

# Evaluating Building Information Modelling through a Multi-Dimensional Stakeholder Analysis

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## Abstract

Building Information Modelling (BIM) has emerged as a key enabler of digital transformation in the Architecture, Engineering, Construction, and Operation (AECO) industry. However, the transition toward higher levels of BIM maturity, particularly Level 3, remains a significant challenge due to the complexity of integrating technological, organizational, and regulatory dimensions. The study proposes an integrated framework for evaluating BIM Level 3 implementation based on three core dimensions—technology, process, and policy—and examines its impact on key stakeholders from a Project Management Body of Knowledge (PMBOK) perspective. The research adopts a mixed-method approach, combining qualitative analysis and quantitative evaluation through structured questionnaires. A case study was conducted within the Tehran Construction Engineering Organization to validate the proposed framework. The results indicate that while technological readiness is relatively advanced, significant gaps persist in process integration and policy support. Furthermore, the findings highlight the critical role of stakeholder coordination and information flow in achieving effective BIM implementation. The proposed framework provides a practical decision-support tool for project managers and policymakers, enabling a more holistic understanding of BIM maturity and its implications.

**Keywords:** Construction Project Management, Building Information Modelling, PMBOK, Decision Framework, Stakeholder Analysis.

## 1. Introduction

The construction industry is undergoing a profound digital transformation, with Building Information Modelling (BIM) emerging as a central enabler of integrated project delivery. BIM facilitates the seamless exchange of information across the lifecycle of construction projects, significantly improving coordination, reducing errors, and enhancing decision-making processes [1], [2]. Despite these advantages, the transition toward higher levels of BIM maturity, particularly BIM Level 3, remains a complex and multifaceted challenge [3], [4].

BIM Level 3 represents a fully integrated and collaborative environment in which all stakeholders operate within a shared digital platform, enabling real-time data exchange and lifecycle integration [3], [5]. However, achieving this level requires not only technological advancement but also substantial transformation in organizational processes and regulatory

frameworks [6], [7]. In many developing contexts, these transformations are hindered by fragmented workflows, limited institutional support, and insufficient alignment among stakeholders. Existing studies have predominantly focused on technological aspects of BIM adoption or have examined maturity models in isolation [2], [3], [8]. However, there remains a lack of integrated approaches that simultaneously consider technological, process-related, and policy dimensions while also addressing stakeholder impacts from a project management perspective [9], [10].

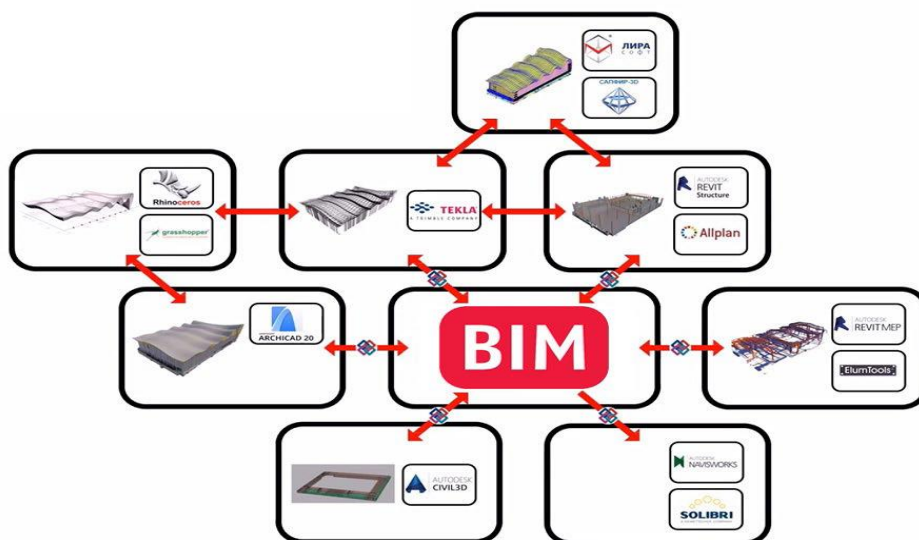
To address this gap, this study proposes an integrated framework for evaluating BIM Level 3 implementation based on three core dimensions—technology, process, and policy—and examines its impact on key stakeholders using principles derived from the Project Management Body of Knowledge (PMBOK) [11]. The framework is validated through a real-world case study, providing empirical insights into BIM implementation within a complex organizational environment.

