Article

Underlying Factors and Strategies for Organizational BIM Capabilities: The Case of Iran

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Abstract: Building information modeling (BIM) has a significant role in the architecture, engineering, construction, and operation (AECO) industries. Most BIM benefits have not been grasped due to the lack of organizational BIM capabilities (OBIMCs). Accordingly, organizations must develop intuitive strategies to support BIM implementation and to fulfill the promised benefits. This study investigates the impact of different capability factors on OBIMC and the underlying strategies to improve OBIMC in Iran. Particularly, this study builds a structural equation model to explain the links between the capability factors and strategies linked to OBIMC in Iran. A systematic literature review of twenty-six papers and semi-structured interviews with fifteen BIM specialists identified nineteen capability factors and fourteen strategies. A survey of 126 BIM professionals was used to assess the importance of the capability factors and strategies. To analyze the collected data, first, an Exploratory Factor Analysis (EFA) was performed. Then, Partial Least-Squares Structural Equation Modeling (PLS-SEM) was employed. The EFA generated two constructs for the capability factors: OBIMC and organizational capabilities (OCA). Furthermore, it categorized the strategies into two constructs: BIM capability requirement (BIMCR) and organizational culture (OCU). The structural equation model demonstrates that BIMCR and OCU enhance OCA and OBIMC. These two elements are also positively impacted by BIMCR. Industry professionals and policymakers can use these findings to develop strategic plans and to prioritize efforts. The significant contribution of this study is to illuminate the interrelationship between capability factors and strategies related to OBIMC in Iran.

Keywords: building information modeling (BIM); organizational BIM; BIM capabilities; automation; building technology; construction management

1. Introduction

Due to the complicated nature of construction projects, decision-makers in the architecture, engineering, construction, and operation (AECO) industries are encouraged to adopt building information modeling (BIM). BIM is a digital version of a facility's physical and functional characteristics that enables architects, engineers, and other construction professionals to plan, design, and construct a structure or building [1]. BIM has played an essential role in improving the design of the demolition phases of construction projects [2]. Significant capabilities of BIM can ease the decision-making process and can improve the productivity between all involved components in construction projects, ultimately improving the efficiency of the whole construction supply chain [2]. In the United States,

BIM has been embraced by over 98 percent of large architecture organizations [3]. In comparison, over 30 percent of smaller organizations use BIM for some modeling and documentation [3]. The design sector as a whole has adopted BIM at a rate of about 80% [3]. Similar tendencies may be seen in industrialized countries such as the United Kingdom [4]. However, despite its popularity, several economies have been slow to implement BIM due to many problems [5].

Despite BIM's promising capabilities, this rise in utilizing BIM in construction projects encompasses a broad spectrum of usage. According to a recent survey, most BIM uses are limited to visualization or idea development models, and only a few professionals take advantage of fully integrated and incompatible BIM systems [6]. Furthermore, in many developing countries, BIM is mainly employed for low-maturity tasks such as visualization and clash detection [7,8]. As a result, many efforts have been made in recent years to investigate the obstacles to achieving the required organizational BIM capabilities (OBIMC) [4,9]. According to prior works, in the various AECO environments, attitudes and technological barriers, as well as management strategies and environmental constraints, differ from one another [4]. As a result, there appears to be no clear path to BIM adoption, and integrating BIM with various contexts is a continuous endeavor [10].

The current study aims to investigate (1) key capability factors affecting OBIMC; (2) key strategies to enhance OBIMC; and (3) the relationships between these capability factors and strategies in Iran. Although Rajabi et al. [11] compared the capability factors affecting the implementation of OBIMC between Iran and Malaysia, no other work in Iran has investigated underly strategies for increasing OBIMC in Iran. To accomplish this, nineteen capability factors and strategies for OBIMC have been evaluated. These capability factors and strategies have been investigated by Munianday et al. [12] using a systematic literature review of 26 papers and semi-structured interviews with 15 BIM specialists. The capability factors and strategies discussed in this article have been examined in Iran through a survey conducted among 126 BIM professionals. In order to analyze the acquired data, the Kruskal–Wallis test was used, as well as Exploratory Factor Analysis (EFA) and Partial Least-Squares Structural Equation Modeling (PLS-SEM).

The remainder of this article is structured as follows. In Section 2, previous work and background information on the topic is described. The elaboration on the methodology applied in this study, including survey development and data collection, is provided in Section 3. Section 4 introduces EFA and PLS-SEM, and the analysis results and the structural model assessment are presented. Finally, Section 5 discusses the findings, and Section 6 concludes the paper.

2. Literature Review and Context Background

As technology advances, building engineering [13,14] and construction [15–17] challenges are being addressed in a variety of ways, particularly with regard to project management [18–20], scheduling [21,22], and safety concerns [23,24]. Accordingly, emerging technologies such as virtual reality (VR) [25–27], augmented reality (AR) [28,29], wearable sensors [23,30,31], drones [32–36], and BIM [37–42] have recently gained increasing attention from the AECO industry because it improves the efficiency, productivity, and safety of projects throughout their life cycle. In the early 2000s, BIM was introduced in pilot projects to support architects and engineers in designing buildings [43]. As a result, significant work has focused on improving preplanning and design, visualization, quantification, costing, and data management. Moreover, BIM technology has been rapidly developing in recent years, and emerging concepts, such as 4D [44] and 5D [45] BIM modeling, have been introduced as part of the development of BIM. Even though BIM has played a significant role in the AECO industry in recent decades, it has not been fully used due to a lack of OBIMC. As a result, AECO companies need to identify capability factors affecting OBIMC and to develop strategies to support the implementation of BIM. Therefore, in this section, capability factors affecting OBIMC adoption, as well as strategies aimed at improving

OBIMC, are discussed. Furthermore, the position of this study and the research gap to be addressed have been described.

