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# Government Initiatives for Enhancing Building Information Modeling Adoption in Saudi Arabia

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**Abstract:** Despite its numerous benefits, many countries are slow in adopting building information modeling (BIM). As a result, policymakers are implementing different government initiatives (GIs) for enhancing BIM adoption globally. However, it is critical to exercise caution when implementing GIs due to each country's specific requirements and rules. Having country-specific GIs can ensure that BIM is appropriately adopted and fits a country's needs and problems. Therefore, this study aims to investigate the effectiveness of the GIs in enhancing BIM adoption in Saudi Arabia. Data from 101 industry professionals were analyzed using a mean ranking analysis, normalization method, exploratory factor analysis (EFA), and fuzzy synthetic evaluation (FSE). Five critical GIs for enhancing BIM adoption were identified: developing programs for improving BIM competencies, developing programs to increase BIM awareness and understanding, developing programs to integrate BIM into education curricula and academia, developing BIM-related contractual frameworks, and providing financial aid to reduce the cost of BIM adoption. The EFA results indicate that the GIs can be grouped into two underlying constructs: national policies and organizational strategies. The FSE results confirmed that all GIs are effective. The study findings can serve as a significant reference for industry practitioners and policymakers in assuring successful BIM adoption.

**Keywords:** building information modeling; BIM; Saudi Arabia; exploratory factor analysis; fuzzy synthetic evaluation

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## 1. Introduction

Building information modeling (BIM) is gaining popularity in the architecture, engineering, and construction (AEC) industries globally. BIM is a resource for information that can be shared and used to make informed decisions and tackle different challenges using computer-based solutions [1]. Given the multiple advantages of BIM, it is widely used in developed countries such as the United States (US), the United Kingdom (UK), and Australia [2]. However, despite its popularity, BIM adoption is limited in many countries due to various problems [3]. As a result, policymakers are seizing possibilities for enhancing BIM adoption locally by mandating BIM in projects and establishing BIM standards and guidelines [4]. However, the poor adoption rates of BIM are exacerbated by social, economic, and technological constraints [5,6]. Therefore, policymakers need to establish effective government initiatives (GIs) for enhancing BIM adoption.

Several research works have been conducted to identify GIs for enhancing BIM adoption. For instance, ref. [7] identified five critical GIs for enhancing BIM adoption in China: well-defined plans and objectives, financial support for organizations, adequate competencies among the workforce, availability and interoperability of engineering information and data, and aligned goals. Other work has found GIs for enhancing BIM adoption in countries such as Nigeria, Singapore, and Turkey [8–10]. However, economic development and conditions vary among countries, resulting in considerable differences in the AEC market environment [11]. Furthermore, BIM adoption is heavily influenced by local organizational culture [12]. As a result, it is critical to exercise caution when adopting BIM in different countries [11]. Therefore, having country-specific GIs for enhancing BIM adoption can ensure effective BIM adoption.

GIs for enhancing BIM adoption differs between countries. Hence, to fully realize the benefit of BIM, having the right GIs in place is essential. Project stakeholders can collaborate more effectively with the right GIs, sharing data and collaborating in real-time. This can result in more efficient project operations and more informed decision-making. In addition, project teams may better plan and manage projects with the correct GIs, resulting in better project outcomes. Moreover, project stakeholders could identify potential risks and evaluate multiple possibilities, allowing them to make more informed decisions and avoid costly mistakes. Before construction begins, project teams can use BIM to simulate and test various design possibilities, detect conflicts, and improve designs. Therefore, there is a need to investigate the right GIs for enhancing BIM adoption to ensure that the industry receives the full benefit of BIM.

This study aims to investigate the effectiveness of the GIs in enhancing BIM adoption in Saudi Arabia. To achieve that aim, the study objectives are to identify the critical GIs, group the GIs, and evaluate the effectiveness of the GIs in enhancing BIM adoption in Saudi Arabia. To accomplish this aim, 101 surveys completed by AEC professionals were collected and analyzed. The mean ranking analysis, normalization method, exploratory factor analysis (EFA), and fuzzy synthetic evaluation (FSE) were used to analyze the collected data. Finally, a set of effective GIs for enhancing BIM adoption was established. This study contributes to a better knowledge of GIs for enhancing BIM adoption in Saudi Arabia. The study findings can serve as a significant reference for industry practitioners and policymakers in assuring the successful adoption of BIM, in addition to addressing a lack of knowledge about GIs for enhancing BIM adoption in Saudi Arabia. Having the right GIs in place for enhancing BIM adoption may accelerate adoption rates as well as improve project outcomes, collaboration, and risk management.

## 2. Literature Review

### *2.1. Building Information Modeling*

BIM has grown in popularity since it was first proposed in 1975 [13]. In recent years, BIM has garnered much global attention due to its immense potential in the AEC industry by transforming the traditional paper-based management paradigm and leading to significant technological innovations [14]. According to the US National BIM Standard [15], BIM is “a digital representation of physical and functional characteristics of a facility. BIM serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward”. In addition, the British Standards Institute defined BIM as “the process of generating and managing information about a building during its entire life [16]. In other words, BIM is a suite of technologies and processes that integrate to form the “system”, at the heart of which is a component-based 3D representation of each building element; this supersedes traditional design tools currently in use”.