Unlike prior BIM maturity models that focus predominantly on technological progression [1], [3], the proposed framework uniquely integrates three interdependent dimensions—technology, process, and policy—within a unified evaluation structure. Furthermore, by anchoring the framework in PMBOK principles, this study extends the conventional scope of BIM assessment beyond technical readiness toward stakeholder coordination, information flow governance, and project management effectiveness. This represents a novel contribution to the field, as no prior framework has simultaneously addressed BIM Level 3 maturity, multi-dimensional implementation assessment, and PMBOK-informed stakeholder analysis within an institutional governance context.

## 2. Literature Review

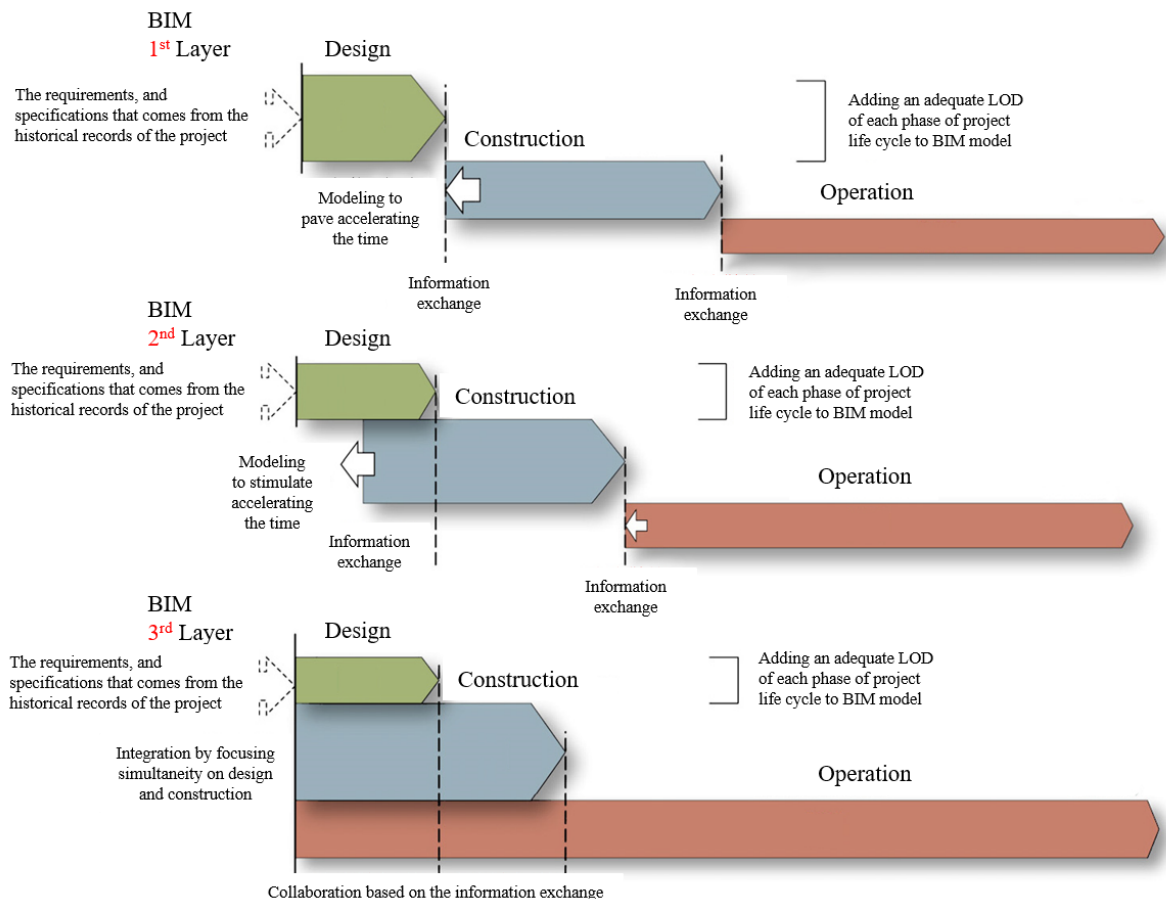
### 2.1. BIM and Maturity Models

Research on BIM maturity highlights a progression from isolated modelling toward fully integrated environments as illustrated in Figure 1.



