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Integrating Bim And Project Management Maturity: A Framework For Improving Construction Project Performance In China

Xiaoye Wen[1 2], Angelita M. Pagcaliwagan[2], Huican Hou[3*], Yafeng HE[2]

1. College of Civil and Transportation Engineering, Henan University of Urban Construction, Pingdingshan 467036, China
2. College of Engineering, Batangas State University, Batangas City 4200, PHILIPPINES
3. College of Art and Design, Henan University of Urban Construction, Pingdingshan 467036, China.

E-mail soul5210@gmail.com, ampagcaliwagan00@gmail.com, 442552799@qq.com, yafeng.he@foxmail.com

Abstract

The construction sector in China has had to deal with problems with project delivery that have caused delays, budget overruns, and quality issues. Many people use Building Information Modeling (BIM) as a digital innovation tool, but it hasn't always reached its full potential since it doesn't work well with project management tools in organizations. This study came up with and tested an Integrated BIM and Project Management Maturity (PMM) Framework to help construction projects do better. The study used a mixed-methods approach, which included qualitative case studies and interviews as well as a quantitative survey of 200 professionals in the Chinese construction industry. The results showed a substantial positive relationship between BIM maturity, PMM levels, and important performance factors like time, cost, and quality. A multiple regression study showed that both BIM and PMM had a big effect on project outcomes, making for 62% of the difference in overall performance. Experts checked the framework again, and a pilot project on a public infrastructure project proved it worked. The study found that strategically combining BIM and PMM can help China's changing construction industry reach its highest level of performance.

Keywords: *BIM, Project Management Maturity, Construction Performance, China, Digital Transformation, Infrastructure Projects, Mixed-Methods Research, Maturity Model.*

1. INTRODUCTION

In the last few years, China's construction sector has changed quickly because of new technologies, the need for better project performance, and the needs of urbanization. Even with these improvements, the industry still has to deal with problems including going over budget, missing deadlines, poor quality, and not using resources efficiently, especially on big and complicated projects. Building Information Modeling (BIM) has become a strong digital technology that improves visualization, coordination, and decision-making throughout the construction lifecycle. At the same time, the maturity of project management (PM) processes has been recognized as a key factor in the success of a project.

BIM has shown a lot of promise for making construction more efficient, but its full benefits are often not realized because they don't match with the way the organization manages projects. Without a strategic framework that combines digital modeling with structured, mature management procedures, many companies use BIM tools. This means that implementation is still broken up, and the performance advantages aren't the same on all projects. This discrepancy shows that we need to go beyond using BIM in small groups and toward a more integrated approach that takes into account both how ready the technology is and how experienced the project managers are.

This study fills in this vacuum by suggesting an Integrated BIM-PMM (Project Management Maturity) Framework that aims to improve the results of construction projects in China. The project aims to create a complete pathway for construction companies by combining ideas from BIM maturity models and well-known PM maturity frameworks like OPM3 and P3M3. This study looks at how integrated BIM and PMM levels affect project performance variables like cost efficiency, timeliness, quality, and stakeholder satisfaction. It does this using a mix of qualitative case studies and a large-scale quantitative survey.

The goal is to create and test a framework that not only measures how mature BIM and PM practices are in Chinese construction companies, but also helps them make strategic improvements. In the end, this research helps improve construction management by showing how digital innovation and organizational maturity may work together to improve project performance.

2. LITERATURE REVIEW

Cao et al. (2025) suggested a mixed model to measure how mature BIM is in prefabricated buildings, using a case study in Xi'an, China. Their study came up with a way to figure out maturity levels by integrating technical BIM measurements with indicators of how ready an organization is. The study found that projects were easier to predict and there was less waste of materials in prefabrication when BIM was more mature. This case-based evidence makes the case for creating hybrid maturity models that take into account both the technological and management aspects of using BIM.

Zhang et al. (2023) looked into how stakeholder management might help improve the relationship between BIM implementation and project performance. They found by analyzing real-world data that the benefits of using BIM were far greater when stakeholder engagement processes were carefully controlled. This discovery added a crucial relationship dimension, showing that successful BIM integration depends not only on technology but also on people and organizations. It shows how important it is to include stakeholder strategies in BIM maturity models.