BIM is powerful as it enables precise, efficient, and cost-effective procedures in construction projects. Unlike traditional drawing sets, BIM allows for sharing and collaboration, which are critical for increasing productivity and efficiency. Prior works have found numerous benefits of BIM adoption that enable high performance in different management processes and analyses. The benefits of BIM include improved design quality and communication as well as reduced project cost and duration [17]. In addition, the specific areas where BIM benefits are project management, design optimization, waste minimization, and safety management [18,19].

There is now an upward trend in using BIM globally. Countries such as Australia, Singapore, the UK, and the US are the leaders in BIM adoption [20]. Some of these countries have established laws and policies to encourage BIM adoption [21]. In addition, Spain, the UK, the US, France, and Denmark have proposed national BIM mandates for construction projects [22]. Unfortunately, BIM adoption rates are lower than expected in developing countries, such as Nigeria and Egypt [5,23]. The low rates have been attributed to a lack of training, varying market readiness across regions, the fragmented nature of the AEC industry, and the industry's unwillingness to change existing work techniques [24]. Moreover, according to [25], the lack of qualified employees is a barrier to BIM adoption. According to [26], the lack of interest in BIM stems from the fact that it does not have any practical application in settings where there are not enough people to execute it. Therefore, policymakers need a plan and establish GIs that cater to their local needs for successful BIM adoption.

### *2.2. Government Initiatives for Enhancing BIM Adoption*

Governments are the sector that benefits the most from BIM adoption. Hence, policymakers are actively encouraging BIM adoption through various projects and policies. As a regulator and standard setters, policymakers must establish the conditions for the AEC industry to transition to BIM [27]. Furthermore, policymakers can develop national standards for enhancing widespread BIM adoption [28].

Different countries have employed specific GIs to promote the use of BIM. In the US, the General Services Administration (GSA) has taken a leading role in implementing BIM, especially in public projects [29]. The GSA, responsible for constructing and managing federal facilities across the country, established a national program called 3D-4D-BIM and made BIM mandatory for spatial program validation on all projects since 2007 [30]. Similarly, policymakers in the UK introduced an initiative in 2011 to make BIM obligatory for public projects by 2016, following a staged plan over five years [29]. To support this, the UK government formed a BIM task group to assist project owners in re-engineering their work practices [31]. The Finnish government also made significant research investments and published a guideline to standardize local BIM practices [32]. The Singaporean government pursued an initiative to widely adopt BIM in public projects by 2015. Since 2000, they have driven industry transformation through the Construction and Real Estate Network (CORENET) program which emphasizes the use of BIM for sector-wide improvements [29].

Researchers globally are also identifying GIs for enhancing BIM adoption. In [7], several GIs for enhancing BIM adoption in China were identified, including the availability of government funding, proper organizational structure, and staff motivation to learn BIM. Ref. [33] suggested that requiring BIM in procurement and encouraging competition among AEC organizations are some GIs for enhancing BIM adoption. Ref. [34] advocated employing BIM champions to drive BIM adoption. Other GIs for enhancing BIM adoption in previous works include the development of skills and knowledge, upper management commitment, free ownership of intellectual property, the establishment of scientific research incentive programs, financial support, and the aggressive promotion of BIM [35]. In other words, countries are implementing different GIs for enhancing BIM adoption.

### *2.3. BIM in Saudi Arabia*

The AEC industry is critical to many countries' economies, generating between 7% and 10% of gross domestic product (GDP) on average [36]. In 2011, Saudi Arabia's AEC industry was worth more than $20 billion, accounting for approximately 12% of the country's GDP [36]. Due to rising investments, high construction demand, and rules that attract international investors, the AEC industry in Saudi Arabia has consistent positive growth [37]. Despite this, Saudi Arabia is not making enough progress toward effective management and good organizational performance. As a result, the industry is lagging, and it must deal with complex problems that harm the success of construction projects [38]. In another work, ref. [39] revealed that the main causes of claims and disputes in construction projects in Saudi Arabia are a change or variation in orders due to new client requirements (78%), variations in quantities due to new client requirements (74%), delays caused by contractors (74%), design errors or omissions (72%), and inconsistencies in the drawings and specifications (70%). To address these causes, policymakers must re-engineer the AEC industry in Saudi Arabia to have simpler coordination and integration processes [40].

Although Saudi Arabia has adopted BIM, the adoption rate is slow [41]. Despite its growing popularity, BIM is still not commonly used in Saudi Arabia [42]. Accordingly, there is little published information on BIM adoption in Saudi Arabia. Examples of published work include ref. [43] that created the Hijazi architectural elements repository to reduce the time required to develop the Jeddah Historical Building Information Modeling (JHBIM) model. In 2015, the same authors created a framework for integrating JHBIM with a Geographic Information System (GIS). Additionally, ref. [44] developed a method for integrating data on the quality of an interior environment into a BIM model. Faster design processes, more effective information reuse, and higher levels of client satisfaction are just some of the benefits of BIM adoption in Saudi Arabia [45]. Moreover, ref. [41] identified GIs for enhancing BIM adoption in Saudi Arabia by analyzing data from 224 industry professionals using descriptive statistics. Enabling laws and a supportive regulatory environment, monetary help from the government, increased education for professionals engaged in BIM, and international benchmarking are some examples of potential GIs for enhancing BIM adoption in Saudi Arabia [41].