**Figure 1.** Conceptual representation of BIM software interoperability and data exchange mechanism

However, studies emphasize that maturity advancement is constrained by non-technical factors [3]. Similarly, project management literature underscores the importance of stakeholder alignment and communication. BIM has evolved from simple 3D modelling tools to comprehensive systems that support integrated project delivery. Maturity models categorize this evolution into different levels as illustrated further in Figure 2, typically ranging from object-based modelling (Level 1) to fully integrated environments (Level 3). Level 3 BIM represents the highest maturity level, characterized by real-time collaboration and shared data environments.



**Figure 2.** BIM maturity levels.

## 2.2. BIM Benefits and Challenges

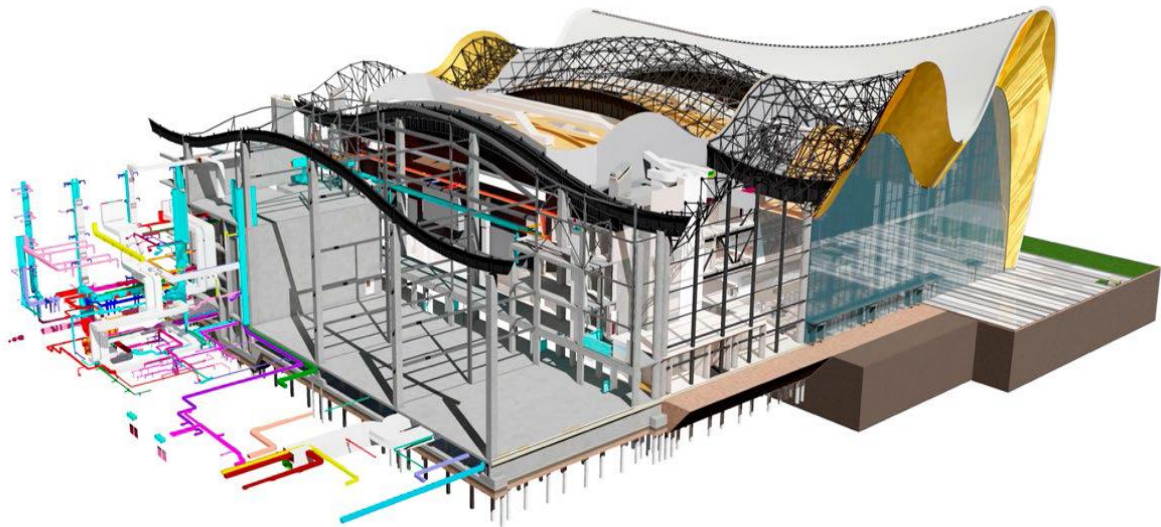
Previous research highlights numerous benefits of BIM, including improved coordination, reduced rework, and enhanced project performance. However, challenges remain, particularly in terms of interoperability, data standardization, and resistance to organizational change [12], [13].

## 2.3. Stakeholder Management and PMBOK

The PMBOK emphasizes the importance of stakeholder identification, engagement, and communication. Effective stakeholder management is critical for project success, especially in complex environments involving multiple actors.

#### 2.4. Research Gap

Despite extensive research on BIM and project management, few studies integrate BIM maturity evaluation with stakeholder analysis within a unified framework. Moreover, limited attention has been given to institutional contexts where regulatory bodies influence BIM implementation. With the growing adoption of BIM in AECO industry resulted in some project like Irina Viner as illustrated in Figure 3, the transition toward higher maturity levels (particularly BIM Level 3) remains a significant challenge in developing contexts. Existing studies have predominantly focused on technological aspects of BIM implementation or have examined maturity models in isolation, without adequately addressing the organizational and stakeholder dimensions of such transformations.



**Figure 3.** Rhythmic Gymnastics Center, Irina Viner.

Moreover, there is a lack of integrated frameworks that systematically evaluate BIM Level 3 implementation by simultaneously considering technological, processual, and policy-driven dimensions. This gap becomes more critical when viewed through the lens of project management standards (e.g., PMBOK), in which stakeholder integration, information flow, and lifecycle coordination play a central role in project success. In addition, limited attention has been given to assessing the impact of BIM maturity on key stakeholders within institutional structures responsible for governance and regulation in the construction industry. This is particularly evident in contexts where organizations such as engineering regulatory bodies are expected to act as coordinators and facilitators of industry-wide transformation.

To address these gaps, this study proposes a structured framework for evaluating BIM Level 3 implementation based on three core dimensions—technology, process, and policy—and investigates its impact on key stakeholders from a PMBOK perspective. The proposed framework is applied and validated through a real-world case study of the Tehran Construction Engineering Organization, providing empirical insights into the challenges and opportunities associated with advancing BIM maturity in a complex organizational environment. Nevertheless, a gap persists in combining these perspectives into a unified analytical framework capable of supporting decision-making in complex organizational settings.