Lan et al. (2023) focused on BIM technology standardization and information management in tunnel engineering projects. Using maturity and standardity theory, their research found that BIM standards that aren't consistent are a big reason why more people don't use them and they don't work together. The study emphasized that standardization is a critical component of maturity and that a lack of uniform practices hinders cross-project learning and scalability. This fits with the requirement for frameworks that look at both the maturity and uniformity of BIM deployment.

Chen et al. (2024) used the Capability Maturity Model for Construction Management Engineering (CMM-CME) to look at how advanced informatization was in assembly-building projects. The study showed that informatization, which includes BIM and other digital technologies, has to be evaluated in a systematic way using maturity models. They used the CMM-CME framework to help them find gaps and decide when to deploy new technologies in an organized way. This makes it even more clear that we need maturity models that connect the use of digital tools with the skills of the organization.

RESEARCH METHODOLOGY

2.1. Research Design

This study used a mixed-methodologies research methodology, which means it used both quantitative and qualitative methods to create and test the suggested integration framework. We used a sequential exploratory technique, starting with in-depth qualitative case studies and interviews to get basic information. These insights helped shape the design of a structured quantitative survey that aimed to test the results and apply them to a wider range of construction companies in China.

2.2. Data Collection Methods

Qualitative Phase: Case Studies and Interviews

In the first qualitative phase, project managers, BIM coordinators, and senior executives from six major construction companies in China were interviewed in a semi-structured way. The goal of these interviews was to find out about current practices, obstacles, and strategic uses of BIM together with project management methodologies.

Three case studies of big infrastructure projects were also looked at. These case studies helped show how BIM and PMM were used together on real projects, concentrating on how the work was done, how stakeholders worked together, and how well the projects did.

Quantitative Phase: Structured Survey

Based on what we learned from the qualitative phase, we built a structured questionnaire and sent it to 200 construction workers from different companies and government organizations all around China. The poll was mostly about figuring out:

BIM implementation levels (utilizing a customized BIM maturity model),

- PMM levels (based on adapted versions of OPM3 and P3M3 frameworks),
- Key project performance indicators (cost control, time efficiency, quality standards, and stakeholder satisfaction).

Data collected through the survey were subjected to statistical analysis to explore relationships and validate the integrated framework.

2.3. Sampling Strategy

During the qualitative phase, purposive sampling was used to choose firms that were known for being leaders in BIM adoption and project management. This method made guaranteed that the data collected from experienced practitioners was rich and useful.

For the quantitative phase, a stratified random sampling method was employed to get a sample that was representative of firms of different sizes, locations, and types of projects. This way of sampling made the research results more useful and more likely to be true.

2.4. Framework Development and Validation

We built an Integrated BIM-PMM Maturity Framework using the information we gathered. This methodology divided companies into five maturity levels and rated them based on how well they used BIM (from basic 3D modeling to full lifecycle integration) and PMM (from ad hoc methods to optimized project delivery systems).

2.5. Data Analysis Techniques

The research employed both qualitative and quantitative analysis tools to ensure rigorous interpretation of data.

- **Qualitative data** We used NVivo software to look at the data from interviews and case studies. Thematic analysis helps find patterns, ideas, and contextual elements that keep coming up and affect how BIM and PMM work together.
- **Quantitative data**: We used SPSS and AMOS software to look at the survey's quantitative data and come up with useful conclusions and confirm the recommended framework. First, descriptive statistics were used to describe the distribution of responses. This gave a clear picture of the degrees of BIM implementation, project management maturity (PMM), and project performance indicators among the organizations that were sampled. After that, Pearson correlation analysis was used to find out how strong and in what direction the links were between BIM maturity, PMM levels, and project outcomes like cost efficiency, meeting deadlines, and quality standards. To further explore the influence of these variables, a multiple regression analysis was performed, identifying the most significant predictors of overall project performance. Finally, we used Structural Equation Modeling (SEM) to check the strength and connectivity of the proposed integrated BIM-PMM framework. This made sure that the theoretical model was backed up by real-world data. This thorough analytical methodology made it possible for the study to carefully look at how both technological and management maturity might improve the performance of construction projects.