### *2.4. Positioning This Study*

According to the above background, although policymakers are implementing GIs for enhancing BIM adoption globally, there is a need for improved GIs in Saudi Arabia. By investigating the effectiveness of GIs, this study can identify areas for improvement and suggest more targeted and tailored approaches for enhancing BIM adoption in Saudi Arabia. Moreover, the existing research on BIM adoption in Saudi Arabia primarily focuses on highlighting the benefits and challenges associated with BIM adoption. Although ref. [41] ranked the GIs for enhancing BIM adoption in Saudi Arabia, the work did not provide any further analyses or explore the interrelationships between different GIs. Selecting GIs solely based on ranking can lead to the inefficient allocation of resources and may not account for the potential relationship or dependencies between GIs. Therefore, this study aims to overcome this limitation by thoroughly examining the effectiveness of the GIs and analyzing their interdependencies, providing a more comprehensive and nuanced understanding of their impact on BIM adoption. This study will contribute to a deeper understanding of the GIs that can effectively promote BIM adoption in the Saudi Arabian context.

## 3. Methodology

### *3.1. Survey Development*

A questionnaire survey was used to quantitatively gather data on GIs for enhancing BIM adoption in Saudi Arabia. A survey is an effective method for assembling a wide range of responses from professionals using random sampling [46]. The following subsections discuss the process involved in developing the survey used in this study.

#### 3.1.1. Systematic Literature Review

A systematic literature review (SLR) was undertaken to identify potential GIs reported by previous literature. The process began with a search in the Scopus database. Scopus was the database used as it is a popular resource for SLRs in the field of construction management [47]. The terms used were ‘BIM’ OR ‘building information modelling’ OR ‘building information modeling’ OR ‘building information model’ AND organization* OR organization* OR firm* OR company* AND ‘construction industry’ OR ‘AEC’ AND implement* OR adopt*. Here, although many prior works have explored the role of policymakers in enhancing BIM adoption, some publications did not include any government-related synonyms in the title or the abstract. Thus, this study used a general search string for the

SLR to maximize the potential pool of relevant literature. Including specific phrases like "government" or "public client" in the search string could potentially limit the number of papers retrieved. Hence, no government-related keywords were used.

Next, inclusion and exclusion criteria were used to assess the papers. First, as most BIM-related publications were published after 2011 [48], the search period was selected from the year 2011 to 2022, resulting in 371 papers. Then, the inclusion criteria included works written in English, works addressing BIM adoption in practice, and peer-reviewed journal articles. Materials written in languages other than English focused on generic words such as "industry 4.0", and those unrelated to BIM were removed. In addition, conference proceedings were also removed due to the possibility of inadequate quality [49]. The search resulted in 217 articles.

After that, to ensure the inclusion of papers specifically related to GIs, the authors invested extra effort in thoroughly reviewing the title and abstract of all 217 papers. The aim was to select publications that were most relevant to the study's aim of investigating effective GIs for enhancing BIM adoption. Finally, fifteen articles were selected for further examination.

#### 3.1.2. Interview

After performing a SLR to find the potential GIs for enhancing BIM adoption, semi-structured interviews with industry professionals were carried out to validate the list of GIs and ensure that the survey contained all of the necessary information. Moreover, the interviews involved reviewing the language and technical phrases used in generating the descriptions of the GIs and removing any uncertainty that arose during the survey production process. As part of the interview process, the interviewees were requested to propose any additional GIs not identified in the SLR. In addition, any GIs deemed irrelevant to the Saudi AEC industry were excluded. The survey was finalized after receiving feedback and recommendations. Table 1 summarizes the 12 potential GIs for enhancing BIM adoption identified through the SLR and semi-structured interviews.

**Table 1.** Government initiatives for enhancing BIM adoption.

| Code | Government Initiative | Sources |
|---|---|---|
| ST01 | Developing programs for improving BIM competencies | [50–55] |
| ST02 | Providing financial aid to reduce the cost of BIM adoption | [52,56–58] |
| ST03 | Developing BIM standards | [51,52,56,59,60] |
| ST04 | Developing a digital transformation strategy for BIM | [50,54,59,61] |
| ST05 | Mandating BIM adoption in the AEC industry | [51,52,56,62,63] |
| ST06 | Developing programs to increase BIM awareness and understanding | [52,54,64] |
| ST07 | Fostering market demand for BIM | [52,59,64] |
| ST08 | Initiating pilot projects to exploit the evidence-based benefits of BIM adoption | [52,53,60] |
| ST09 | Developing programs to integrate BIM into the education curricula and academia | [51,53] |
| ST10 | Developing BIM-related contractual frameworks | [51] |
| ST11 | Developing BIM adoption guidelines | [60] |
| ST12 | Creating BIM institutes for training young/fresh graduates | [63] |

#### 3.1.3. Survey Design

The survey has two major sections. Section one of the survey asked respondents about their backgrounds. Section two of the survey required respondents to rank the list of identified GIs on a five-point Likert scale in terms of their effectiveness. In addition, the survey allowed respondents to elaborate on and list GIs that were not included in this study. The survey was written in both English and Arabic to decrease the possibility of rejection and increase response rates.