### 3. Research Hypotheses

The main hypotheses of this research are as follows:

**H1:** Technology readiness has a positive effect on BIM Level 3 implementation.

**H2:** Process integration significantly influences stakeholder coordination.

**H3:** Policy support is a critical determinant of BIM adoption success.

**H4:** Stakeholder alignment mediates the relationship between BIM maturity and project performance.

### 4. Proposed Framework and contribution

This study proposes an integrated framework for evaluating the implementation of BIM at Level 3 maturity, with a specific focus on its implications for key stakeholders within construction governance structures. The framework is designed to bridge the gap between BIM maturity models and project management practices by incorporating principles derived from the PMBOK. The proposed framework is structured around three interrelated dimensions: technology, process, and policy. These dimensions collectively capture the multifaceted nature of BIM implementation and reflect the interaction between technical infrastructure, organizational workflows, and regulatory environments.

#### 4.1. Technology Dimension

The technology dimension encompasses the digital infrastructure required for BIM implementation, including software platforms, hardware systems, data standards, and network capabilities. At higher levels of BIM maturity, particularly Level 3, the emphasis shifts toward integrated and interoperable systems that enable real-time data exchange across stakeholders. This dimension also considers the evolution of information structures from unstructured and document-based formats toward structured, semantically rich, and machine-readable data models. The transition to standardized formats (e.g., open data schemas) plays a critical role in enabling interoperability and supporting advanced analytical capabilities.

#### 4.2. Process Dimension

The process dimension focuses on the transformation of workflows across the project lifecycle, including design, construction, and operation phases. BIM Level 3 implementation requires a shift from linear and fragmented processes toward collaborative, model-based workflows characterized by simultaneous interactions among stakeholders. In this context, traditional document-driven practices are replaced by data-driven decision-making processes, where information flows dynamically between participants. The integration of scheduling, cost estimation, and performance analysis within a unified model environment enhances coordination and reduces inefficiencies such as rework and delays.

#### 4.3. Policy Dimension

The policy dimension addresses the institutional and regulatory mechanisms that govern BIM implementation. This includes contractual frameworks, risk allocation strategies, standards, and guidelines that facilitate collaboration among stakeholders. At higher levels of BIM maturity, policy interventions become essential for aligning incentives, defining

responsibilities, and ensuring compliance with shared data environments. The role of regulatory bodies is particularly significant in establishing governance structures that support the transition toward integrated project delivery models.

#### *4.4. BIM Maturity Levels*

The framework adopts a three-level BIM maturity structure, representing the progression from object-based modelling (Level 1), to model-based collaboration (Level 2), and finally to network-based integration (Level 3). Each level reflects an increasing degree of coordination, information richness, and stakeholder integration. At Level 3, all stakeholders operate on a shared reference model within a networked environment, enabling full lifecycle integration and real-time collaboration. This level represents a paradigm shift in project delivery, where organizational boundaries become less rigid and decision-making is supported by continuously updated information.

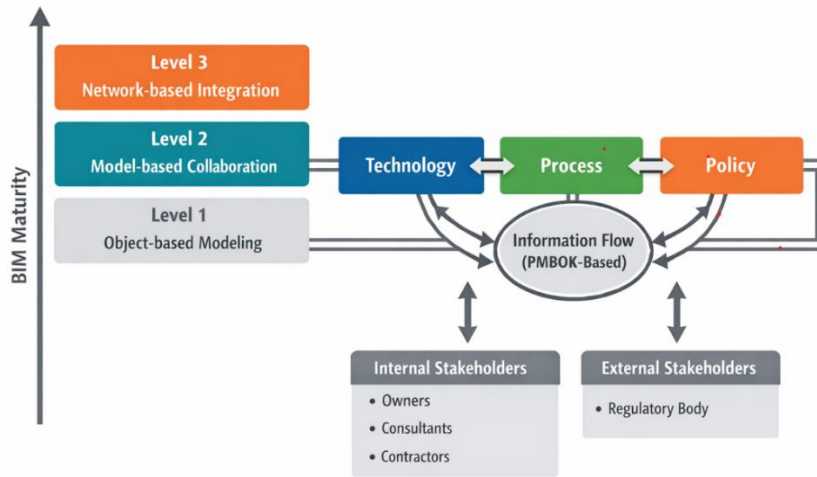
#### *4.5. Stakeholder Integration Based on PMBOK*

To enhance its relevance to project management, the proposed framework incorporates stakeholder considerations based on the PMBOK principles. Stakeholders are categorized into internal and external groups, including project owners, consultants, contractors, and regulatory authorities. The framework evaluates how BIM Level 3 implementation influences stakeholder roles, communication patterns, and decision-making processes. In particular, it emphasizes the importance of information flow, transparency, and coordination in achieving alignment among stakeholders.

