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Perceived Critical Success Factors for Implementing Building Information Modelling in Construction Small- and Medium-Sized Enterprises

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Abstract: Building information modelling (BIM) is an emerging technology in the building sector. As with any emerging technology, the identification of critical success factors (CSFs) for BIM is essential. On the other hand, small- and medium-sized enterprises (SMEs) consistently play a vital role in the construction industry. Therefore, it is essential to determine the critical success elements for the effective implementation of BIM in these companies. Hence, this study aims to determine the CSFs for implementing BIM in SMEs in the developing country of Iran. To accomplish this, three rounds of the Delphi technique were carried out with the participation of fifteen BIM professionals from SMEs based in Iran. According to the Delphi survey findings, a total of 27 CSFs were identified for the effective utilisation of BIM in SMEs. Subsequently, to assess the CSFs, a questionnaire utilising a five-point Likert scale measurement was designed. Then, it was distributed among specialists in construction SMEs in Iran. The questionnaire included twenty-seven factors categorised into four primary groups: technical, managerial, financial, and legal. A total of 56 questionnaires were gathered and examined. The findings indicate that the CSFs highlighted for implementing BIM in SMEs are above the average level. Furthermore, the CSFs with a high impact on successful BIM implementation in construction SMEs in Iran were determined. Four high-impact CSFs are (1) the employer's demand; (2) understanding the advantages and practicality of implementing BIM; (3) awareness of and ensuring a return on investment; and (4) efficient and suitable legislation. The findings of this study can serve as a valuable resource for stakeholders, providing them with a useful tool to enhance decision-making about the implementation of BIM in SMEs, especially in developing countries.

Keywords: building information modelling (BIM); success factors; SMEs; Delphi survey; Iran

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1. Introduction

Developing countries are recognised as promising and lucrative markets for the architecture, engineering, construction, and operation (AECO) industry [1]. Studies indicate that the construction projects in these countries can achieve improved time, financial, and quality results with the adoption and utilisation of technology. Moreover, the execution of smart city initiatives and sustainable development requires significant expenditures from many AECO industry subsectors [2]. In this vein, emerging technologies, such as building information modelling (BIM), have been developed [3]. BIM is considered a very promising advancement in the construction industry for achieving long-term objectives, such as enhancing industry quality through efficient design and focused project management [4,5]. The solution facilitates problem-solving by facilitating the exchange of data, information, and models among stakeholders, hence aiding the industry [6,7]. BIM plays an effective role in aiding efficient collaboration among project team members by enabling the more streamlined sharing and updating of data. In fact, BIM enhances the process of communication and the management of information about the project [8].

On the other hand, based on the companies' survey, it can be asserted that both large and small- and medium-sized enterprises (SMEs) encounter diverse economic and social issues and obstacles that result in organisational structure and behaviour exhibiting distinctions. Data indicate that SMEs are slower in embracing BIM technology compared to large companies [9]. This phenomenon can be explained by the reluctance of SMEs to embrace technology and their hesitancy to engage in innovation due to the substantial financial commitment required. The potential benefits of these investments may not be realised in the short term, as noted by Sexton and Barrett [10]. Conversely, SMEs are crucial for economic growth [11]. To facilitate significant changes such as the integration and adoption of BIM in the industry, it is crucial for SMEs to be able to effectively incorporate BIM into their operations. SMEs play a pivotal role in the industry, and their compatibility with BIM is essential for its widespread implementation [12]. Based on the research conducted by Hosseini et al. [13], it can be concluded that SMEs are not as advanced as large companies when it comes to applying BIM. Based on the literature, the implementation of BIM in projects and enterprises is hindered by constraints such as the lack of financial resources, human resources, necessary technology, and organisational and managerial abilities [7,14]. However, these studies have not been successful in delivering a comprehensive study of the critical success factors (CSFs) derived from projects and organisational structures. Furthermore, there is a lack of study on the background of BIM implementation in developing countries. Therefore, it is crucial to gain a deeper understanding of the CSFs that contribute to the creation of effective strategies. Moreover, the implementation of BIM is deemed essential, particularly in countries where BIM is still relatively nascent in the construction industry [15].

Hence, the main objective of this study is to identify and analyse the CSFs for implementing BIM in SMEs in the developing country of Iran. Consequently, through reviewing prior research, a compilation of critical determinants for the successful implementation of BIM in SMEs was established. The Delphi technique was used to screen and match the identified CSFs according to SMEs based in Iran. Subsequently, the confirmed CSFs were further examined to determine the most significant ones. The findings of this study can assist governments, especially in developing countries, in facilitating the advancement of BIM technology within the private sector, as well as aiding SME owners in making more informed choices regarding the implementation of BIM in their projects.

2. Literature Review

2.1. Definition of Small- and Medium-Sized Enterprises (SMEs)

The categorisation of SMEs varies across different countries [16]. Nevertheless, despite variations in their definitions, these companies possess comparable attributes. Table 1 displays the employee numbers and overall cash flow of enterprises in both developed and developing countries. Typically, SMEs are differentiated based on the number of employees, as stated by multiple sources. Additional factors to consider are the overall capital, total assets, annual cash flow or sales, and the ownership structure. When comparing SMEs to larger enterprises, it is evident that their distinct characteristics result in the two entities operating in independent spheres within the construction industry.

Given the disparities between SMEs and large corporations, it would be impractical to provide a single approach for evaluating their achievements in the construction sector. Since SMEs are crucial for the economy and are expected to play a significant part in the future of the construction industry [17], it is essential to examine the CSFs of construction SMEs to enhance their contribution to the industry [18]. Although construction SMEs may vary in their characteristics, they can nonetheless achieve similar outcomes by adapting their strategy to pursue new business opportunities [2,19].

Table 1. The summary of definitions for SMEs [2].

Category	Country	SMEs	Number of Employees	Annual Turnover	Sources
Developed countries	Australia	98%	<200	Unknown	[17]
	Canada	98%	<499	<CAD 5 million	[9]
	France	98%	<250	<EUR 50 million	[20]
	UK	98%	<250	<GBP 2.8 million	[12]
	USA	98%	<500	Unknown	[21]
Developing countries	Indonesia	96%	<100	Unknown	[22]
	Malaysia	98.5%	<200	<MYR 50 million	[23]
	Nigeria	96%	<200	<NGN 499 million	[24]
	Turkey	99%	<250	<TRY 25 million	[25]
	Iran	96%	<100	Unknown	[2]

2.2. Critical Success Factors (CSFs) of BIM Implementation in Construction SMEs

BIM technology involves gathering extensive data about buildings from a unified information repository [26]. The stored information is characterised by its parametric nature. Hence, several facets of the project are interrelated, and any alteration in the objective promptly impacts the overall vision and objectives [27,28]. According to Morlhon et al. [29], it has been determined that the identification of these factors is essential and helps to effectively deploy new systems and technologies.