#### 3.1.4. Pilot Test

The design and instrumentation problems in a survey can be uncovered via a pilot test [65]. Furthermore, the pilot test feedback is crucial to improve a survey's quality and estimate the time required to complete it [66]. To remove vague phrases and verify proper usage of technical jargon, a pilot test involving three professors and two industry professionals with over ten years of experience in construction management was conducted. During the pilot study, the authors determined that the amount of retrieved information had reached a point of data saturation. Data are saturated when collecting additional data is unlikely to reveal any new insights beyond those already there [67]. The survey was then finalized based on comments from the participants in the pilot test.

### *3.2. Data Collection*

All AEC professionals with extensive knowledge were included in the target population. Probability sampling methods could not be employed due to the lack of an appropriate sample frame. To obtain a representative sample, the non-probability sampling technique was used instead [68]. This technique has also been employed in earlier BIM works, as identifying the entire community of BIM professionals is challenging [69,70]. Convenience sampling was initially used via the authors' referrals and network to locate respondents with adequate BIM experience. The number of participants was further increased using the snowball sampling technique [71]. Then, initial respondents were asked to recommend any other AEC professionals who may be suitable for answering the survey. This study obtained 101 valid responses after several reminders and interactions.

Table 2 reveals that the majority of respondents (79.2% of the total sample) had a bachelor's degree. In addition, 2.0% of respondents have a diploma, 11.9% have a master's degree, and 6.9% have a Ph.D. The sample included respondents from various organizations, with 37.6% being consultants, 28.7% being contractors, and 9.9% being clients. Only 2.0% of respondents had less than one year of experience working in the AEC industry. Over seventy-five percent of the respondents (75.2%) had more than ten years of experience in the AEC industry.

Regarding BIM experience, 54.5% of those surveyed reported no prior experience. The remaining sample, on the contrary, had at least one year of BIM experience. This limited experience is because Saudi Arabia is currently in the initial phase of BIM adoption, meaning there may be a limited number of AEC professionals with prior BIM experience. Nevertheless, the primary objective of this study is to identify GIs for enhancing BIM adoption in Saudi Arabia. In order to develop effective GIs, it is essential to consider the perspectives of professionals with and without BIM experience. Having both inputs can shed light on the specific challenges and requirements that must be addressed during the adoption process. Furthermore, incorporating the viewpoints of professionals without BIM experience allows for a comprehensive analysis of the current state of BIM adoption in Saudi Arabia. It helps identify any knowledge gaps, misconceptions, or concerns that professionals may have regarding BIM. Accordingly, GIs can be tailored and designed to bridge the gap between existing practices and the requirements of BIM. In other words, the participation of professionals without BIM experience is necessary to obtain a comprehensive understanding of the current state of BIM adoption in Saudi Arabia and to develop effective GIs that meet the specific needs of the local AEC industry. This concept has also been used by other prior works to gain a better understanding of the overall perspectives of AEC professionals on BIM [72,73]. Therefore, the data can be considered reliable for further analysis due to the professionals' working experience in the AEC industry.

**Table 2.** Respondent profiles.

| Characteristics | Categories | Frequency | Percent (%) |
|---|---|---|---|
| Highest education level | Diploma | 2 | 2.0 |
| | Bachelor's degree | 80 | 79.2 |
| | Master's degree | 12 | 11.9 |
| | Ph.D. | 7 | 6.9 |
| Type of organization | Client | 10 | 9.9 |
| | Contractor | 29 | 28.7 |
| | Consultant | 38 | 37.6 |
| | Other | 24 | 23.8 |
| Working experience in the AEC industry | Less than one year | 2 | 2.0 |
| | One to five years | 12 | 11.9 |
| | Six to ten years | 11 | 10.9 |
| | Eleven to fifteen years | 20 | 19.8 |
| | Sixteen to twenty years | 28 | 27.7 |
| | More than twenty years | 28 | 27.7 |
| Working experience using BIM | None | 55 | 54.5 |
| | Less than one year | 17 | 16.8 |
| | One to five years | 17 | 16.8 |
| | Six to ten years | 7 | 6.9 |
| | Eleven to fifteen years | 1 | 1.0 |
| | Sixteen to twenty years | 0 | 0.0 |
| | More than twenty years | 4 | 4.0 |

### *3.3. Data Analysis*

#### 3.3.1. Data Reliability

Reliability analysis was undertaken to assess the survey's reliability and consistency. The internal consistency of variables in a questionnaire survey is often calculated using Cronbach's alpha ($\alpha$). The value of Cronbach's alpha coefficients must be more than 0.70 [74]. The 12 GIs obtained an overall score of 0.916 at the 5% significance level, confirming data reliability. As a result, the acquired data are suitable for further investigation.

Then, the data were screened using the two-standard deviation method to find any outliers [75]. Outliers are data that vary greatly and can considerably impact the results. The two-standard deviation method entails determining two standard deviation intervals. Outliers were defined as variables with mean values that fell beyond the two standard deviation intervals. The means, standard deviations, and two standard deviation intervals of all GIs were computed. The calculated intervals for the two standard deviation methods were 4.173 and 3.809. As a result, no outliers were found during the screening.

Furthermore, the Kruskal–Wallis test was used to assess the significant differences between respondents with and without BIM experience. A significant difference is established when the asymptotic significance value is less than 0.05 [76]. As the p-value of the test was greater than 0.05, there were no significant differences between respondents with and without BIM experience on the effectiveness of the GIs.