2.1. Capability Factors Influencing OBIMC

One of the major challenges to implementing BIM is the diversity of working conditions in the construction industry, engaging a variety of concerns such as real-time progress, cost management, and construction safety [23,46]. According to Succar et al. [47], the traditional education system has focused on acquiring theoretical knowledge regardless of whether it is a degree-based educational system. A person's attitude toward technology is the key determinant of their risk acceptance level. Consequently, many professionals working in the AECO industry, particularly in developing countries, express concerns about BIM implementation. BIM is often regarded as a "disruptive technology" that challenges traditional construction methods. In the meantime, a person's skill level in BIM is determined by the personal traits, professional knowledge, and technical ability required to facilitate the integration of BIM-related activities in a project or generate BIM-related outputs, regardless of their employment. Individuals might be professionals, tradespeople, scholars, or learners in any field. Additionally, the absence of collaboration between professionals and organizations has resulted in a lack of understanding of the BIM procedure and challenges with compatibility [6]. Most frameworks for BIM adoption have not addressed the human behaviors and organizational factors that influence BIM performance, even though these factors are important [48].

Furthermore, recent work found that staff experience significantly influences BIM implementation success. Moreover, educational qualities and individual skills are essential determinants of BIM adoption [49]. Indeed, previous organizational BIM experience and contractor and consultant proper selection policies were underlined as crucial aspects in the broad application of BIM. Particularly, according to Chen et al. [50], most existing frameworks for assessing capability highly rely on process maturity or the presence of technological infrastructure rather than previously identified indicators. It is worth mentioning that in the pre-qualifying and selection process, prior experience with BIM has been recognized as the most significant qualification.

Due to the sophisticated nature of the BIM process, the deployment of professional technical abilities is needed. Certainly, selecting and applying proper hardware and software and continuous monitoring and technical support require hiring Information technology (IT) professionals. Generally, the variety of BIM software used at the project scale contributes to data interoperability issues. As a result, professional assistance in solving probable technical issues is a requirement to speed up BIM adoption. Consequently, the amount of assistance a professional receives in selecting hardware/software and implementing BIM may be an indicator of the quality of their competence. On the contrary, BIM implementation can be hindered by the lack of human resources [5,8]. Nevertheless, Qin et al. [51] stated that the number of BIM experts and technical employees had an insignificant impact on BIM adoption, significantly influencing company workflow and the human aspect of the implementation.

Leaders knowledgeable about BIM can lead their teams to analyze unverified design data and to verify the shared data within the project team. Additionally, their other role is to create an atmosphere where the impact of probable modification has been minimized. Further, influence and motivation may be valuable in aiding BIM leaders in developing a cooperative work environment and overcoming obstacles to data sharing. A collaborative approach can help overcome negative attitudes toward BIM adoption and motivate subordinates to adopt BIM by demonstrating its benefits [52,53]. Positive attitudes toward new technologies are also crucial to fostering an organizational learning culture and can enhance learner acceptance which is a key component of successful technology adoption [54]. Consequently, the adoption of new and necessary insights about the essential abilities and values of BIM can be facilitated by a positive corporate culture.

Another crucial element for actual BIM adoption is utility acceptance. A recent work by Lee et al. [55] evaluated organizational acceptability by identifying the processes through which organizations agreed to implement, adopt, or encourage other organizations to adopt BIM. Willingness to expend time and effort in learning is the first step in learning BIM and, ultimately, BIM adoption. All organization members must be informed of the BIM applications, even if they do not fully comprehend the technical design processes involved. The information can enable organizations to create meaningful data that can assist them in their project duties. Unfortunately, organizational models, processes, roles, and work content are difficult to change, making BIM adoption more difficult. The inherent difficulties hinder BIM implementation in altering organizational models, processes, and roles in the AECO industry. The BIM process offers limited advantages to current organizational models and workflows, often involving process-related and organizational task adjustments during the integration phase [56].

The commitment of senior management is vital to guarantee the success of BIM adoption [55]. Technology-related challenges are addressed most effectively by high-ranking authorities, introducing changes to job profiles and duties, and resolving conflicts of interest. A senior executive should be educated on the benefits and hazards of any new technology before deploying it. If the corporate policy supports BIM, enabling organizational adoption becomes easier. In this regard, the work by Succar et al. [47] demonstrated the importance of senior management support in promoting BIM adoption through employee training.

Creating, maintaining, and disseminating construction data is described by BIM standards, which are an essential component of BIM implementation. Therefore, developing open and standardized systems for data and information throughout a project's lifecycle is vital. To accomplish so, governments publish documents to ensure the implementation of BIM in public projects is consistent. Although such guidelines are commonly used in public projects, private organizations can create standards incorporated into most industry organizations. These steps include planning for BIM implementation, establishing information exchange-capable systems; creating modeling standards, guidelines, and effective practices; and promoting, communicating, and explaining BIM advantages to other parties [57].

As another important factor, financial support for setup costs has been highly considered for BIM implementation, specifically in small and medium-sized enterprises (SMEs). Senior management must be ready to support the sustained development of BIM financially. BIM projects often involve several offices and locations with teams operating centralized sites and practicing their duties [6]. Moreover, due to technological challenges related to BIM-authoring software, BIM leaders need to develop and maintain strategic partnerships with their BIM-authoring software suppliers, consultants, contractors, and the external BIM community. In order to ensure the successful implementation of change, a strategic policy is required. It can be achieved by gradually engaging members in change activities, such as decision-making and planning, over time. Furthermore, stakeholders need an appropriate plan to use their accumulated information and lessons. Change management is essential when accepting, authorizing, and verifying BIM-based information [53]. Overall, the ability to successfully employ BIM is correlated with an organization's investment in BIM research and development [58].