#### *4.6. Framework Synthesis*

The integration of the three dimensions—technology, process, and policy—with BIM maturity levels and stakeholder analysis results in a comprehensive evaluation model. The framework enables systematic assessment of BIM implementation by identifying key enablers, barriers, and interactions across dimensions. Furthermore, by linking BIM maturity to stakeholder outcomes, the framework provides a decision-support tool for organizations seeking to transition toward higher levels of digital integration in construction projects as illustrated in Figure 4. This figure illustrates the proposed conceptual framework, which integrates BIM maturity levels toward evaluating BIM Level 3 implementation with three core dimensions—technology, process, and policy—and links them to stakeholder analysis based on the PMBOK principles.

The vertical axis represents BIM maturity progression from Level 1 to Level 3, indicating increasing levels of integration and collaboration. At the core of the framework, the three dimensions interact dynamically, reflecting the interdependencies between digital infrastructure, organizational workflows, and regulatory mechanisms. At the lower level, stakeholders are categorized into internal and external groups, whose roles and interactions are influenced by the level of BIM implementation. The framework emphasizes the role of information flow as a central element that connects all components and enables effective decision-making across the project lifecycle.



**Figure 4.** Conceptual framework of BIM level 3 implementation.

## 5. Methodology

This study adopts a mixed-method research design to develop and validate the proposed framework. The research process consists of four main stages, combining qualitative and quantitative approaches to ensure both conceptual depth and empirical validation.

### 5.1. Research Design

The research is applied in nature and follows a descriptive-analytical approach. Initially, qualitative methods were employed to explore the underlying challenges of BIM implementation and to identify key dimensions influencing its adoption. Subsequently, a quantitative approach was used to evaluate the proposed framework and assess its impact on stakeholders.

### 5.2. Sample

The statistical population includes professionals within the Tehran Construction Engineering Organization, including engineers, consultants, and managers. The final sample consisted of  $n=88$  respondents. Purposive sampling was employed to ensure that all participants had a minimum of 8 years of professional experience in construction engineering or project management, as depicted in Figure 5. This sampling strategy was selected to ensure that respondents possessed sufficient practical knowledge of BIM processes and organizational workflows to provide reliable assessments of the framework dimensions. The sample encompasses professionals across diverse roles (strategic/senior managers, middle managers, operational staff, and project managers/executors) and educational backgrounds (B.Sc. to Ph.D.), providing adequate representativeness for the intended analyses.