#### 3.3.2. Mean Ranking Analysis and Normalization Method

The mean score ranking analysis was used to determine the relative rankings of the GIs. In cases where two or more GIs had identical mean values, the GI with the lowest standard deviation (SD) was given the highest rank. A smaller SD suggests that the differences in responses are not statistically significant; therefore, the mean value is more likely to be accurate for most respondents [74].

The normalization method was used after ranking the GI as it enables a better interpretation of the data, particularly when identifying critical variables. The normalization method was adapted from [77]. The procedure was used to turn the minimum mean value to 0 and the maximum mean value to 1. The other mean values were then converted to decimal values ranging from 0 to 1. GIs with normalized values of at least 0.50 were recognized as critical for enhancing BIM adoption in Saudi Arabia.

3.3.3. Exploratory Factor Analysis

To discover any statistical correlations between the GIs, EFA was used. EFA is a data reduction technique that regroups and reduces a large number of interconnected variables into smaller and more relevant sets of variables or constructs [78]. The sample size for the EFA approach was determined using the ratio of the sample size to the number of variables. The calculated ratio of sample size to the number of variables was 8.42, which was higher than the recommended value of 5.00 [79]. As a result, the sample size was deemed sufficient for EFA.

The KMO measure of sample adequacy and Bartlett's test of sphericity were used to determine the suitability of the data. The KMO assesses the data sampling appropriateness by comparing the squared correlation between variables to the squared partial correlation between variables [80]. For a good EFA, the KMO value should be higher than 0.50 [81]. On the contrary, Bartlett's test of sphericity highlights relationships between variables. It checks to see if the original correlation matrix is an identity matrix, which means there is no relationship between the variables and that EFA is unsuitable. A high degree of related significance and a high level of sphericity show that the population correlation matrix is not an identity matrix, implying that the EFA is appropriate [82].

This study employed the principal axis factoring technique for factor extraction to identify the underlying constructs. Variables with an eigenvalue higher than one, indicating a contribution to the principal constructs, were retained. Following that, the GIs were subjected to a varimax rotation to uncover any latent constructs. Finally, variables with factor loadings higher than 0.60 were considered important and beneficial in interpreting the constructs [83].

3.3.4. Fuzzy Synthetic Evaluation

The effectiveness of the GIs and constructs was then assessed using the FSE technique. The field of construction management uses FSE as an approach to examine policymaking issues in the AEC industry [84]. The individual effectiveness indexes (EIs) and overall effectiveness indexes (OEIs) of the GIs were calculated using the techniques outlined by [84].

## 4. Results

### *4.1. Mean Ranking Analysis and Normalization Method Results*

The results of ranking the GIs for enhancing BIM adoption in Saudi Arabia are presented in Table 3. The mean value of the GIs extends from 4.168 to 3.871. The critical GIs have normalized mean values of at least 0.50 and five GIs were found to have normalized values of 0.50 or above, making them critical GIs. The critical GI with the highest mean value is developing programs for improving BIM competencies (ST01). Other critical GIs include developing programs to increase BIM awareness and understanding (ST06), developing programs to integrate BIM into education curricula and academia (ST09), developing BIM-related contractual frameworks (ST10), and providing financial aid to reduce the cost of BIM adoption (ST02).

**Table 3.** Results of the mean ranking analysis and normalization method.

| Code | Mean | SD | NV |
|---|---|---|---|
| ST01 | 4.17 | 0.88 | 1.00 * |
| ST06 | 4.10 | 0.85 | 0.77 * |
| ST09 | 4.08 | 1.04 | 0.70 * |
| ST10 | 4.02 | 0.77 | 0.50 * |
| ST02 | 4.02 | 0.99 | 0.50 * |

**Table 3.** *Cont.*

| Code | Mean | SD | NV |
|---|---|---|---|
| ST04 | 3.99 | 0.89 | 0.40 |
| ST08 | 3.97 | 1.07 | 0.33 |
| ST12 | 3.95 | 1.19 | 0.27 |
| ST07 | 3.94 | 0.84 | 0.23 |
| ST05 | 3.89 | 0.96 | 0.07 |
| ST03 | 3.89 | 0.97 | 0.07 |
| ST11 | 3.87 | 1.04 | 0.00 |

Notes: SD = standard deviation; NV = normalization value; and * = critical government initiatives.

### *4.2. EFA Results*

The calculated KMO value for the GIs is 0.870, higher than the minimum value of 0.50 [81]. On the contrary, Bartlett's test of sphericity had a significance value of 0.000, indicating that it is not an identity matrix. Therefore, the data are suitable for EFA. According to Table 4, all GIs were successfully loaded into two underlying constructs, with eigenvalues greater than one accounting for 64.391% of the total variance. The two constructs are national policies (NP) and organizational strategies (OS).