BIM comprises three distinct elements: software, hardware, and data/networks. Through a BIM tool (BIM Stage 1 requirement), you can transfer from drawing-based workflows to object-based workflows, which are organized around resources, processes/workflows, products, and leadership. The model-based collaboration includes working together and sharing database information (BIM Stage 2) [59]. BIM capabilities within organizations may be affected greatly by this. Organizations can assess their performance through self-assessment, using suggested standards for internal benchmarking, and assessing their suitability for tendering for projects based on the weighting of qualifying conditions [58,60,61]. In this way, organizations can observe their BIM capabilities and areas that need enhancement. One major barrier to BIM adoption is implementation costs. Identifying what areas of BIM

capability building to focus on is crucial in optimizing adoption [62]. Organizations can enhance their BIM capabilities by benchmarking and focusing on specific BIM targets.

Finally, BIM capability evaluation is vitally important when considering the contribution of BIM to previous successful projects. BIM performance and capabilities are a key part of BIM Execution Plans (BEPs). As a result, different BIM capability elements within an organization can be evaluated according to their influence on the different factors involved in successful BIM delivery. To ensure the success of a project, it is necessary to recognize the importance of prioritizing the standard process of assessing BIM capability based on its contribution to project success through standards, such as the Publicly Available Specifications (PAS) established by the UK government [61].

2.2. Strategies for Improving OBIMC

2.2.1. Standardization

As part of its ongoing effort to foster the development of integrated teams, the AECO firm has formed a broad range of technological procedures, including interoperable programs and means for sharing information. In order to achieve greater success during the implementation of BIM, project teams should communicate effectively and building components should be standardized [63]. Standardizing BIM guidelines and processes are important to guarantee successful and effective implementation [64]. Furthermore, the advancement of BIM-related technical procedures and standards can facilitate a successful cooperative environment. Consequently, the organization's senior management should implement a clear operational strategy for improving BIM capabilities.

2.2.2. Policy

Among factors affecting BIM adoption, BIM policy plays a crucial role. The AECO industry still relies on traditional working techniques, as evidenced by an evaluation of current procedures and survey results. Therefore, a BIM implementation policy must be formed at macro- and micro-adoption levels to guarantee successful implementation [63]. This requires the introduction of BIM into the contractual environment gradually. BIM can also be applied to construction projects by adopting policies that lead to clearer visions regarding project delivery methods, the excellence of processes, and the consistency of information across AECO organizations [65]. One perspective suggests that policy is a fundamental element of BIM operations [58]. Based on this perspective, organizations must establish internal BIM policies to enhance their BIM capabilities.

2.2.3. Training and Education

Different ethnic and cultural backgrounds of industry stakeholders greatly affect their experiences with BIM. Therefore, AECO organizations should implement BIM learning curves tailored to each stakeholder. In addition, comprehensive and well-developed education and training programs help employees upskill and increase their knowledge of BIM technologies and concepts [64]. Major education and training groups include individual characteristics, training intervention design and delivery, and workplace context factors [66]. Furthermore, the evaluation should also be based on the trainee's learning outcomes, behavioral reactions, expectations of what the training programs expect to accomplish, and the extent to which work performance increases due to new knowledge and skills [67]. A comprehensive training and education program is essential to meeting end-user demands and ensuring continuous developments in products and services [68]. Moreover, BIM is a relatively new technology, which can cause varying degrees of expertise among industry participants, directing to results of varying quality. To increase BIM performance, vendors and organizations must collaborate on making learning and training easier [69]. Additionally, training programs can be tailored to meet different preferences, including global and standard requirements and specific and advanced requirements [70].

2.2.4. Motivation

Adriaanse et al. [71] noted the value of personal and external motivation to embrace new information and communication technology, such as BIM, in the AECO environment. Individual motivation is defined as the level of curiosity and willingness to employ new technologies. In construction, motivation comes from the perceived upsides and downsides of different technology applications in meeting a short deadline and working in a short-term relationship [72]. External motivators include contractual agreements for BIM and the presence of stakeholders seeking the technology [71]. These demonstrate the influence of competitors, collaborators, and other stakeholders within the AECO industry. Establishing a learning-friendly environment is also important for BIM adoption to succeed. A learning-oriented organization builds a culture of experimentation and risk-taking within the organization so everyone can grow, develop, and learn from it [73]. The processes of deconstruction (new methods of accomplishing a task) and reconstruction (correcting a mistake) that are involved during BIM organizational transformation are reflective [74]. Through a learning-by-doing approach, employees can easily realize BIM implementation proficiencies [56].

2.2.5. Cultural Readiness

Previous explanations mentioned that some might oppose the introduction of BIM. As a solution, communicating effectively allows people to be engaged in the employment of BIM while instantaneously becoming familiar with organizational procedures, expectations, and goals. In order to avoid resentment among employees, organizations with robust change management programs are more likely to adopt new strategies [66]. Organizational cultures (OCU) that are open to innovation and adhere to consistent values and objectives are most likely to successfully adopt new initiatives [56]. Potential clients must adopt a positive mindset before implementing BIM. This demonstrates that controlling the organization's readiness for change is key to successful implementation [75]. It is also imperative that the management includes users as early as possible. BIM users should be consulted to gather their requirements, remarks, responses, and approvals [56]. To drive consensus throughout the implementation process, leaders need to recognize and investigate the causes of objections to BIM tools and systems [55]. In addition, change agents play a key role in advancing skills and abilities that contribute to changing behavior, attitudes, and behaviors [47].