In recent years, there has been a significant increase in the use of BIM technology, particularly in developed countries. As a result, extensive research has been conducted to identify and investigate the obstacles and problems associated with BIM implementation, as well as the risks involved. Additionally, researchers have examined the level of detail in BIM and explored its various applications. However, because BIM technology is relatively new in the construction sector, researchers have been interested in identifying and analysing the main elements that contribute to its successful application. Boktor et al. [30] have found that access to appropriate information and software is a crucial aspect for the successful adoption of BIM in building projects, based on their long and significant research. BIM is not widely adopted in many countries, particularly in developing ones, because of budgetary constraints that prevent organisations from purchasing the necessary equipment and technology for its implementation. However, China and their colleagues conducted an extensive and thorough research, which yielded a significant finding. They discovered that the level of expertise within a company, as well as its cooperation and collaboration with leading BIM users and organisations, is crucial for the successful implementation and utilisation of BIM. According to Chien et al. [14], having a strong organisational culture can be seen as a crucial element for effectively implementing BIM in firms. In addition, Lee et al. [31] conducted a thorough search and examination of the elements that can facilitate the adoption of BIM in both enterprises and projects. Thus, they comprehended that a crucial aspect for successfully implementing new technologies in organisations is the presence of skilled and capable staff. However, in previous studies, researchers have identified the CSFs. In this particular study, they discovered that by demonstrating the alignment of BIM with the interests of all stakeholders, through the provision of comprehensive explanations by BIM experts to relevant individuals involved in the project (such as contractors, consultants, engineers, and employers), BIM not only avoids disrupting their work situation and financial concerns, but companies also deploy BIM by adopting it throughout their organisations [32]. In their extensive research, Boi et al. examined the crucial variables that contribute to the successful deployment of BIM in building projects. They discovered that investment in BIM yields a favourable return on investment in terms of predicted time savings. BIM has significant implications for the adoption and integration of technology in financially vulnerable companies, particularly SMEs [33]. Research has shown that government programs and initiatives, such as offering tax incentives to companies, play a crucial role in promoting the implementation of BIM [34]. Additionally, a study conducted by Cheng and Lu [35] found that the involvement of regulatory bodies in establishing and overseeing standards and contracts related to BIM, as well as investigating any violations resulting from its use in construction projects, is a significant factor influencing the implementation of BIM.

SMEs in the construction industry are compelled to adopt emerging technologies, like BIM, to remain competitive and ensure their survival. Given that BIM is a recent innovation in the construction sector, it is crucial to determine the critical variables that contribute to its effective adoption and integration in construction SMEs. These characteristics can present more opportunities for construction SMEs due to a variety of technical, financial, legal, and managerial reasons, ultimately resulting in successful implementation. Some key success factors for implementing BIM in these companies include upgrading hardware systems and providing necessary electronic equipment for BIM implementation to enhance the company's capabilities, sharing BIM information among all project factors, and having competent consultants to establish a suitable platform for BIM integration, as well as driving changes in the organisation's structure and culture, effective leadership (the commitment and approach of top management to facilitate BIM in the organisation), coordination among the project stakeholders (existence a collaborative project environment for the successful implementation of BIM), demand from the employer (the existence of a specified need or pressure imposed by the employer), getting to know and increasing the awareness of stakeholders about the current level of applications in the industry, BIM policy and policy (the existence of a plan and map for the implementation of the building information model) in the company, understanding the benefits and usefulness of building information modelling through the use of BIM, the vision and strategy of the company (being aligned and in line with the benefits provided by BIM with the vision and strategy of the company), the willingness of employees to learn new technologies, understanding the ease of using BIM with its experimental implementation in projects, defining and clearly understanding the needs of users in using BIM, creating competitiveness in the labour market for the implementation of BIM, holding suitable and free courses for BIM training for employees on behalf of executive institutions, access to financial resources (the organisation's ability to allocate sufficient funds for the implementation of BIM), and appropriate laws (the existence of instructions—BIM standards and roles in the industry). However, the ability of construction SMEs to effectively use BIM depends on several factors, such as company size, national regulations, and other relevant conditions.

Previous studies have highlighted several essential elements that influence successful BIM adoption in SMEs, emphasising the need for tailored strategies that address their unique challenges. One significant finding is the importance of a qualitative research approach, which has been instrumental in gathering insights from BIM experts through semi-structured interviews. This method has revealed that understanding the specific needs and barriers faced by SMEs is crucial for formulating effective strategies for BIM implementation [19]. The qualitative data collected have underscored the necessity of recognising different CSFs at various stages of the implementation process, as SMEs often encounter distinct challenges compared to larger firms [2]. Among the barriers identified, financial constraints and a lack of knowledge about BIM technologies are particularly pressing issues for SMEs [19]. These challenges necessitate the development of low-cost solutions and tools that require minimal training, thereby reducing the learning curve associated with BIM adoption [11–13]. The concept of "touch the BIM lightly" has emerged as a recommended approach, advocating for a gradual and less intensive implementation of BIM, which can make the technology more accessible to small construction contracting businesses [2]. This approach aligns with the need for stylised BIM applications that cater specifically to the capabilities of SMEs, as opposed to those designed for larger design authoring firms [3]. Furthermore, stakeholder engagement has been recognised as a critical component in the BIM adoption process. Engaging various stakeholders can help address the unique needs of SMEs and facilitate knowledge exchange initiatives that enhance their understanding of BIM [12]. This collaborative approach not only legitimises the research findings but also improves the overall quality of the implementation efforts. Generally, previous studies have effectively addressed the CSFs for BIM implementation in SMEs by employing qualitative research methods to identify specific barriers and needs. The emphasis on low-cost, low-learning-time solutions, along with stakeholder engagement and tailored applications, provides a comprehensive framework for supporting SMEs in their BIM adoption journey. These insights are vital for developing strategies that can enhance productivity and competitiveness in the construction industry [2,19].

Understanding the interdependencies among the CSFs is essential for enhancing BIM adoption and effectiveness in construction SMEs. Recognising and addressing these interdependencies can lead to more effective strategies for promoting BIM adoption, ultimately enhancing project outcomes and sustainability in the construction sector [2]. Technical factors encompass the technology and tools necessary for BIM implementation. The effectiveness of these tools is often contingent upon managerial factors, such as leadership styles and management practices, which can either facilitate or hinder the integration of BIM technologies within an organisation [7]. For instance, a supportive management team can foster an environment conducive to adopting new technologies, thereby enhancing the overall effectiveness of BIM tools. Financial factors play a crucial role as well, as the economic considerations surrounding funding and investment directly impact an SME's ability to implement BIM technologies. Limited financial resources can restrict access to advanced tools and training, which are vital for successful BIM integration [12]. This financial constraint can create a dependency on managerial decisions regarding budget allocation for technology investments, highlighting the interconnectedness of financial and managerial factors. Legal factors also significantly influence BIM implementation. Regulatory and compliance issues must be addressed to ensure that BIM practices align with local laws and standards. The interplay between legal requirements and technical capabilities can create challenges; for example, if legal frameworks are not supportive of BIM practices, it may deter SMEs from investing in necessary technologies [6]. Thus, the legal landscape can shape both the technical and financial aspects of BIM adoption. Moreover, organisational readiness, which includes the culture and resources of an organisation, is a critical factor that influences the successful adoption of BIM. A well-prepared organisation is more likely to navigate the complexities of interdependencies among the various CSFs effectively [17]. This readiness can enhance stakeholder engagement, which is vital for ensuring that all parties involved in a construction project are aligned and committed to the BIM process [13]. The present study aims to identify and analyse the CSFs for the adoption of BIM in construction SMEs in Iran, which is a developing nation. By recognising these characteristics, it is anticipated that the deployment of BIM in construction SMEs will become more efficient and successful.