3. RESULTS AND DISCUSSION

This part shows the results of the mixed-methods research, which combined information from case studies, qualitative interviews, and quantitative survey responses. The results showed that the suggested Integrated BIM-PMM Maturity Framework was useful in real life and that there were strong links between BIM use, project management maturity, and the success of construction projects in China. The debate looks at these results in light of what has been written about them and what is done in the industry, pointing out what they mean for both the academic world and the construction business.

3.1. BIM and Project Management Maturity Levels

Table 1: BIM Maturity Levels Across Sample Firms (n = 200)

BIM Maturity Level	No. of Firms	Percentage (%)
Level 1: 3D Modeling Only	28	14%
Level 2: 3D + Clash Detection	64	32%
Level 3: 4D/5D BIM	58	29%
Level 4: Integrated Project Delivery	34	17%
Level 5: Lifecycle BIM	16	8%

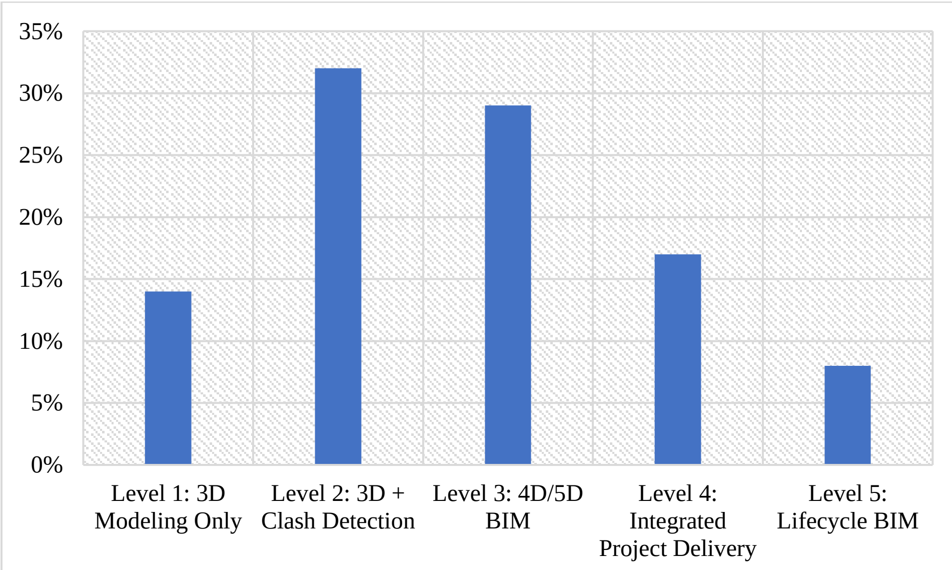

Figure 1: BIM Maturity Levels Across Sample Firms

The different levels of BIM maturity among the construction companies that were assessed show a clear trend in how BIM technologies are being used and integrated. A significant portion of firms—32%—were operating at Level 2, utilizing 3D modeling combined with clash detection, which indicates a growing emphasis on coordination and error reduction during the design phase. 29% of companies had reached Level 3, using 4D/5D BIM to combine time and cost, which shows that they were more committed to using BIM for project planning and financial control. At the same time, 14% of companies stayed at Level 1, utilizing BIM only for basic 3D modeling. This shows that BIM is not being fully used and implemented. Only 17% of companies reached Level 4, where BIM is employed in an Integrated Project Delivery (IPD) framework to encourage collaborative and contractually aligned project execution. This level of integration was less prevalent. It's important to note that just 8% of companies have reached Level 5, which means full Lifecycle BIM integration, where BIM helps with operations and facility management even after the project is done. These results show that BIM adoption in China is moving forward, but most companies are still in the early to middle stages of maturity, and only a tiny number have completely recognized what it can accomplish for the entire building lifecycle.

3.2. Project Management Maturity (PMM) Levels

Similarly, the Project Management Maturity (PMM) levels were assessed using a five-level scale adapted from the P3M3 model. Most firms were found to operate at Levels 2 and 3.