2.2.6. Network Relationships

Organizations driving the implementation process of IT systems, systems integration, and software must collaborate with consultants, supply chain partners, vendors, and internal stakeholders to resolve implementation problems [56]. In most AECO organizations, particularly SMEs, in-house capability or sources are insufficient to implement BIM. That is why external consultants and software suppliers are crucial. Sometimes software suppliers perform the role of consultants. Establishing long-term relationships with suppliers and external partners is imperative during BIM implementation. The ability to foster a network of organizations with a wealth of BIM knowledge offers the opportunity to achieve knowledge in BIM applications [2].

2.2.7. Management of Processes and Performance

The BIM maturity model can assist businesses in understanding the BIM implementation processes. In addition to determining the maturity level of an organization, these tools can serve many other purposes, such as assessing readiness and capability and establishing internal benchmarking. Regardless of their breadth of application, maturity models and tools that clearly described phases can provide a roadmap for organizations to ascend to higher maturity levels. Generally, there are three main types of maturity evaluations: project-oriented, such as the virtual design and construction scorecard; organizational-oriented, such as the BIM maturity measurement [59]; and macro-level maturity models [76]. Considering this variety, objectives should be determined prior to selecting BIM tools. In addition to preparing a maturity model and examining BIM-enabled processes and compo-

nents, data collection methods and tools should be used to monitor BIM implementation. Managers and leaders of BIM can then use the information collected from performance evaluations to verify that the BIM practices comply with the defined policies and plans.

Comparing BIM performance across organizations can be accomplished with external benchmarking tools and data [77]. This provides the information that organizations need to execute long-term improvement plans. However, adopting BIM successfully relies heavily on ingrained, tacit knowledge, which makes duplicate tasks more challenging. Knowledge can be effectively transferred across organizations via the transmission of individuals between organizations, the creation of industry networks, or the replication of practices by regular and systematic observation [78]. AECO organizations should carefully review their circumstances to determine the best methods to apply to their business operations. There is no single, universal way to implement BIM [2].

2.3. Study Positioning and Research Gap

Based on recent work, it is crucial to identify, understand, and evaluate OBIMC to enhance BIM adoption. Different organizations react to BIM capabilities and strategies differently, which is why AECO firms must navigate the influencing capability factors of BIM capabilities. According to the best knowledge of the authors, there is no work conducted to investigate the impact of different capability factors and strategies on an organization's BIM performance in Iran. More particularly, this study attempts to fill the research gap by recognizing the underlying capability factors and strategies that affect OBIMC in the AECO industry in Iran.

3. Research Methodology

3.1. Survey Development

In this study, data were collected through a questionnaire survey. Questionnaire surveys have often been used in research to obtain opinions from experts in the construction management area. To develop the questionnaire survey, a systematic literature review (SLR) was conducted to review the existing literature. The objective of the SLR is to identify a list of capability factors and strategies for OBIMC from prior works. The SLR method is divided into two steps. In the first step, the database of Scopus was searched using the 'title/abstract/keyword'. The terms used were 'building information modelling' OR 'building information modeling' AND 'capability' OR 'capabilities'. Based on the search terms, 205 articles were retrieved. Afterward, titles, keywords, and abstracts of the 205 articles were examined, and unrelated articles were removed. Finally, 26 articles were chosen for further investigation.

To obtain any additional strategies or capability factors missing from the existing body of knowledge, semi-structured interviews with fifteen BIM professionals were performed. To validate the output of the interview, a thorough synopsis of the interview's results was sent to the participants after each session. Based on the data from SLR and interviews, a survey was developed. Capability factors and strategies with similar meanings were merged. Finally, a list of nineteen capability factors and fourteen strategies was established. Table 1 presents strategies for improving OBIMC. On the contrary, Table 2 shows the capability factors affecting OBIMC derived from the SLR and interviews. Three professors in the construction management field participate in the pilot test. The pilot test was conducted to eliminate vague questions and phrases and to ensure the proper use of technical language.

The questionnaire survey was divided into two sections. The first section of the survey includes questions related to the respondent and organization backgrounds. This section is crucial to evaluate the reliability of the respondents. The second section consists of the capability factors and enhancement strategies. Respondents were required to rate the criticality of the strategies on a five-point Likert scale with 1 being not critical, 2 being less critical, 3 being neutral, 4 being critical, and 5 being extremely critical. The third section consists of a list of capability factors affecting the OBIMC. Respondents were required to rank the criticality of the capability factors on a five-point Likert scale with 1 being not

critical, 2 being less critical, 3 being neutral, 4 being critical, and 5 being extremely critical. Researchers have used the five-point Likert scale in the construction management field because of its ability to give clear results [79]. Finally, at the end of the questionnaire survey, spaces are given to respondents to add and rank the criticality of any additional strategies and capability factors on a five-point Likert scale.

Table 1. List of strategies for enhancing OBIMC.

Code	Strategies for Improving Organizational BIM Capabilities	References
SBIM1	Change staff attitude toward new technology	[47,80]
SBIM2	Encourage creativity among staff	[81]
SBIM3	Motivate staff to help each other	[81]
SBIM4	Provide the necessary BIM training	[80–84]
SBIM5	Have internal BIM policies	[57,85]
SBIM6	Hire competent supervisors to provide guidance	[2,53]
SBIM7	Ensure the database is sufficient for BIM-based projects	[2,47,76,86]
SBIM8	Create a partnership with BIM expert companies	[57]
SBIM9	Establish strategies to cater to client's demand for BIM	[57,82]
SBIM10	Hire BIM experts into the company	[2,53]
SBIM11	Ensure good company history	[80]
SBIM12	Provide rewards and recognition to staff	[81]
SBIM13	Have top management provide clear company direction	[57,80,81,87]
SBIM14	Prepare staff for the demanding BIM-based construction projects	[47,83]

Table 2. List of capability factors affecting OBIMC.