**Table 4.** Results of the EFA.

| Constructs | Code | Factor Loadings | Variance Explained | Cronbach Alpha |
|---|---|---|---|---|
| National policies (NP) | ST3 | 0.820 | 34.731 | 0.896 |
| | ST4 | 0.797 | | |
| | ST5 | 0.756 | | |
| | ST7 | 0.726 | | |
| | ST1 | 0.682 | | |
| | ST2 | 0.660 | | |
| | ST6 | 0.620 | | |
| Organizational strategies (OS) | ST9 | 0.863 | 29.660 | 0.853 |
| | ST11 | 0.774 | | |
| | ST10 | 0.749 | | |
| | ST8 | 0.706 | | |
| | ST12 | 0.614 | | |

The construct label can be determined by using variables with higher factor loadings or the entire set of variables [85]. To ensure that the factors were correctly grouped, Cronbach's alpha reliability test was conducted. As shown in Table 4, Cronbach's alpha coefficients exceeded the minimum required threshold of 0.60 [86], indicating that each construct had good internal consistency.

### *4.3. FSE Results*

#### 4.3.1. Input Variables and Linguistic Terms

The two constructs (NP and OS) form the basis for assessing the effectiveness of GIs in enhancing BIM adoption in Saudi Arabia. The constructs were presented as first-level index systems and as $U = (u_1, u_2, u_3, u_m)$, where $U$ is the universal set in a fuzzy set environment and $u_1, u_2, u_3,$ and $u_m$ are the constructs. Each construct, which is defined as a second-level system, comprises some GIs. Therefore, the set $U_{GI}$ can be expressed as $U_s = (u_{np}, u_{os})$. In Table 5, the descriptive statistics of the input variables are presented.

**Table 5.** Description of government initiative input variables.

| Code | MI | SD | NV | CI | OR | CR | TM | CW |
|---|---|---|---|---|---|---|---|---|
| NP | - | - | - | $u_{np}$ | - | - | 28.00 | 0.585 |
| ST01 | 4.17 | 0.88 | 1.00 | $u_{np1}$ | 1 | 1 | - | - |
| ST06 | 4.10 | 0.85 | 0.77 | $u_{np2}$ | 2 | 2 | - | - |
| ST02 | 4.02 | 0.99 | 0.50 | $u_{np3}$ | 5 | 3 | - | - |
| ST04 | 3.99 | 0.89 | 0.40 | $u_{np4}$ | 6 | 4 | - | - |
| ST07 | 3.94 | 0.84 | 0.23 | $u_{np5}$ | 9 | 5 | - | - |
| ST05 | 3.89 | 0.96 | 0.07 | $u_{np6}$ | 10 | 6 | - | - |
| ST03 | 3.89 | 0.97 | 0.07 | $u_{np7}$ | 11 | 7 | | |
| OS | - | - | - | $u_{os}$ | - | - | 19.89 | 0.415 |
| ST09 | 4.08 | 1.04 | 0.70 | $u_{os1}$ | 3 | 1 | - | - |
| ST10 | 4.02 | 0.77 | 0.50 | $u_{os2}$ | 4 | 2 | - | - |
| ST08 | 3.97 | 1.07 | 0.33 | $u_{os3}$ | 7 | 3 | - | - |
| ST12 | 3.95 | 1.19 | 0.27 | $u_{os4}$ | 8 | 4 | - | - |
| ST11 | 3.87 | 1.04 | 0.00 | $u_{os5}$ | 12 | 5 | - | - |
| | | | Total | | | | 47.89 | 1.000 |

Notes: MI = mean index; SD = standard deviation; NV = normalized value = (mean e minimum mean)/(maximum mean × minimum mean); CI = codes for index system; OR = overall rank; CR = construct rank; TM = total mean; and CW = construct weighting.

#### 4.3.2. Membership Functions (MFs) of the Variables and Constructs

Fuzzy mathematics was used to generate the membership functions (MFs) for variables and constructs. The MFs of the variables were first calculated using the grading selections used to assess the level of effectiveness during the questionnaire survey. The formula used to calculate the MF for a given variable is shown in Equation (1).

$$\mathrm{MF}u_{in} = \frac{Z_{1u_{in}}}{k_1} + \frac{Z_{2u_{in}}}{k_2} + \frac{Z_{3u_{in}}}{k_3} + \frac{Z_{4u_{in}}}{k_4} + \frac{Z_{5u_{in}}}{k_5} \tag{1}$$

$$k_1 = very\ low,\ k_2 = low,\ k_3 = neutral,\ k_4 = high,\ \text{and}\ k_5 = very\ high$$

Here, the MF of a specific variable $u_{in}$; $u_{in} = n$th variable of a given construct $i$ $[i = u_{pr} = u_{dfs}, u_{ifs}, u_{dns}, u_{ins}, u_{pmk}]$ was indicated by the MF. Respondents' percentage of assigning a score of $g$ to indicate the level of effectiveness of a given variable was demonstrated by $Z_{g_{u_{in}}}(g = 1, 2, 3, 4, 5)$. Moreover, a relationship between $z_{1_{u_{in}}}$ was indicated by the terms $Z_{1_{u_{in}}}/k_i$, rather than an addition to its respective grade scale $k_i$, and the symbol + represents a notation. Therefore, the MF of a given variable can be represented by Equation (2).

$$\mathrm{MF}u_{in} = \left(z_{1u_{in}} + z_{2u_{in}} + z_{3u_{in}} + z_{4u_{in}} + z_{5u_{in}}\right) \tag{2}$$

The range of possible values for a given MF is between 0 and 1, and the total of all possible values must add up to 1. The MF for the construct was calculated by combining the MFs and weightings for each construct. Table 6 (see level 3) shows the MFs for the individual variables.