3. Research Methodology

This study aimed to identify the factors influencing the implementation of BIM in construction SMEs. A descriptive survey method was employed for data collection. To achieve this objective, the factors influencing BIM implementation were initially examined in the literature. Subsequently, the list of factors was further refined using the three-round Delphi survey method, which has been previously employed in similar research studies [8,36–38]. The decision to focus exclusively on the Delphi method was due to several reasons. The methodological rigor associated with the Delphi approach ensures a systematic and structured process, which is crucial for maintaining reliability and validity in research [37]. For instance, studies have shown that the Delphi method can achieve high reliability [38]. This focus on internal consistency is essential, especially when matching a set of variables according to a particular situation, as it enhances the credibility of the findings. In this study, the identified CSFs in BIM from the literature were required to be modified to align with the conditions of SMEs in Iran. Furthermore, the Delphi method, with its iterative rounds, allows for a more efficient gathering of expert insights without the extensive time commitment that other methods might require. Combining the Delphi method with a systematic review of the literature to identify the CSFs and adapt them based on the Iranian construction SMEs in this study can significantly improve the validation process, addressing the Delphi limitations and enhancing the overall quality of research outcomes. In conclusion, while the Delphi method has its limitations regarding generalisability, its structured approach and high reliability make it a justified choice for this research.

The Delphi panel comprised 15 experts. All experts had prior experience in BIM and SMEs, with over 10 years of experience in the construction industry. There is no definitive guideline regarding the selection and hiring process for experts who are identified as respondents in Delphi questionnaires. A panel of 15 experts can provide reliable outcomes in well-defined knowledge areas, making it an optimal size for achieving meaningful consensus without overwhelming complexity [37]. Moreover, smaller panels, particularly those with fewer than 10 individuals, are effective for exploring conceptual or philosophical issues [38]. This suggests that a slightly larger panel of 15 can similarly address complex topics while still maintaining a manageable size that fosters in-depth discussion and reflection among experts. It is worth mentioning that the expertise quality holds greater significance than the quantity of experts [39]. Therefore, participants in the Delphi survey are required to possess a high level of expertise, critical thinking abilities, and experience in a relevant field. Additionally, they must have enough time to actively participate and possess strong communication skills [40]. Typically, the number of professionals involved is relatively small, usually ranging from 10 to 20 and rarely exceeding 50 [37]. The composition of the expert panel is crucial, as the quality of input directly affects the outcomes of the Delphi study [27]. The experts of the Delphi panel for this study, each with relevant expertise, can provide diverse perspectives while minimising the influence of individual biases. This balance is essential for achieving a robust consensus, which is a primary goal of the Delphi method [8]. Moreover, the iterative nature of the Delphi process, characterised by controlled feedback and the opportunity for experts to revise their opinions based on previous rounds, enhances the overall quality of the consensus reached [2]. The number of experts is influenced by various factors, including the homogeneity of the sample, the objective of the Delphi process, the level of difficulty, the quality of decision-making, the expertise of the research team, the internal and external validity, the time required for data collection, the available resources, and the scope of the problem being studied [41]. This study employed the purposive sampling method to select survey respondents, a technique commonly used by other researchers in similar studies [38].

After conducting previous studies and initial monitoring, the researchers compiled a Delphi first-stage questionnaire consisting of 44 factors related to BIM implementation. The questionnaire's face validity was confirmed through the input of multiple respondents. The content validity was established through a rigorous process involving a Delphi panel of 15 experts, which spanned three rounds of Delphi. Additionally, the content validity was assessed using Lawshe and Kendall's agreement coefficient. The data analysis in each Delphi round involved utilising the content validity equation and Lawshe and Kendall's coefficient of agreement. The content validity of Lawshe was assessed using Equation (1) [42], and Kendall's Coefficient of Concordance (W) was evaluated using Equation (2) [43].

$$\mathrm{CVR} = \frac{\left(\mathrm{ne} - \frac{\mathrm{N}}{2}\right)}{\frac{\mathrm{N}}{2}} \tag{1}$$

where CVR refers to content validity ratio. The variable ne represents the number of experts who deemed the items in the questionnaire appropriate, while N represents the total number of experts who reviewed the questionnaire.

Kendall's coefficient of agreement is a metric used to assess the level of coordination and agreement among multiple rating categories associated with N objects or individuals. Using this scale allows for the determination of rank correlation between K rank sets. This scale is particularly valuable for conducting inter-judge validity studies. According to Schmidt [44], Kendall's coefficient of agreement indicates that individuals who have organised multiple categories based on their significance have generally employed similar criteria to assess the importance of each category and have reached a consensus in this regard. The calculation of this scale is based on Equation (2).

$$\mathrm{W} = \frac{\mathrm{S}}{\frac{1}{12}\,\mathrm{k}^2\left(\mathrm{N}^3 - \mathrm{N}\right)} \tag{2}$$

where the sum of the squares of the deviations of $\mathrm{R_j}$ is from the mean of $\mathrm{R_{js}}$, i.e., $\mathrm{S} = \sum[\mathrm{R_j} - \frac{\sum \mathrm{R_j}}{\mathrm{N}}]^2$), where the following variables are used:

$\mathrm{R_j}$: the set of ranks related to a factor.

K: number of sets of ratings (number of judges).

N: number of ranked factors.

$\frac{1}{12}\,\mathrm{k}^2\left(\mathrm{N}^3 - \mathrm{N}\right)$: the maximum sum of squares of deviations from the average of $\mathrm{R_{js}}$.

In this case, the sum of S is determined when there is complete agreement between K ratings.

The scale used in this study measures the level of consensus achieved through the Delphi panel. The values on this scale range from zero to one, with different thresholds indicating the strength of the consensus. A value below 0.9 indicates very strong agreement, below 0.7 indicates strong consensus, 0.5 indicates medium consensus, 0.3 indicates weak consensus, and 0.1 indicates very weak consensus. It is important to mention that the significance of the W coefficient alone does not suffice to halt the Delphi process. According to Schmidt [44], even panels with over 10 members regard small values of *W* as significant.