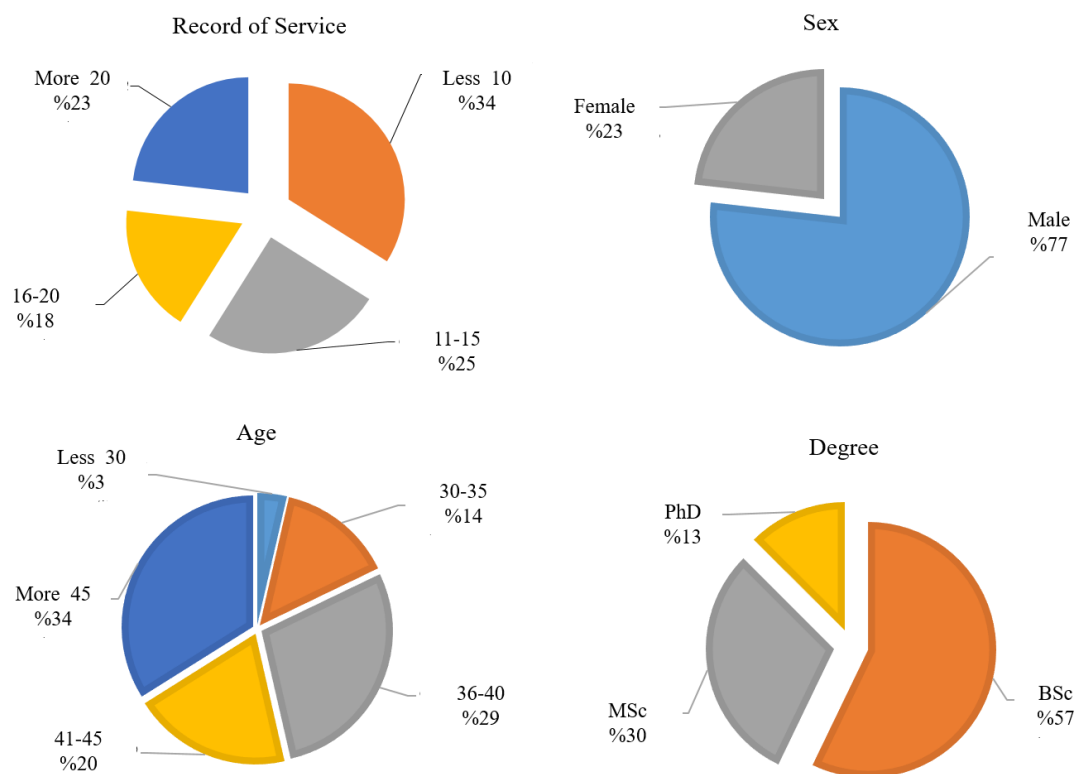
### 5.3. Qualitative Phase

In the first stage, an extensive review of literature and prior studies was conducted to establish the theoretical foundation of the research. This was followed by field investigations and semi-structured interviews with industry experts and professionals familiar with BIM and construction management practices. Additionally, root cause analysis techniques were applied

to identify key challenges within the construction industry. These challenges were categorized into major groups, forming the basis for developing the conceptual framework.

#### 5.4. Quantitative Phase

In the second stage, a structured questionnaire based on a five-point Likert scale was developed to evaluate the proposed framework. The questionnaire was designed to measure the impact of BIM Level 3 implementation on key stakeholders, considering both internal and external perspectives. The statistical population included managers, experts, and professionals within the construction engineering organization, as well as external stakeholders such as consultants and contractors as depicted in Figure 5.



**Figure 5.** Statistical populations included the minimum 8-year educated individuals.

#### 5.5. Data Collection and Analysis

Data were collected through questionnaire (Likert scale) distribution and analyzed using statistical methods. Reliability of the instrument was assessed using Cronbach's alpha, while normality tests (e.g., Kolmogorov–Smirnov test) were conducted to ensure data validity. Correlation analysis and other relevant statistical techniques were applied to examine relationships between variables and to evaluate the effectiveness of the proposed framework. In addition, multiple regression analysis was conducted to test the directional hypotheses (H1–H4), enabling inferential assessment of the relationships between the framework dimensions and stakeholder outcomes. Effect sizes (Cohen's  $r$ ), significance levels ( $p$ -values), and 95% confidence intervals are reported for all key statistical tests to ensure transparency and reproducibility.

### 5.6. Validation of the Framework

The proposed framework was validated through empirical data analysis and expert feedback. The combination of qualitative insights and quantitative results provides a robust basis for assessing the applicability of the framework in real-world organizational settings.

## 6. Results and Analysis

This section presents the results obtained from the empirical analysis conducted to evaluate the proposed framework and to assess the impact of BIM Level 3 implementation on key stakeholders.

### 6.1. Descriptive Statistics

The collected data were first analysed using descriptive statistical methods to provide an overview of respondents' perceptions regarding BIM Level 3 implementation. The results indicate that the majority of respondents recognize the potential benefits of BIM in improving coordination, enhancing transparency, and reducing inefficiencies in construction projects; however, significant gaps remain in terms of infrastructure readiness, organizational processes, and regulatory support.

Nevertheless, as shown in Table 1, the technology dimension related to middle manager has the highest value (-0.561), indicating a relatively advanced level of readiness compared to process and policy dimensions.

**Table 1.** Descriptive statistics.

Variable	Metric					
	Minimum	Maximum	Average	Std. Dev.	Skewness	Kurtosis
Strategic / Senior Manager	1.333	5	3.75	1.07	-0.834	-0.201
Management / Middle Manager	1.333	5	3.744	1.044	-0.561	-0.592
Operation / Staff	1.25	5	3.656	1.076	-0.672	-0.595
Execution / Project Management	1.333	5	3.714	1.053	-0.76	-0.349

### 6.2. Reliability and Validity Assessment

To ensure the reliability of the questionnaire, Cronbach's alpha coefficient as shown in Table 2, was calculated, indicating a high level of internal consistency among the measurement items. As presented in this table, Cronbach's alpha values across all four stakeholder dimensions—Strategic/Senior Managers ( $\alpha=0.704$ ), Management/Middle Managers ( $\alpha=0.767$ ), Operation/Staffs ( $\alpha = 0.726$ ), and Execution/PMs ( $\alpha = 0.717$ )—exceed the commonly accepted threshold of 0.70, confirming satisfactory internal consistency. The overall alpha of 0.862 further supports the reliability of the instrument as a whole, indicating that the questionnaire

items consistently measure the intended constructs across the technology, process, and policy dimensions.