**Table 6.** Results from the fuzzy synthetic evaluation.

| Code | Level | MI | Weightings | MF Value |
|---|---|---|---|---|
| Overall | 1 | - | - | 0.03, 0.04, 0.16, 0.45, 0.32 |
| NP | 2 | - | 0.585 | 0.03, 0.03, 0.16, 0.47, 0.31 |
| ST01 | 3 | 4.17 | 0.149 | 0.02, 0.03, 0.11, 0.45, 0.40 |
| ST06 | 3 | 4.10 | 0.146 | 0.03, 0.02, 0.08, 0.56, 0.31 |
| ST02 | 3 | 4.02 | 0.144 | 0.02, 0.08, 0.12, 0.43, 0.36 |
| ST04 | 3 | 3.99 | 0.143 | 0.04, 0.01, 0.13, 0.56, 0.26 |

**Table 6.** *Cont.*

| Code | Level | MI | Weightings | MF Value |
|---|---|---|---|---|
| ST07 | 3 | 3.94 | 0.141 | 0.02, 0.01, 0.23, 0.50, 0.25 |
| ST05 | 3 | 3.89 | 0.139 | 0.02, 0.05, 0.25, 0.39, 0.30 |
| ST03 | 3 | 3.89 | 0.139 | 0.03, 0.04, 0.23, 0.42, 0.29 |
| OS | 2 | - | 0.415 | 0.05, 0.04, 0.15, 0.42, 0.34 |
| ST09 | 3 | 4.08 | 0.205 | 0.04, 0.04, 0.14, 0.37, 0.42 |
| ST10 | 3 | 4.02 | 0.202 | 0.02, 0.00, 0.17, 0.56, 0.25 |
| ST08 | 3 | 3.97 | 0.200 | 0.05, 0.04, 0.17, 0.38, 0.37 |
| ST12 | 3 | 3.95 | 0.199 | 0.06, 0.07, 0.16, 0.29, 0.43 |
| ST11 | 3 | 3.87 | 0.195 | 0.06, 0.04, 0.13, 0.51, 0.26 |

Notes: MI = mean index and MF = membership function.

#### 4.3.3. Membership Function Weightings

The relative importance of a particular GI was indicated by the weighting of the GI as expressed by the respondents. The weightings for the variables and constructs were estimated using the normalized mean method. The mean indexes of the independent variables and constructs were normalized using this technique. The formula used to estimate the weighting is demonstrated in Equation (3).

$$W_i = \frac{M_i}{\sum_{i=1}^{n} M_i},\ 0 < w_i < 1, \text{ and } \sum_{i=1}^{n} w_i = 1 \tag{3}$$

where $w_i$ = the weighting function of a specific GI or construct $I$; and $M_i = MI$ of a specific variable or the sum of the $MI_i$ for each variable in a construct. The estimated weighting functions of a particular variable or construct are depicted in Equation (4). Table 6 shows the weightings of all the variables and their related constructs.

$$W_i = (w_1, w_2, w_3, w_4, \ldots, w_n) \tag{4}$$

#### 4.3.4. Multicriteria and Multilevel Model Development

Each construct's effectiveness was first measured to establish its index before the OEI was established. The membership functions of all GIs are expressed in a fuzzy relational matrix denoted by $R_i$ (Equation (5)) to determine the effectiveness of a construct. $Z_{k_{u_{in}}}$ presents the elements representing the individual MFs at level two and level three.

$$R_i = \begin{vmatrix} \mathrm{MF}_{u_{i1}} \\ \mathrm{MF}_{u_{i2}} \\ \mathrm{MF}_{u_{i3}} \\ \vdots \\ \mathrm{MF}_{u_{in}} \end{vmatrix} = \begin{vmatrix} Z_{1_{u_{i1}}} & Z_{2_{u_{i1}}} & Z_{3_{u_{i1}}} & Z_{4_{u_{i1}}} & Z_{5_{u_{i1}}} \\ Z_{2_{u_{i2}}} & Z_{2_{u_{i2}}} & Z_{3_{u_{i2}}} & Z_{4_{u_{i2}}} & Z_{5_{u_{i2}}} \\ Z_{3_{u_{i3}}} & Z_{2_{u_{i3}}} & Z_{3_{u_{i3}}} & Z_{4_{u_{i3}}} & Z_{5_{u_{i3}}} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ Z_{1_{u_{in}}} & Z_{2_{u_{in}}} & Z_{3_{u_{in}}} & Z_{4_{u_{in}}} & Z_{5_{u_{in}}} \end{vmatrix} \tag{5}$$

Therefore, the fuzzy evaluation matrix represented by $D_i$ was calculated using the weighted function set of both the GIs and constructs (Equation (6)).