To assess the effectiveness of the identified CSFs as a significant factor in BIM implementation in Iranian construction SMEs, the opinions of 15 experts were sought. Next, the experts' agreement with the CSFs was assessed in terms of amount and frequency. Following this, the content validity of Lawshe was calculated. The minimum content validity value for a panel of 15 experts is 0.49. Based on the initial findings, it was determined that out of the 44 items in the questionnaire, 17 items lacked the required validity and needed to be eliminated (as their validity value was less than 0.49). Additionally, experts suggested adding 2 new items as CSFs. For the second round, the experts were provided with a revised questionnaire containing 29 items. Out of the total, 29 items were deemed valid, although 2 had to be consolidated with similar items. As part of the process, the experts were sent a revised questionnaire containing 27 items during the third round. At this stage, experts unanimously concluded that all 27 identified factors can be recognised as CSFs of BIM implementation in construction SMEs in Iran. The content validity obtained in this step was estimated to be 0.854. Given that the content validity ratio exceeded the minimum threshold, it can be inferred that the research questionnaire possesses content validity. This indicates that all items included in the questionnaire are valid. Table 2 displays the validity of each questionnaire item using the Lawshe equation during the final round of the Delphi process. Furthermore, the coefficient of agreement in Kendall's study yielded a value of 0.792, signifying a robust consensus and positive agreement among the participants.

Table 2. Validity of each questionnaire item with Lawshe equation.

Code	Indicators	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Ratio of Lawshe Content Validity
CSF_1	Accessing information and knowledge pertaining to BIM and the necessary software preparation.	13	2	0	0	0	0.73
CSF_2	Utilising the insights gained from successful SMEs to facilitate the integration of BIM in smaller organisations.	14	1	0	0	0	0.86
CSF_3	Enhancing the SMEs capabilities through the upgrade of hardware systems and provision of electronic equipment necessary for BIM implementation.	15	0	0	0	0	1
CSF_4	Access to skilled personnel for project model modification.	13	2	0	0	0	0.73
CSF_5	Facilitating the exchange of BIM information among all project stakeholders.	13	2	0	0	0	0.73
CSF_6	It is essential to have knowledgeable consultants who can establish an appropriate platform for implementing BIM within the company.	15	0	0	0	0	1
CSF_7	Modifying the structure and culture of the SMEs.	13	2	0	0	0	0.73
CSF_8	Efficient leadership (including a strong commitment from top management to support and facilitate the integration of BIM in SMEs.	14	1	0	0	0	0.86
CSF_9	Effective coordination (a collaborative project environment to ensure that all parties involved are working together seamlessly).	14	1	0	0	0	0.86
CSF_{10}	The employer's demand (refers to a specific need or pressure imposed by them).	13	2	0	0	0	0.73
CSF_{11}	Increasing stakeholder awareness of current industry applications is essential.	13	1	0	1	0	0.73

Table 2. *Cont.*

Code	Indicators	Completely Agree	Agree	Neutral	Disagree	Completely Disagree	Ratio of Lawshe Content Validity
CSF_{12}	BIM implementation policy (involving the use of plans and maps to guide the implementation of the BIM).	15	0	0	0	0	1
CSF_{13}	Understanding the advantages and practicality of implementing BIM.	13	2	0	0	0	0.73
CSF_{14}	The organisation's vision and strategy align with the benefits provided by BIM.	13	2	0	0	0	0.73
CSF_{15}	The eagerness of employees to acquire knowledge about emerging technologies.	13	2	0	0	0	0.73
CSF_{16}	Exploring the practicality of utilising BIM through its experimental integration in various projects.	15	0	0	0	0	1
CSF_{17}	Understanding and defining the needs of users in the use of BIM is crucial.	13	1	1	0	0	0.73
CSF_{18}	Enhancing labour market competitiveness to facilitate BIM implementation.	13	2	0	0	0	0.73
CSF_{19}	Providing comprehensive and educational BIM training courses to employees on behalf of executive institutions.	15	0	0	0	0	1
CSF_{20}	Creating a well-defined timetable for the implementation of BIM as a requirement by regulatory authorities.	15	0	0	0	0	1
CSF_{21}	Ensuring alignment with the interests of all stakeholders (involving conducting briefing courses led by BIM experts with an emphasis on the financial and commercial interests enhancing performance and optimising the work system).	13	0	1	1	0	0.73
CSF_{22}	Awareness and ensuring the return on investment resulting from the adoption of BIM.	15	0	0	0	0	1
CSF_{23}	Government programs and tax incentives to encourage the implementation of BIM in SMEs.	15	0	0	0	0	1
CSF_{24}	Providing low-interest and long-term loans to SMEs to promote the adoption of BIM	15	0	0	0	0	1
CSF_{25}	Accessing to financial resources (refers to an organisation's capacity to allocate adequate funds for the BIM implementation).	14	1	0	0	0	0.86
CSF_{26}	Efficient and suitable legislation (presence of regulations, criteria, and functions of BIM in the field).	13	2	0	0	0	0.73
CSF_{27}	The involvement of regulatory organisations in the development and effective monitoring of BIM-based standards and contracts, as well as the investigation of violations caused using BIM in construction projects.	15	0	0	0	0	1

Ultimately, a total of 27 factors were identified and categorised into 4 groups: technical, managerial, financial, and legal. These findings are presented in Table 3. The selection of this grouping was informed by various studies [45] as well as the input and approval of researchers and experts. A questionnaire was developed to assess the identified factors using a 5-point Likert scale measurement.

Table 3. CSFs in BIM implementation in construction SMEs in Iran.

Code	Dimensions	Sources
CSF_1	Technical	[30,46]
CSF_2		[7,14,47]
CSF_3		[48,49]
CSF_4	Managerial	[7,14,29,31,50,51]
CSF_5		[7,35,52]
CSF_6		[47,48]
CSF_7		[1,7,52,53]
CSF_8		[9,48,51,54]
CSF_9		[30,47]
CSF_{10}		[31,55,56]
CSF_{11}		[48,54]
CSF_{12}		[47,57]
CSF_{13}		[9,52,58,59]
CSF_{14}		[46,60]
CSF_{15}		[7,29,61,62]
CSF_{16}		[48,59]
CSF_{17}		[29,63]
CSF_{18}		[58,64]
CSF_{19}		[51,61,62]
CSF_{20}		Interview with experts
CSF_{21}		[7,32]
CSF_{22}	Financial	[33,63]
CSF_{23}		[34,51]
CSF_{24}		Interview with experts
CSF_{25}		[7,56,65]
CSF_{26}	Legal	[7,14,34,66]
CSF_{27}		[35,67]

In factor analysis, it is imperative to ascertain that the available data are suitable for the study. Measurement model fitting is employed for this purpose. Two models are evaluated in PLS frameworks. The initial model is the external model, synonymous with the measurement model, whereas the subsequent model is the internal model, analogous to the structural model in covariance-based frameworks. Consequently, in the initial phase, the measurement model undergoes validity and reliability analysis, followed by the second phase, where the structural model is evaluated by estimating the path coefficients across variables and assessing the model fit indices. To assess the adequacy of the initial segment, specifically the measurement models, three criteria are employed: index reliability, convergent validity, and divergent validity. Index reliability is assessed using three criteria: factor loading coefficients, Cronbach's alpha coefficient, and composite reliability.