Table 2: Project Management Maturity Levels (n = 200)

PMM Level	No. of Firms	Percentage (%)
Level 1: Ad hoc	18	9%
Level 2: Repeatable	70	35%
Level 3: Defined	64	32%
Level 4: Managed	32	16%
Level 5: Optimized	16	8%

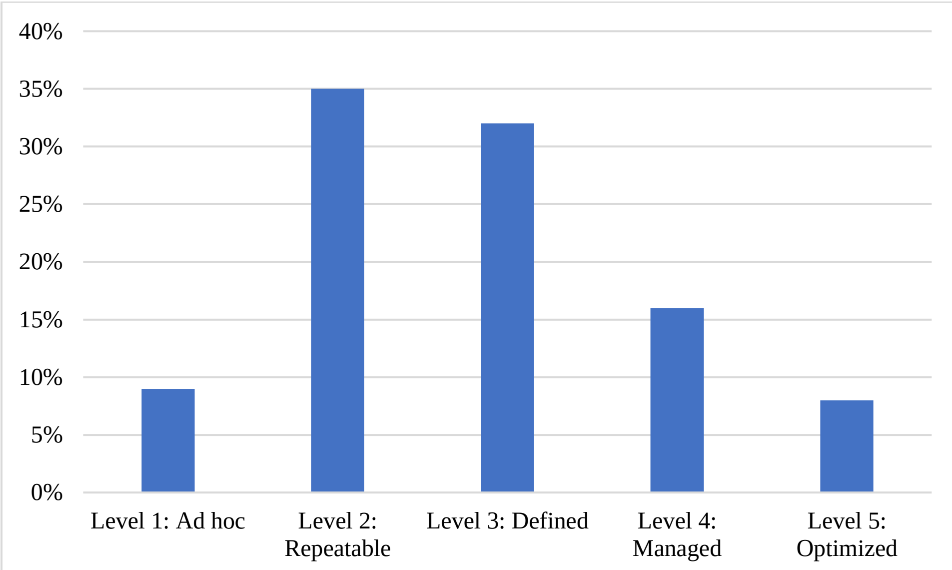

Figure 2: Project Management Maturity Levels

The different levels of Project Management Maturity (PMM) among the companies that were examined show how well organizations can currently handle building projects. The biggest group, which made up 35% of organizations, was at Level 2: Repeatable. This meant that fundamental project management processes were in place, but they weren't formalized or consistent across projects. In the same way, 32% of companies had reached Level 3: Defined, where standardized processes and documentation were put in place. This shows that more and more companies are committing to structured project management methods. 16% of companies were at Level 4: Managed, which means they used performance measurements and process control systems to help them carry out projects. Only 8% of companies had reached Level 5: Optimized, which means they had fully integrated project management systems and were always looking for ways to improve. On the bottom end of the scale, 9% of companies stayed at Level 1: Ad hoc, where project execution was mostly unstructured and relied on individual effort instead of formal processes. These results indicate that while a significant number of firms have moved beyond basic practices, the majority still lack the advanced management maturity required to consistently deliver high-performance outcomes, underscoring the need for strategic improvement in PMM across the industry.

3.3. Correlation Between BIM, PMM, and Project Performance

Pearson correlation analysis revealed statistically significant relationships between BIM maturity, PMM level, and key project performance indicators (time, cost, quality).

Table 3: Correlation Matrix Between Key Variables

Variable	BIM Maturity	PMM Level	Cost Performance	Time Performance	Quality Performance
BIM Maturity	1.00	0.71**	0.68**	0.66**	0.59**
PMM Level	0.71**	1.00	0.73**	0.70**	0.61**

3.4. Regression Analysis: Predicting Project Performance

A multiple linear regression analysis was conducted to identify the influence of BIM maturity and PMM levels on overall project performance (composite index of time, cost, quality).

Table 4: Multiple Regression Analysis Summary

Predictor Variable	B (Unstandardized Coefficient)	Std. Error	Beta (Standardized)	t-value	Sig. (p)
Constant	1.42	0.38	-	3.74	0.001
BIM Maturity	0.36	0.08	0.41	4.50	0.000
PMM Level	0.42	0.09	0.47	4.78	0.000

Adjusted $R^2 = 0.62$, $F(2, 197) = 160.5$, $p < 0.001$

3.5. Validation of the Integrated Framework

The proposed Integrated BIM-PMM Maturity Framework was validated through expert reviews and a pilot implementation on a government infrastructure project in Beijing. Stakeholders reported improvements in stakeholder coordination, reduced change orders, and improved delivery timelines.