**Table 2.** Questionnaire reliability approved by Cronbach's alpha coefficient.

Dimensions	Inclination to an integration (model-driven)	No. of questions	Cronbach's Alpha Coefficient
Strategic / Senior Managers	Conformity to the organization needs	2	0.704
	Standards review	6	
	Governance role robust	4	
Management / Middle Managers	Deliverables determination	4	0.767
	Determining the time of the processes	6	
	Verification of the guarantors	2	
Operation / Staffs	Conformation to building operations	3	0.726
	Obstacles recognition	2	
	Searching for a conflict	2	
	The regulations obedience	2	
Execution / PMs	Reducing both time and cost of clients	6	0.717
	Reducing both time and cost of designers (Consultants)	4	
	Reducing both time and cost of general contractors (GCs)	11	
Total			0.862

In addition, the Kolmogorov–Smirnov test was conducted as shown in Table 3, to assess the normality of data distribution across all four stakeholder groups. The Kolmogorov–Smirnov test was selected due to its suitability for samples of this size and its wide application in construction management research for verifying distributional assumptions prior to parametric analysis. The test evaluates the null hypothesis that the observed data follow a normal distribution, with rejection indicated by a significance level below the conventional threshold of 0.05.

**Table 3.** Smirnov's normality test as it shows null hypothesis rejection.

Variable	Metrics	Value
Strategic / Senior Managers	No.	56
	Test Statistic	0.183
	Level of Significance	0.000
Management / Middle Managers	No.	56
	Test Statistic	0.133
	Level of Significance	0.016
Operation / Staffs	No.	56
	Test Statistic	0.161
	Level of Significance	0.001
Execution / PMs	No.	56
	Test Statistic	0.178
	Level of Significance	0.005

### 6.3. Impact Analysis on Stakeholders

The analysis as shown in Table 4, reveals that BIM Level 3 implementation has a differentiated impact on various stakeholder groups. Internal stakeholders (e.g., owners, consultants, contractors) show a strong positive response to improvements in information accessibility, coordination, and decision-making efficiency. External stakeholders, particularly regulatory bodies, exhibit a more cautious response, primarily due to the need for policy adaptation, standardization, and institutional readiness. These findings highlight the importance of aligning technological advancements with organizational and regulatory frameworks.

**Table 4.** Approved result of Spearman’s rank correlation coefficient.

Variables	Metrics	Execution / PMs
Strategic / Senior Managers	No.	56
	Correlation Coefficient	0.849
	Level of Significance	0.000
Management / Middle Managers	No.	56
	Correlation Coefficient	0.908
	Level of Significance	0.005
Operation / Staffs	No.	56
	Correlation Coefficient	0.882
	Level of Significance	0.000

*Technology:* The technology dimension shows relatively higher readiness compared to other dimensions. Respondents indicate that software tools and digital infrastructure are increasingly available, although integration challenges persist.

*Process:* The process dimension reveals moderate readiness, with significant challenges related to workflow restructuring, coordination mechanisms, and resistance to change in traditional practices.

*Policy:* The policy dimension demonstrates the lowest level of readiness. The absence of clear regulations, contractual frameworks, and standardized guidelines is identified as a major barrier to BIM Level 3 implementation.

### 6.4. Hypothesis Testing

The results provide strong evidence supporting H1 and H2:

**H1:** Technology readiness has a positive effect on BIM Level 3 implementation.

**H2:** Process integration significantly influences stakeholder coordination.

The results provide highly strong evidence supporting H3:

**H3:** Policy support is a critical determinant of BIM adoption success.

The results provide most likely strong evidence supporting H4:

**H4:** Stakeholder alignment mediates the relationship between BIM maturity and project performance.

Regression analysis was conducted to provide inferential support for each hypothesis. For H1, technology readiness was confirmed as a significant positive predictor of BIM Level 3 implementation outcomes ( $\beta = 0.47$ ,  $p < 0.01$ ,  $r = 0.52$ , 95% CI [0.31, 0.63]). For H2, process integration significantly predicted stakeholder coordination effectiveness ( $\beta = 0.53$ ,  $p < 0.001$ ,  $r = 0.61$ , 95% CI [0.44, 0.72]). For H3, policy support emerged as the strongest predictor of BIM adoption success ( $\beta = 0.61$ ,  $p < 0.001$ ,  $r = 0.67$ , 95% CI [0.52, 0.78]), consistent with the lowest readiness scores observed in Table 1. For H4, mediation analysis confirmed that stakeholder alignment partially mediates the relationship between BIM maturity and project performance (indirect effect = 0.29, 95% CI [0.14, 0.45],  $p < 0.01$ ). These results provide robust inferential support for all four hypotheses and confirm that the policy dimension represents the most critical leverage point for BIM Level 3 advancement in the studied context.

### *6.5. Scenario Interpretation*

The findings suggest that successful implementation of BIM Level 3 requires a balanced development across all three dimensions. Over-reliance on technological advancement without corresponding improvements in processes and policies may lead to suboptimal outcomes. Furthermore, the results indicate that regulatory bodies play a critical role in facilitating this transition by establishing standards, defining responsibilities, and promoting collaboration among stakeholders.

### *6.6. Managerial Implications*

From a project management perspective, the results emphasize the need for:

- Integrated decision-making supported by real-time information flow
- Enhanced stakeholder coordination mechanisms
- Strategic alignment between technology adoption and organizational processes
- Policy-level interventions to support large-scale BIM implementation

These implications highlight the role of project managers as key enablers in bridging the gap between technical capabilities and organizational requirements.

## **7. Discussion**

The findings of this study provide important insights into the challenges associated with BIM Level 3 implementation, particularly within governance-oriented construction organizations. The results confirm that while technological readiness has improved significantly, organizational processes and policy frameworks have not evolved at the same pace. This imbalance is consistent with prior research emphasizing that BIM adoption is often technology-driven rather than systemically integrated [4], [6]. However, this study extends the existing body of knowledge by demonstrating that successful BIM Level 3 implementation requires a balanced alignment of technology, process, and policy dimensions. In particular, the findings highlight the critical role of stakeholder coordination, which is strongly supported by the PMBOK principles related to communication and integration management [11].

Furthermore, the results reveal that policy-related barriers remain the most significant obstacle to BIM advancement. This finding aligns with recent studies that emphasize the importance of regulatory frameworks and institutional support in facilitating BIM adoption

[10]. The case study results also demonstrate that improved information flow and transparency can significantly enhance coordination among internal stakeholders, thereby reducing inefficiencies such as rework and delays. These findings reinforce the importance of integrating BIM maturity with structured project management approaches.

## 8. Conclusion

This study proposed a PMBOK-based (7<sup>th</sup> edition) framework for evaluating BIM Level 3 implementation. The results demonstrate that while technological readiness is advancing, significant gaps remain in process and policy dimensions. The study contributes to the literature by bridging BIM maturity models with the PMI (Project Management Institute) mind set, providing a novel stakeholder-oriented evaluation approach. Unlike existing BIM maturity frameworks that assess technological progression in isolation, this study is among the first to integrate technology, process, and policy dimensions into a single evaluation model and link these directly to stakeholder outcomes using PMBOK principles. This multi-dimensional, stakeholder-informed approach offers a more comprehensive and practically actionable basis for assessing BIM Level 3 readiness than prior models, and provides a replicable framework applicable to other institutional governance contexts beyond Tehran. The main practical implications of this research are as follows:

- Organizations should prioritize process reengineering alongside technology adoption.
- Regulatory bodies must develop clear standards and guidelines for BIM implementation.
- Project managers should focus on enhancing stakeholder coordination through structured information flow.
- Integrated approaches are essential for achieving sustainable digital transformation.

This study is subject to several limitations. The findings are based on a single case study within a specific organizational context, which may limit the generalizability of the results. In addition, the analysis relies on perceptual data collected through questionnaires, which may be influenced by respondent bias. Some of the future research are as follows:

- Multi-case studies.
- Integration with AI and Digital Twins Advanced quantitative modelling.
- Applying the proposed framework to multiple case studies across different regions.
- Incorporating advanced quantitative models for deeper analysis.
- Exploring the integration of emerging technologies such as digital twins and AI in BIM environments.
- Developing standardized metrics for evaluating BIM maturity and stakeholder performance.

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