The primary criterion to examine in assessing the model is the one-dimensionality of its indicators. Each indicator in the set is loaded with a substantial factor loading value corresponding to a single latent variable. The factor loading value must exceed 0.5. A factor loading value below 0.3 is deemed negligible and should be excluded from the indicator set. This is accomplished manually by eliminating signs with a factor loading below 0.3. To assess the construct validity of the questionnaire, factor analysis was conducted using SmartPLS 4 software. Figure 1 displays the factor loadings for all questions. Given that all factor loadings of the questions exceeded 0.3, it can be inferred that the model demonstrates a satisfactory fit. The questionnaire's reliability coefficient was calculated to be 0.958 using Cronbach's alpha coefficient. Descriptive statistics such as frequency, percentage, mean, and standard deviation, as well as inferential statistics including kurtosis and skewness tests, single-sample *t*-test, and Friedman test, were utilised in the analysis of the data using SPSS 25 software. Furthermore, the selection of experts and the methodology for administering questions were essential in the validity of this research. The primary criteria for decision-making about the validation of this research were grounded in possessing expertise and knowledge in the domain of BIM and comprehending the associated challenges. The experts were selected by strategic sampling. Participants were selected according to their educational qualifications, professional experience, and functional expertise: engineers in construction, architecture, and urban development; economists in academia; and urban construction managers affiliated with small and medium construction companies in Iran. All specialists possessed prior experience in BIM and SMEs. This diverse group was included to determine the priority of each identified factor. The sample size was estimated using Cochran's sample size formula equation, assuming an unknown population size of 56 individuals. The convenience sampling method was also employed for the purpose of sampling. The questionnaires were disseminated to 56 experts who participated in this study.

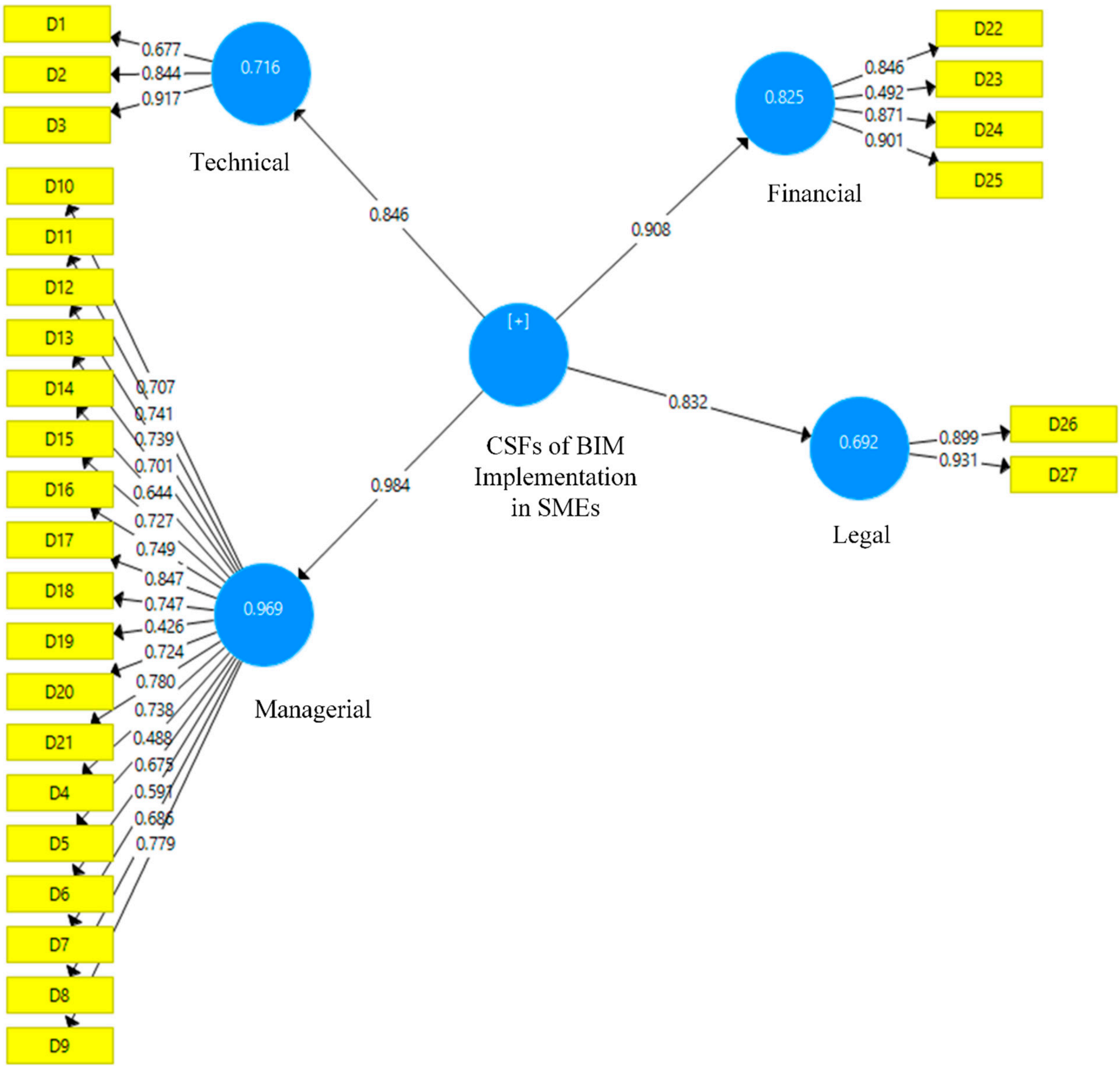

Figure 1. Factor load model of research questions.

The research analysis was conducted using SPSS 25 statistical software at descriptive and inferential statistical levels. In the descriptive statistics section, statistical measures including frequency, percentage, mean, and standard deviation were employed, while the inferential statistics component utilised the kurtosis and skewness tests, one-sample *t*-test, and Friedman test. The normality of the statistical distribution of the variables is a precondition for parametric tests. Parametric tests typically rely on the mean and standard deviation; however, if the population distribution is abnormal, accurate conclusions cannot be drawn from the results. Therefore, the normality test is essential. In this study, the kurtosis and skewness tests were analysed to evaluate the normality of the data. Furthermore, a one-sample *t*-test was employed to analyse each research topic pertaining to the variables under investigation. The one-sample *t*-test is a parametric analysis that compares the mean of the research variables to the test value, which in this case is 3. This study employed a one-sample *t*-test to examine the CSFs of BIM implementation in construction SMEs in Iran. Moreover, the Friedman test is employed to compare the mean ranks among k variables or groups. This study employed the Friedman test to prioritise the significance of the dimensions and identified the CSFs of BIM implementation in construction SMEs in Iran.

4. Results

4.1. Data Normality Evaluation

The analysis of this research was conducted using SPSS 25 statistical software, encompassing both descriptive and inferential statistics. The descriptive statistics section included statistical characteristics such as frequency, percentage, mean, and standard deviation. In the inferential statistics section, tests for skewness and skewness, the one-sample test, and Friedman's test were utilised.

