchers may conduct a comparative study of pre-project management practices in South Asia with other regions like Europe or North America, identify best practices from leading regions and explore their transferability to the South Asian context.

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