Code	Capability Factors Affecting Organizational BIM Capabilities	References
CBIM1	Staff have enough BIM experience	Interview, [47,49,61,88]
CBIM2	Staff have adequate academic qualifications	[47,49,88]
CBIM3	Company has sufficient BIM experience	[47,49,61,88,89]
CBIM4	Company has a standard process for evaluating BIM capability	Interview, [49,61,88,90]
CBIM5	Company has sufficient resources to implement BIM demand	[47,49,59,61,88,89]
CBIM6	Company has the necessary infrastructure (software and hardware) to implement BIM	Interview, [49,59,85,88]
CBIM7	Company has a good history of implementing BIM	[49,61,88]
CBIM8	Staff can design specific models using BIM	[49,61,88]
CBIM9	Company has specific roles for staff	[90]
CBIM10	Company and staff have the same goals	[47]
CBIM11	Company can provide a good cost structure	[6,49,88]
CBIM12	Company has a standard performance benchmarked	[47,59,61]
CBIM13	Staff receive guidance and supervision from BIM experts	Interview, [47,53,59]
CBIM14	Company has a good attitude toward new technology	[5,80]
CBIM15	Company can provide an example with rich BIM data	[90]
CBIM16	Company can provide the best products and services	[59]
CBIM17	Company has official standard contracts and agreements for BIM	[57,59]
CBIM18	Company has a Research and Development (R&D) department/team for BIM	[47]
CBIM19	Company understands its expertise	[47,90]

3.2. Data Collection

In this study, the target population includes all BIM professionals. In this study, BIM professionals mean individuals with knowledge and experience using BIM. Due to the lack of a sampling frame, the sampling method used was a non-probability sampling method [91]. Non-probability sampling can be used to create a representative sample [92]. It is appropriate when a random sampling method cannot be used; hence, survey respondents might be selected based on their desire to participate [93]. Thus, a snowball sampling method was employed in this study because it allows for data collection and distribution through referrals or social networks [94]. It has also been used in earlier construction management work [11,16].

In order to determine the first respondent, BIM professionals who have been participating in the construction industry were approached. Then, the link to the questionnaire survey was shared with them. Afterward, they were requested to share information about other industry professionals that they deemed relevant for this study based on industrial or academic experience. Two follow-up emails were sent to the target populations two weeks after the first contact to increase the number of respondents. Finally, a total of 126 valid responses were obtained.

Table 3 illustrates the demographic background of the respondents in terms of their experience in the construction industry and BIM. Most of the respondents have two or more years of experience in the construction industry. Among all the respondents, 60 respondents have 2–5 years of experience, 25 respondents have 6–9 years of experience, and 15 respondents have more than ten years of experience, respectively. This shows that the respondents for the questionnaire survey have great experience in the construction industry. In terms of experience with BIM, 62.7% of the respondents have used BIM in 1 to 5 projects, 16.7% of the respondents have used BIM technology in 6 to 10 projects, and 20.6 % have used BIM in more than 10 projects. As BIM is a relatively recent technology in the construction industry, the respondent's background satisfies this survey.

Table 3. Respondent's profile.

Characteristics	Categories	Frequency	Percentage (%)
Years of experience in the construction industry	Less than 2 years	26	20.6
	2–5 years	60	47.6
	6–9 years	25	19.8
	10 years and above	15	11.9
Type of organization	Clients	13	10.3
	Contractors	29	23.0
	Consultants	63	50.0
	Others	21	16.7
Types of projects that used BIM	Infrastructure construction	11	8.7
	Building construction (residential)	42	33.3
	Building construction (non-residential)	52	41.3
	Industrial construction	17	13.5
	Others	4	3.2
Number of BIM projects involved	1 to 5 projects	79	62.7
	6 to 10 projects	21	16.7
	More than 10 projects	26	20.6

4. Analysis and Results

4.1. Exploratory Factor Analysis (EFA)

There exist two forms of factor analysis: EFA and confirmatory factor analysis. EFA seeks to regroup and reduce many interrelated variables into a group of constructs [95]. Contradictory, confirmatory factor analysis verifies if a certain group of constructs is influencing variables in a predicted way. This study used the EFA to discover the multiple dimensions of capability factors affecting OBIMC and strategies for improving OBIMC.

Regarding the sample size for EFA, the ratio of a sample size to the number of variables method was used. As recommended by [96], the minimum ratio value should be 5.00. In this study, the ratio value is 126/14 = 9.00 for the strategies data and 126/19 = 6.63 for the capability factors data. Therefore, using the mentioned method, the sample size for this study is considered adequate for conducting EFA. Then, to ensure that the data are suitable for EFA, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were conducted. Accordingly, the strategy data have a KMO value of 0.899, which was greater than the threshold value of 0.80 [97]. For capability factors, the KMO value was 0.927. Based on KMO values for both data, the data were considered suitable for EFA. Furthermore, the result of the Bartlett's test of sphericity revealed a significance value of less than 0.001, indicating that the correlation matrix is significant at $p < 0.05$ and, thus, is not an identity matrix. Therefore, the data are suitable for the EFA method.