The data normality test is a technique used to assess whether the distribution of collected data follows a normal distribution. Prior to conducting any test that assumes the normality of the data, it is necessary to perform a normality test. To achieve this goal, various methods can be employed. When dealing with Likert spectrum data and questionnaires, it is recommended to assess the curvature and skewness of the data. Skewness quantifies the level of symmetry or asymmetry in the distribution function. In a perfectly symmetrical distribution, the skewness is zero. However, in an asymmetric distribution that leans towards higher values, the skewness is positive. Conversely, in an asymmetric distribution that leans towards smaller values, the skewness is negative. Skewness is a measure of the distribution's height. Skewness is a measure that indicates the degree of peakedness in a distribution. Put simply, kurtosis quantifies the degree of curvature at the highest point of the curve. Positive skewness indicates that the peak of the distribution is higher than that of a normal distribution, while negative skewness suggests that the peak is lower. If the kurtosis and skewness fall within the range of (2, −2), it can be inferred that the data follow a normal distribution.

If μ is the mean and σ is the standard deviation of the random variable *X*, then the coefficient of kurtosis and skewness will be as follows:

$$Kurtosis(X) = \mathrm{E}\left[\left(\frac{X-\mu}{\sigma}\right)^4\right] = \frac{\mu^4}{\sigma^4} \tag{3}$$

$$Skewness(X) = \mathrm{E}\left[\left(\frac{X-\mu}{\sigma}\right)^3\right] = \frac{\mu^3}{\sigma^3} \tag{4}$$

The results presented in Table 4 demonstrate that the kurtosis and skewness of all research components fall within the range of (2, −2), suggesting a normal distribution of the data.

Table 4. Kurtosis and skewness tests.

Variable	Kurtosis	Skewness
Technical	1.659	−1.183
Managerial	1.659	−1.183
Financial	−0.699	−0.322
Legal	0.148	−0.840
CSFs of BIM implementation in construction SMEs in Iran	0.808	−0.885

4.2. CSFs of BIM Implementation in Construction SMEs

The *t*-test was utilised to analyse the identified CSFs of BIM implementation in construction SMEs in Iran, considering the normality of the data. The one-sample *t*-test is a statistical test that compares the average of the research variables with a specified test value. If the *p*-value in the test is greater than 0.05, it indicates that the investigated variable is not significantly different from the test value, which is the average value of 3. Therefore, the investigated factor can be considered to exist at an average level in the statistical population. If the *p*-value is less than 0.05, it indicates a significant difference between the investigated variable and the test value. In this scenario, if the average of the investigated factor is higher than the test number, it suggests a strong presence of the investigated factor in the statistical population. Conversely, if the average of the factor in the item under investigation is found to be lower than the test number, this indicates a weak presence of the investigated factor in the statistical population.

Based on the data presented in Table 5, the average dimensions of the main variable in the research, which are technical, managerial, financial, and legal, are 3.722, 3.722, 3.785, and 3.723, respectively. The overall score of the entire questionnaire is 3.709. Given that the *p*-value is less than 0.05, it can be concluded that the CSFs of BIM implementation in construction SMEs in Iran, across various dimensions such as technical, managerial, financial, and legal, are significant. The questionnaire results show a notable disparity from the test value (specifically, the number 3) and indicate an above-average scenario. Alternatively, with the acquisition of the upper and lower limits of the positive confidence interval, it can be inferred that the items and dimensions utilised possess considerable potential as catalysts for the adoption of BIM in construction SMEs in Iran.

Table 5. The results of one-sample *t*-test.

Variable	No.	Mean	SD	Test Value = 3			Lower Limit	Upper Limit
				t	df	*p*-Value		
Technical	56	3.722	0.802	6.738	55	0.000	0.5074	0.937
Managerial	56	3.722	0.802	6.738	55	0.000	0.5074	0.937
Financial	56	3.785	0.813	7.225	55	0.000	0.5678	1.003
Legal	56	3.723	1.151	4.699	55	0.000	0.4148	1.031
CSFs of BIM implementation in construction SMEs in Iran	56	3.709	0.693	7.657	55	0.000	0.5239	0.895

4.3. Ranking of the CSFs of BIM Implementation in Construction SMEs in Iran

The Friedman test, used in the two-way ANOVA by the ranking procedure, was used to assess the prioritisation of dimensions (technical, managerial, financial, legal) in the CSF variables for BIM implementation in construction SMEs in Iran. Based on the findings presented in Table 6, it can be concluded that there is no significant difference between the dimensions (technical, managerial, financial, legal) in the BIM variable. This conclusion is supported by the level of significance being higher than the threshold of 0.05 ($p < 0.05$).

Table 6. Results of Friedman test (significance of groups).

Chi-Square	df	Sig.	Test Result
0.676	3	0.879	H_0 confirmed

H_0: the mean rank of the item dimensions is equal. H_1: the mean rank of the item dimensions is not equal.

Based on the findings from Table 7 of Friedman's test ranking, the financial dimension has the highest average rank of 2.59, followed by the legal dimension with an average rank of 2.54. The technical dimension and management both have an average rank of 2.44, placing them in third position. These rankings reflect the importance of these dimensions in driving the implementation of building information modelling in small construction companies in Iran. Upon closer examination, it becomes evident that the dimension ratings are quite similar.

Table 7. Friedman test results (mean group ranks).

No.	Dimensions	Mean Ranks	Ranks
1	Technical	2.44	3
2	Managerial	2.44	3
3	Financial	2.59	1
4	Legal	2.54	2

The results presented in Table 8 indicate that the significance level is below the threshold of 0.05 ($p < 0.05$). Therefore, it can be inferred that there exists a significant difference among the variable indicators of CSFs of BIM implementation in construction SMEs in Iran.

Table 8. Friedman test results (significance results of indices).

Chi-Square	df	Sig.	Test Result
45.284	26	0.011	H_0 rejected

H_0: the mean rank of the item dimensions is equal. H_1: the mean rank of the item dimensions is not equal.

According to the findings in Table 9 regarding the ranking of CSFs for BIM using the Friedman test, the top-ranked indicator is the employer's demand (refers to a specific need or pressure imposed by them) (CSF_{10}), with an average rank of 16.43. The second-highest-ranked indicator is the understanding of the advantages and practicality of implementing BIM (CSF_{13}), with an average rank of 16.15. Awareness of and ensuring the return on investment resulting from the adoption of BIM (CSF_{22}) was ranked third. Additionally, efficient and suitable legislation (presence of regulations, criteria, and functions of BIM in the field) (CSF_{26}) was given a rating of 15.14, ranking it in fourth place.

4.4. Discussion of Analytical Results

The analytical results are helpful for SMEs as they help identify which strategies yield better outcomes, thereby informing decision-making processes. While presenting these statistical tests is essential, it is vital to understand how the statistical differences can be translated into actionable insights. For instance, when a significant difference is found in the ranking of various CSFs, SMEs can prioritise the most effective approaches in BIM implementation, thereby optimising resource allocation and enhancing overall performance. This process of translating the results of the research into practical applications is what ultimately drives improvement in decision-making and strategic planning within organisations. Furthermore, understanding the implications of statistical significance is crucial. Statistical significance indicates that the observed differences are unlikely to be due to random chance, thus providing a reliable basis for action. By integrating this understanding with the context of CSFs, SMEs can focus on the areas that are critical for successful BIM implementation, ensuring that their strategies align with their operational goals and market demands.