Table 5: Expert Evaluation of the Framework (n = 10)

Evaluation Criteria	Mean Score (out of 5)
Clarity of Framework	4.6
Practical Applicability	4.4
Potential Impact on Performance	4.7
Ease of Adoption	4.2

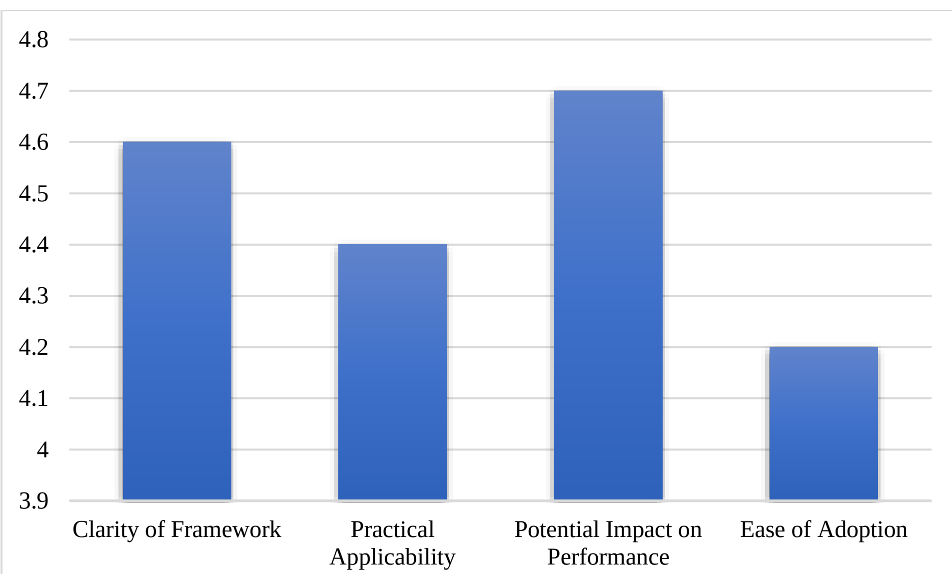

Figure 3: Expert Evaluation of the Framework

Experts gave the proposed Integrated BIM-PMM Maturity Framework very high marks on all categories. The Clarity of Framework had a high average score of 4.6, which means that reviewers thought the framework was well-organized and easy to understand. The Practical Applicability got a score of 4.4, which means that experts think the framework can be realistically used in construction companies. The criterion of Potential Impact on Performance got the highest average score of 4.7, which shows that most people agree that using the framework might greatly improve project outcomes. Lastly, the Ease of Adoption had a little lower, but still good, mean score of 4.2. This shows that there are some worries about how easy it will be to add the framework to current workflows, but overall, people are hopeful that it will work. These results show that experts are sure that the framework would be useful and valuable for enhancing construction project management and BIM integration in China.

3.6. Discussion

The results supported the idea that China's construction performance may be greatly improved by combining the development of BIM skills with the growth of project management skills. The close link between the two dimensions showed how technical tools and administrative skills depend on one other. Companies who used more BIM and PMM routinely finished projects on time and on budget better than other companies. The results were in line with what other global studies had shown, but they also gave special information about the Chinese construction industry, where structured project governance needs to keep up with fast digital change.

Furthermore, the validation exercise demonstrated the framework's real-world relevance and provided actionable insights for policy makers, particularly in mandating BIM and PMM assessments in public sector procurement processes.

4. CONCLUSION

The study found that combining Building Information Modeling (BIM) with Project Management Maturity (PMM) produced a strong framework for making building projects in China work better. The results showed that developing BIM and PMM together greatly improved important project outcomes, such as cost-effectiveness, on-time delivery, and quality assurance. Quantitative results showed that there were strong positive links between maturity levels and performance measurements. Regression analysis backed up these results by showing that they could be used to make predictions. Interviews and case studies that looked at qualitative data showed that the technology's influence was often constrained by the fact that BIM implementation didn't match the organization's level of maturity. The research created a useful tool for construction companies who want to strategically improve both their management processes and their technology capabilities by testing the suggested Integrated BIM-PMM Maturity Framework with experts and in real life. In the end, the study showed that those who work in construction in China need to focus on both digital innovation and process optimization in order to fulfill the expanding needs of complex infrastructure projects.

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