The factor extraction method used was Principal Axis Factoring (PAF) because it yields more stable loadings than other extraction methods [98]. PAF has been used in other construction management works [99,100]. The factor loading threshold value for identifying a construct is 0.50 [101]. After conducting EFA on strategies data, ten strategies were finally included in the analysis. From ten strategies, two constructs are extracted. The two constructs demonstrate approximately 64.329% of the total variance, which is greater than 60%, indicating adequate construct validity [102]. In addition, fourteen capability factors were finally considered in the analysis, from which two constructs were extracted. The two constructs explain approximately 66.248% of the total variance. Finally, Cronbach's alpha reliability test was conducted to ensure that strategies and capability factors were appropriately grouped. Accordingly, all constructs have Cronbach's alpha value greater than the required minimum of 0.70 [103]. Tables 4 and 5 illustrate the EFA results and Cronbach's alpha values.

Table 4. Results of FA on strategies for improving OBIMC.

Constructs	Code	Factor Loadings	Variance Explained (%)	Cronbach's Alpha
BIM Capability Requirement (BIMCR)	SBIM5	0.637	52.481	0.886
	SBIM6	0.590		
	SBIM7	0.648		
	SBIM8	0.663		
	SBIM9	0.765		
	SBIM10	0.716		
	SBIM14	0.560		
OCU	SBIM2	0.721	11.848	0.791
	SBIM1	0.650		
	SBIM3	0.742		

Table 5. Results of FA on capability factors affecting OBIMC.

Constructs	Code	Factor Loadings	Variance Explained (%)	Cronbach's Alpha
OBIMC	CBIM4	0.834	58.057	0.935
	CBIM9	0.823		
	CBIM8	0.712		
	CBIM17	0.711		
	CBIM13	0.695		
	CBIM5	0.689		
	CBIM18	0.657		
	CBIM15	0.532		
OC	CBIM16	0.751	8.192	0.870
	CBIM11	0.677		
	CBIM12	0.633		
	CBIM14	0.600		
	CBIM19	0.585		
	CBIM10	0.552		

4.2. Hypotheses for Structural Models

Then, the following hypotheses are developed to determine relationships between the capability factors and strategies. These hypotheses were proposed based on the EFA method conducted in the last section.

H1. *BIMCR positively affectsOBIMC.*

H2. *BIMCR positively affectsorganizational capabilities (OCA).*

H3. *OCU positively affects OBIMC.*

H4. *OCU positively affects OCA.*

4.3. PLS-SEM Analysis

Next, Structural Equation Modeling (SEM) was used to test the proposed hypotheses. Covariance-based SEM (CB–SEM) and partial least squares SEM (PLS-SEM) are the two forms of SEM. PLS-SEM was chosen over CB-SEM because it is better able to handle non-normal datasets and small sample sizes [104]. It is also best used for exploratory research with theoretical models that are not well-developed [105]. PLS-SEM produces two sets of models: a measurement model and a structural model. First, the validity of the measurement model is assessed using composite reliability, loadings of indicators, and Average Variance Extracted (AVE). To assess the internal consistency reliability of the measurement model, the value of composite reliability should be more than 0.70 [106]. Indicator loadings are used to assess indicator reliability, which should be greater than 0.70 [106]. Then, the convergent validity is assessed using the value of AVE, which should be greater than 0.5 [106]. After that, discriminant validity is assessed using indicators cross-loadings. Finally, the validity of the structural model is evaluated utilizing the importance and relevance of the structural model relationships.

4.4. Measurement Model Assessment

Table 6 and Figure 1 illustrate the results of the assessment. Loadings of all indicators and AVE values are greater than the recommended threshold value of 0.7 and 0.5, which indicates a satisfactory level of indicator reliability and convergent validity. Moreover, the composite reliability values and Cronbach's alpha values of all constructs are above

the required threshold of 0.7, which indicates that internal consistency reliability is adequate [106]. Then, the discriminant validity of the measurement model was assessed. Discriminant validity can be assessed using an analysis of cross-loadings [107]. Based on Table 7, all indicators have loadings that are higher on the construct. They were theoretically arranged compared to other constructs. This means that all constructs have adequate discriminant validity.

Table 6. Measurement model assessment.

Constructs	Indicators	Loadings	AVE	CR	CA
BIMCR	SBIM5	0.799	0.596	0.911	0.887
	SBIM6	0.720			
	SBIM7	0.773			
	SBIM8	0.728			
	SBIM9	0.774			
	SBIM10	0.841			
	SBIM14	0.763			
OCU	SBIM2	0.799	0.705	0.878	0.791
	SBIM1	0.852			
	SBIM3	0.866			
BIMCR	CBIM4	0.866	0.689	0.946	0.935
	CBIM9	0.882			
	CBIM8	0.845			
	CBIM17	0.892			
	CBIM13	0.801			
	CBIM5	0.774			
	CBIM18	0.810			
	CBIM15	0.760			
OCA	CBIM16	0.823	0.606	0.902	0.870
	CBIM11	0.739			
	CBIM12	0.806			
	CBIM14	0.788			
	CBIM19	0.778			
	CBIM10	0.733			

Note: AVE = Average variance extracted; CR = Composite reliability; CA = Cronbach's alpha.