Table 9. Friedman test results (mean ranking).

Identified Indicator Code	Mean Rank	Rank	Identified Indicator Code	Mean Rank	Rank
CSF_1	12.97	22	CSF_{15}	13.20	21
CSF_2	13.61	18	CSF_{16}	12.08	24
CSF_3	11.36	26	CSF_{17}	11.61	25
CSF_4	14.46	11	CSF_{18}	14.99	7
CSF_5	13.77	15	CSF_{19}	12.80	23
CSF_6	13.80	14	CSF_{20}	14.53	10
CSF_7	14.56	9	CSF_{21}	13.59	19
CSF_8	13.88	13	CSF_{22}	15.39	3
CSF_9	14.38	12	CSF_{23}	13.80	14
CSF_{10}	16.43	1	CSF_{24}	13.72	16
CSF_{11}	15.09	6	CSF_{25}	13.28	20
CSF_{12}	14.65	8	CSF_{26}	15.14	4
CSF_{13}	16.15	2	CSF_{27}	13.63	17
CSF_{14}	15.13	5			

The ranking of CSFs for BIM adoption in Iran reveals that the foremost indicators are employer's demand, understanding the advantages and practicality of implementing BIM, awareness of return on investment (ROI), and efficient legislation. These factors are pivotal not only in Iran but also resonate with challenges faced in other developing countries. Firstly, the employer's demand is a CSF for BIM adoption, as it reflects the specific needs of and pressures from stakeholders in the construction industry. This demand is crucial for generating KPIs that measure BIM's effectiveness, which is essential for performance management systems [68]. In many developing countries, similar pressures exist, but they may be less pronounced due to varying levels of market maturity and stakeholder engagement. Understanding the advantages and practicality of BIM is another critical factor. Stakeholders must recognise the benefits of BIM to facilitate its adoption effectively. This understanding is vital in overcoming misperceptions about BIM, which are prevalent in regions that have adopted the technology later, such as [2]. In contrast, other developing countries may struggle with a lack of awareness regarding BIM's practical applications, which can hinder its implementation. Awareness of ROI is essential for encouraging BIM adoption. Stakeholders need to be informed about the financial benefits that can arise from implementing BIM technologies. This awareness is particularly crucial in developing regions where financial constraints may limit investment in new technologies [69]. In many cases, the lack of clear evidence regarding ROI can deter stakeholders from embracing BIM, leading to slower adoption rates compared to more developed markets. Lastly, efficient and suitable legislation plays a significant role in facilitating BIM practices. The presence of supportive regulations can enhance the implementation of BIM by providing a structured framework for its use in construction projects [70]. In other developing countries, the absence of such legislation can create barriers to BIM adoption, as stakeholders may lack the necessary guidance and support to navigate the complexities of BIM integration.

When comparing these CSFs with those in developing countries, it is evident they may be different. For example, in many developing regions, the lack of government support and inadequate training programs often hinder BIM adoption. For instance, while employer demand remains a critical factor globally, developing countries may struggle with insufficient regulatory frameworks and a lack of awareness regarding the advantages of BIM, which can impede progress [13,45]. Moreover, training and education in BIM are often less developed in these regions, leading to a workforce that may not fully understand or utilise BIM technologies effectively [19]. However, the findings of this study align closely with the research mentioned earlier. As an illustration, Boktor et al. [30] published a study in 2014. Through thorough research in the industry, it has been determined that access to pertinent knowledge, information, and software is a crucial factor. In a study conducted by Chien et al. [14], the researchers have shown that leveraging the experiences of established companies to facilitate the implementation of BIM in start-ups is regarded as a highly effective factor. In a study conducted by Lee et al. [31], extensive research led to the conclusion that the presence of skilled personnel can greatly influence the implementation of BIM in construction companies. A further study was conducted by Kent and Becerik-Gerber [32]. Significant research has revealed that aligning BIM with the interests of all stakeholders is a crucial factor for successful implementation [33]. According to the research, the expected return on investment is regarded as a crucial factor. In a study conducted by Eadie et al. [34], through further investigation, the significance of government programs and measures in relation to the topic has been highlighted. In a study conducted by Cheng and Lu [35], it was discovered that the involvement of regulatory bodies in establishing and overseeing BIM-based standards and contracts plays a crucial role in the successful implementation of such practices.

The CSFs for BIM implementation in construction SMEs require greater focus, although the adoption of BIM in developing countries encounters numerous obstacles. Technical challenges primarily revolve around the confusion regarding the necessary skilled personnel and the training required to operate BIM software effectively. SMEs often struggle to identify the right talent and the specific training programs needed, which complicates the transition from traditional methods to BIM-based project management [71]. Additionally, the costs associated with software applications pose a significant barrier, as many small construction businesses may not have the financial resources to invest in the required technology [72]. Managerial challenges include resistance to change and the need for effective project management strategies. Many organisations may not fully understand the capabilities of BIM or how to leverage it for their specific needs, leading to a lack of clear objectives and strategies for implementation [2]. Furthermore, the necessity for comprehensive training programs is critical, as inadequate training can hinder the successful adoption of BIM [19,72]. On the financial front, SMEs face substantial economic hurdles, including the costs of software acquisition, training, and the potential return on investment. These financial challenges can deter SMEs from adopting BIM, as they may perceive the initial investment as too high relative to the expected benefits [49,58]. The financial strain is exacerbated by the fact that many SMEs constitute the weakest link in BIM-based supply chains, which can limit their competitiveness in the market [2]. Legal challenges are also significant, as the implementation of BIM introduces new regulatory and contractual issues that were not present in traditional construction processes. Concerns regarding intellectual property rights, liability, and compliance with local laws can create additional barriers for SMEs looking to adopt BIM [70]. The complexities of sharing digital information and managing associated risks necessitate a clear understanding of legal responsibilities among all stakeholders involved in a project [12,14].

Based on previous research and the findings of this study, it is evident that researchers have made significant efforts to raise awareness and introduce the emerging technology of BIM in the construction industry in recent years. Nevertheless, employers, contractors, and all key stakeholders of construction projects who aim to implement BIM in construction SMEs continue to encounter numerous uncertainties and challenges. However, it is worth noting that SMEs play a significant role in the industry. Surprisingly, there is a lack of research on how these companies implement and embrace BIM. Additionally, there is limited understanding of how SMEs adopt and promote BIM to integrate the fragmented industry and ensure their survival. Insufficient research has been conducted on SMEs in developing countries, despite their significance [19]. The level of awareness plays a crucial role in the adoption and implementation of BIM in developing countries, which is significantly lower compared to developed countries [33,72]. Implementing BIM in SMEs is a significant concern. Addressing the challenges and obstacles in implementing BIM in SMEs requires identifying CSFs in four dimensions: technical, managerial, financial, and legal. By focusing on these CSFs, effective solutions can be introduced to improve the implementation of BIM in SMEs. The moderate approach ultimately leads to a positive step in implementing this technology and process.

The research results indicate that in the technical dimension, it is important to have access to information and knowledge about BIM, as well as the necessary software. Learning from the experiences of leading companies can be beneficial in implementing BIM in smaller companies and improving their capabilities. Upgrading hardware systems and providing the necessary electronic equipment are also crucial for successful BIM implementation. In the managerial dimension, having qualified personnel is essential for adapting the project model. It is also important to promote information sharing among all project stakeholders and seek the guidance of capable consultants to establish a suitable platform for BIM implementation and drive change. Within the organisation's structure and culture, as well as in the financial dimension, factors such as the anticipated return on investment, government tax programs, and incentives for companies, including long-term loans with low interest rates for financially vulnerable companies, are considered. In the small and legal dimension, BIM guidelines, standards, and maps, along with the involvement of regulatory bodies in providing and monitoring standards and contracts, can enhance the BIM implementation process in SME companies. BIM managers and experts should approach the implementation process in small and medium companies with systematic thinking and coherent management, considering the identified key success factors to accomplish the desired objectives in SMEs, particularly in developing countries like Iran.

Based on the study results, to effectively address the financial and technical challenges of adopting BIM in SMEs in developing countries, several strategies can be recommended. First, a "touch the BIM lightly" approach is essential. This strategy promotes a gradual and less intensive adoption of BIM, making it more accessible for small construction contracting businesses, which often face significant financial and technical barriers [2]. By avoiding forced uptake, SMEs can transition to BIM at a pace that aligns with their capabilities and resources, thereby reducing the risk of overwhelming their operations. Second, the development of stylised BIM applications tailored specifically for the needs of small construction firms is crucial. These applications should address the unique challenges faced by these businesses, such as limited technical expertise and financial constraints [57,58]. By focusing on low-cost solutions, SMEs can implement BIM without incurring significant financial burdens, which is particularly vital in developing countries where resources are often scarce [69]. Additionally, emphasising low learning time is critical. Solutions that require minimal time to learn can significantly enhance the adoption process for SMEs, allowing them to overcome technical challenges more effectively [35]. This focus on simplicity can be complemented by prioritising site-specific tasks that can be managed with BIM, ensuring that the technology directly benefits their operations [47]. By concentrating on practical applications, SMEs can implement BIM in a way that is manageable and relevant to their daily activities. Moreover, simplifying information flows is another important strategy. By prioritising one-way information flows, SMEs can avoid the complexities that often accompany BIM implementation, making it easier for them to adopt the technology without feeling overwhelmed [72]. This approach can help streamline communication and enhance collaboration among stakeholders, which is essential for successful project management. Lastly, government support plays a pivotal role in facilitating BIM adoption. Policies that provide funding, training, and resources tailored for SMEs can significantly enhance their readiness to adopt BIM [51]. Furthermore, outsourcing IT services can help SMEs overcome technical challenges by leveraging external expertise, thus allowing them to focus on their core competencies while still benefiting from advanced technologies [73].

4.5. Research Implications and Future Research Directions

Concerning the practical implications, to improve the effectiveness of implementing BIM in developing countries for construction SMEs, it is advised, based on this study's findings, that government departments and professional bodies set BIM standards and protocols in advance. Implementing a systematic guideline for BIM increases the likelihood of the effective adoption of BIM in SMEs. In terms of theoretical implications, this work makes a substantial contribution to the management of Iranian construction SMEs by highlighting the critical success factors in the adoption of BIM. The study results highlighted the significance of financial factors as a primary determinant that enables construction SMEs to improve their efficiency and productivity in BIM deployment. This study also emphasised some suggestions for promoting these CSFs of BIM deployment in SMEs in the construction industry.

To achieve success in the adoption of BIM, SMEs must enhance their technological, financial, and management capacities. Therefore, more study avenues can be pursued to further enhance the given outcomes, for example, examining the specific managerial skills that can facilitate the use of BIM by SMEs. Furthermore, this inquiry explores how technological advancements can facilitate the triumph of construction SMEs in projects that rely on BIM. Additional research is necessary to improve the applicability of the acquired findings by increasing the number of construction SMEs involved. Furthermore, a meta-analysis can be conducted to evaluate survey findings about the implementation of BIM in SMEs in the construction industry, both in emerging and established economies. While this paper presents valuable data on CSFs and their rankings, a deeper exploration of statistical significance is essential for a comprehensive understanding of BIM adoption in SMEs, ultimately leading to more informed decision-making and strategic planning. The use of methodologies like the Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Interpretive Structural Modelling (ISM) can help visualise and analyse these relationships, providing a clearer picture of how different factors interact and influence each other.

5. Conclusions

This study aimed to identify and investigate the CSFs of BIM in construction SMEs in Iran. The success factors of BIM implementation were identified from the research literature and monitored through three rounds of the Delphi technique. In the end, a total of 27 significant factors were identified. A questionnaire was created by the researchers, which consisted of twenty-seven factors categorised into four groups: technical, managerial, financial, and legal. Participants were asked to rate each factor on a five-point Likert scale. The validity and reliability of the questionnaire were thoroughly examined and confirmed. Next, the questionnaire was distributed among a panel of experts. The research included a statistical population of experts, engineers, consultants, and contractors who are active in the field of BIM. Using Cochran's sample size equation and the available sampling method, a statistical sample of 56 construction experts in Iran was selected. The data were analysed using SPSS 25 software after the questionnaires were collected. The research findings indicated that the CSFs of BIM implementation in construction SMEs in Iran are above the average. Therefore, all identified CSFs could be considered relatively strongly as CSFs of BIM implementation in construction SMEs in Iran. These factors can be seen as a potential solution to the challenges faced in BIM implementation in Iranian SMEs. Furthermore, the ranking of BIM implementation CSFs in construction SMEs in Iran reveals that the financial group holds the top position with an average rating of 2.59. Following closely behind is the legal group with an average rating of 2.54, securing the second rank. The technical dimension and management, both with an average rating of 2.44, share the third rank. In the ranking of BIM implementation CSFs in construction SMEs in Iran, several key factors were identified. The most important factor is the employer's demand (refers to a specific need or pressure imposed by them), which has an average rank of 16.43. Another important indicator is the understanding of the advantages and practicality of implementing BIM, which has an average rank of 16.15. The third-ranked factor was the awareness of and ensuring the return on investment resulting from the adoption of BIM. In addition, efficient and suitable legislation (presence of regulations, criteria, and functions of BIM in the field) received a rating of 15.14, positioning it as the fourth-highest ranked. Based on this study's findings, to enhance the construction SMEs' success in implementing BIM in Iran, several recommendations were provided. It is highlighted in this study that the use of a structured guideline for BIM implementation will increase the opportunity for the successful implementation of BIM in construction SMEs. This study provides useful insights into the proposition of pragmatic recommendations for considering and enhancing these CSFs of BIM implementation in construction SMEs in the future.

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