4.5. Structural Model Assessment

Bootstrapping is a technique for estimating the distribution of any statistic for any distribution. Thus, it was used to assess the importance of path coefficients and to test the proposed hypotheses. The number of bootstrap samples used in this study was 5000 (Hair et al., 2011 [106]). The critical t-values for a two-tailed test were 2.58 (significance level = 1%), 1.96 (significance level = 5%), and 1.65 (significance level = 10%) [108]. All four hypotheses were supported (Table 8). Hypotheses 1 and 4 were found positive and significant at the 1% level, whereas Hypothesis 2 was found positive and significant at the 5% level. In addition, Hypothesis 3 was found positive and significant at the 10% level.
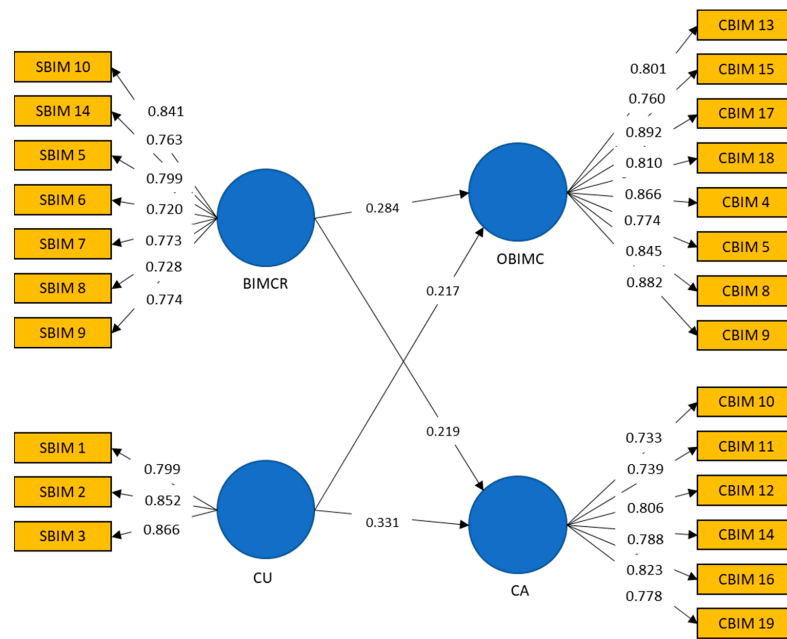
Figure 1. Measurement model.

Table 7. Cross loadings.

Constructs/Indicators	BIMCR	OCU	OBIMC	OCA
SBIM5	0.799	0.509	0.327	0.385
SBIM6	0.720	0.504	0.266	0.226
SBIM7	0.773	0.536	0.204	0.275
SBIM8	0.728	0.362	0.325	0.274
SBIM9	0.774	0.327	0.370	0.306
SBIM10	0.841	0.489	0.388	0.398
SBIM14	0.763	0.553	0.311	0.345
SBIM1	0.569	0.799	0.275	0.362
SBIM2	0.462	0.852	0.325	0.389
SBIM3	0.495	0.866	0.369	0.413
CBIM4	0.302	0.273	0.866	0.612
CBIM5	0.229	0.258	0.774	0.592
CBIM8	0.357	0.384	0.845	0.646
CBIM9	0.409	0.312	0.882	0.635
CBIM13	0.301	0.295	0.801	0.600
CBIM15	0.298	0.313	0.760	0.632
CBIM17	0.446	0.394	0.892	0.701
CBIM18	0.342	0.304	0.810	0.622
CBIM10	0.257	0.286	0.644	0.733
CBIM11	0.261	0.316	0.473	0.739
CBIM12	0.279	0.401	0.655	0.806
CBIM14	0.411	0.402	0.573	0.788
CBIM16	0.406	0.384	0.598	0.823
CBIM19	0.296	0.348	0.621	0.778

Table 8. Structural model assessment.

Hypotheses	Paths	Path Coefficient	t-Value	Decisions
H1	BIMCR→OBIMC	0.284	2.779 ***	Supported
H2	BIMCR→OCA	0.219	2.252 **	Supported
H3	OCU→OBIMC	0.217	1.907 *	Supported
H4	OCU→OCA	0.331	2.900 ***	Supported

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

5. Discussions

5.1. Relationship between BIMCR and OBIMC

The results show that BIMCR positively impacts OBIMC; therefore, H1 holds. This study confirms the findings of recent work in Iran [109]. According to Iran's BIM strategic plan for public construction projects vision document [109], BIMCR is highly correlated with BIM maturity levels and may ultimately support OBIMC. In accordance with ISO 19,650, BIM maturity levels are categorized into four levels [110]. BIM maturity level zero implies that no BIM has been applied. BIM maturity level one is where CAD drawings are used with BIM applications. In the BIM maturity level two, the implementation of BIM is widespread, but it is evenly distributed through the projects. Ultimately, BIM maturity level three is when BIM is adopted comprehensively and combined with the use of cloud servers. Based on Iran's BIM strategic plan on project documents for public construction, considering the knowledge obtained about the readiness of the organizations and the existing infrastructure, the possibility of implementing organizational BIM applications in the short- and medium-term horizon within the next five years in the construction projects within the BIM maturity level 3 is not predicted. Therefore, in the medium term, implementing organizational BIM applications is considered in the BIM maturity levels 1 and 2. As a result, a vital development strategy is to enhance BIM capability requirements' and to implement organizational measures, such as establishing strategies to provide to clients' demand for BIM and hiring BIM experts into organizations to accelerate activation and implementation of OBIMC.

5.2. Relationship between BIMCR and OCA

The findings demonstrate that BIMCR positively and substantially affects OCA. Thus, Hypothesis H2 is supported. Hiring BIM experts demonstrated one of the most effective strategies for proper BIMCR. Based on Oraee et al. [6], collaboration with external entities and supply chain partners is crucial to achieving success, which is also illustrated in this study's findings in BIM implementation. Maintaining close and confiding relationships with other organizations with a wealth of BIM knowledge is the way to ease gaining knowledge and learning about BIM implementation. Furthermore, Iran's BIM strategic plan on project documents for public construction recently established a standard to define the BIMCR based on examining the level of preparation, infrastructure, and resources needed to implement BIM applications in construction projects. In this standard, level one refers to BIM applications in the initial phase of projects. In level two, BIM applications are used during the design and planning phase of the project and before it goes into construction. The third level consists of the projects that BIM applications that are involve during the construction and operation phases of a project and even during the life cycle of the projects. As a result, level one and two applications require less preparation and resources than level three. Therefore, policymakers should pay attention to BIMCR.

5.3. Relationship between OCU and OBIMC

Based on the study findings, Hypothesis H3 is also supported due to the positive and substantial effect of OCU on OBIMC. The results are inconsistent with the existing literature. According to the findings of this study and a work by Khosrowshahi et al. [75] the BIM implementation team must explicitly generate a change management program and

be aware of the requirement to evaluate the ramifications of a project, which highly correlates with OCU. Technology generally causes extensive organizational changes, requiring adaptation to new conditions and acceptance. BIM is also an emerging technology in the AECO industry. Despite its many advantages, its implementation has always faced many challenges. One of its most significant challenges is the lack of preparation in organizations to implement and use BIM. Thus, one of the most critical steps to activate OBIMC is to improve OCU. Iran's BIM strategic plan on project documents for public construction recently introduced a new program to improve OCU. Several training was introduced in this program to increase different aspects of OCU, including motivation and technology readiness. The training includes preparing technical personnel with the necessary expertise, designers with specialized and general software expertise, and personnel involved with BIM software expertise

5.4. Relationship between OCU and OCA

The study results support Hypothesis H4, indicating that OCU positively affects OCA. Broadly, policymakers and governments should invest more attention and budgets to increase personnel preparation and to create a cultivation culture through different educational and culture-building activities. The study results align with prior works indicating the importance of OCU in strengthening OCA. Generally, new technologies in any organization cause extensive changes that require adaptability to new conditions and acceptance of new technology. The lack of preparation in organizations to implement and use new technologies is a barrier to fully achieving the required OBIMC. There are several important technical aspects to consider when assessing OCA. All of them are deeply associated with OCU, such as software functionality, interoperability, user-friendliness, BIM standards, data privacy protocols, potential application integration/extension, and accessibility of BIM software. Moreover, as the work of Arayici et al. [56] suggested, organizational capabilities, including senior management support, are necessary for successful BIM adoption.

6. Conclusions

BIM plays a key role in project management in the AECO industry during the construction and operation phases. Despite increasing BIM adoption in the AECO industry, most BIM benefits have not been realized due to the lack of OBIMC. In this regard, it is important to establish and develop a plan to succeed in BIM deployment and to guarantee its promised advantages. Although the recently established Iran BIM strategic plan for public construction projects vision document tried to provide a plan to activate and adopt OBIMC in Iran, no study was conducted to deeply evaluate the capability factors affecting OBIMC and to suggest strategies to enhance them among AECO organizations in Iran. As a result, the present study aims to demonstrate causal links between the underlying capability factors and strategies of OBIMC in Iran. A survey was designed to evaluate nineteen capability factors and fourteen strategies among 126 BIM professionals. The collected data were analyzed using EFA and PLS-SEM. The results indicate that developing an organization's BIM capability involves a mixture of BIMCR and OCU. Organizations must identify their expertise before establishing a consistent procedure for evaluating their OBIMC. OCU and CR contribute to an effective transition resulting in improved OBIMC. The most significant capability factors and strategies associated with improving OBIMC are the availability of adequate resources and formulation strategies to meet capability requirements. Overall, the study results demonstrated that OCU plays a significant role in developing BIM capabilities in the AECO industry. This indicates that a healthy OCU can enhance OBIMC among AECO organizations. As a result, organizations are more capable when their cultures are planned and responsive. This work enhances the knowledge of the capability factors and strategies for supporting OBIMC in Iran and demonstrates the importance of BIMCR and OCU in enhancing OBIMC.

6.1. Theoretical Implications and Contribution

The primary purpose of the current study is to gain a deeper insight into the capability factors and strategies for OBIMC in Iran. AECO organizations, industries, and individual businesses can benefit from the results of this study. Furthermore, policymakers and industry professionals can use the results to identify the most effective methods of implementing BIM. Finally, the computing and information science community can use the study findings to develop systems and innovative solutions for predicting OBIMC as well as strategy optimization. In addition to researchers, industry professionals and policymakers can use the study findings to enhance the development of BIM in the AECO industry.

6.2. Limitations and Future Research

Even though the findings align with prior works and the body of literature, there remain limitations that can be explored in future research. In spite of the fact that PLS-SEM and bootstrapping techniques were used to reduce the problem caused by small sample sizes in this study, a larger sample can be used to validate the model. Furthermore, the data collection was conducted online, and no in-person data collection took place. The case study concept used in this study is another limitation. Rather than interpreting data across broad regions, this study mainly dealt with data collected in Iran. As a result, the findings might not be applicable to other countries with different conditions, such as different income levels. In this way, a broader scope of data collection across different regions and countries could facilitate the identification of optimal BIM strategies for organizations.

Abbreviations

BIM	Building Information Modeling
AECO	Architecture, Engineering, Construction, and Operation
OBIMC	Organizational BIM Capabilities
EFA	Exploratory Factor Analysis
PLS-SEM	Partial Least-Squares Structural Equation Modeling
VR	Virtual Reality
AR	Augmented Reality
OCA	Organizational Capabilities
BIMCR	BIM Capability Requirement
OCU	Organizational Culture
IT	Information Technology
SMEs	Small and Medium-sized Enterprises

BEPs	BIM Execution Plans
SLR	Systematic Literature Review
R&D	Research and Development
KMO	Kaiser-Meyer-Olkin
PAF	Principal Axis Factoring
SEM	Structural Equation Modeling
CB–SEM	Covariance-based SEM
AVE	Average Variance Extracted

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