$$D_i = W_i \times R_i$$

$$D_i = (w_1, w_2, w_3, \ldots, w_n) \times \begin{vmatrix} Z_{1_{u_{i1}}} & Z_{2_{u_{i1}}} & Z_{3_{u_{i1}}} & Z_{4_{u_{i1}}} & Z_{5_{u_{i1}}} \\ Z_{2_{u_{i2}}} & Z_{2_{u_{i2}}} & Z_{3_{u_{i2}}} & Z_{4_{u_{i2}}} & Z_{5_{u_{i2}}} \\ Z_{3_{u_{i3}}} & Z_{2_{u_{i3}}} & Z_{3_{u_{i3}}} & Z_{4_{u_{i3}}} & Z_{5_{u_{i3}}} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ Z_{1_{u_{in}}} & Z_{2_{u_{in}}} & Z_{3_{u_{in}}} & Z_{4_{u_{in}}} & Z_{5_{u_{in}}} \end{vmatrix}$$

$$D_i = (d_{in}, d_{in}, d_{in}, \ldots, d_{in}) \tag{6}$$

where $d_{in}$ = thedegreeofmembership, $k_i$, of specific GIs constructs $i$; and a composite operation in the fuzzy environment is indicated by the designation $\times$. The EI for each construct was calculated using Equation (7) after the deduction into fuzzy evaluation matrixes.

$$\sum_{i=1}^{5} D \times K^t,\ 1 \leq OEI \leq 5 \tag{7}$$

The computed evaluation fuzzy matrixes, $D_i(i = 1, 2, 3, 4, 5)$, then form the fuzzy matrix $\overline{R}$ (Equation (8)) for computing the overall EIs of the GIs. Table 7 presents the EIs for the GI constructs.

$$\overline{R}_{(oei)} = \begin{vmatrix} \mathrm{MF}_1 \\ \mathrm{MF}_2 \\ \mathrm{MF}_3 \\ \mathrm{MF}_4 \\ \mathrm{MF}_5 \end{vmatrix} = \begin{vmatrix} d_{11} & d_{12} & d_{13} & d_{14} & d_{15} \\ d_{21} & d_{22} & d_{23} & d_{24} & d_{25} \\ d_{31} & d_{32} & d_{33} & d_{34} & d_{35} \\ d_{41} & d_{42} & d_{43} & d_{44} & d_{45} \\ d_{51} & d_{52} & d_{53} & d_{54} & d_{55} \end{vmatrix} \tag{8}$$

where $i = (1, 2, 3, 4, 5)$ represents the individual constructs.

**Table 7.** Effectiveness index of the GI constructs.

| No | GI Construct | Construct Code | Weighting |
|---|---|---|---|
| 1 | National policies | NP | 4.00 |
| 2 | Organizational strategies | OS | 3.98 |

For the final stage of the fuzzy evaluation matrix to be calculated, $\overline{R}$ was once more normalized using the weighted function $\overline{W}_{(oei)} = w'_1, w'_2, w'_3, \ldots, w'_n$ in Equation (9) using the individual constructs.

$$\overline{D}_{(oei)} = \overline{W}_{(oei)} \times \overline{R}_{(oei)}$$

$$\overline{D}_{(oei)} = (w'_1, w'_2, w'_3, \ldots, w'_n) \times \begin{vmatrix} d_{11} & d_{12} & d_{13} & d_{14} & d_{15} \\ d_{21} & d_{22} & d_{23} & d_{24} & d_{25} \\ d_{31} & d_{32} & d_{33} & d_{34} & d_{35} \\ d_{41} & d_{42} & d_{43} & d_{44} & d_{45} \\ d_{51} & d_{52} & d_{53} & d_{54} & d_{55} \end{vmatrix}$$

$$\overline{D}_{(oei)} = \left(D'_1, D'_2, D'_3, \ldots, D'_n\right) \tag{9}$$

where $oei$ = the OIE of the GIs; and the fuzzy evaluation matrix for the OEI of the GIs were indicated by $\overline{D}_{(oei)} = \left(D'_1, D'_2, D'_3, \ldots, D'_n\right)$, which can be measured using the grading scores $(k = 1, 2, 3, 4, 5)$ as per Equation (10).

$$OEI_{gi} = \sum_{i=1}^{5} \overline{D} \times K^t = \left(D'_1, D'_2, D'_3, \ldots, D'_n\right) \times (1, 2, 3, 4, 5), 1 \leq OEI \leq 5 \tag{10}$$

where the index generated for the OEI of the GIs is represented by $OEI_{gi}$. This stage entails the defuzzification process, which involves converting the fuzzy members into crisp values or outputs. The OEI of the GIs is calculated to be 4.00 using Equation (10). Hence, the GIs for enhancing BIM adoption in Saudi Arabia is effective. Thus, implementing any of the GIs or related constructs may lead to the success of BIM adoption in Saudi Arabia.

## 5. Discussions

### 5.1. National Policies

The first construct extracted from the EFA was national policies. This construct is related to GIs for enhancing BIM adoption, which consists of seven GIs: ST03, ST04, ST05, ST07, ST01, ST02, and ST06.

One way to successfully exchange information between stakeholders during BIM-based projects is through a standardized data exchange format [87]. BIM standards enable project continuity while providing the project owner with the desired format. Hence, they have the potential to significantly enhance productivity and guarantee the long-term viability of the BIM project as a whole. Consistent BIM standards are crucial for government agencies and departments that manage multiple projects involving numerous stakeholders. For example, the US developed the national BIM standard to offer the digital schema and requirements for efficient BIM use in the AEC industry. In the UK, national BIM standards have been established due to the relevant mandate. Without BIM standards, different stakeholders may collect and store data in various formats, creating inconsistencies and errors in the data, leading to confusion, misinterpretation of the data, and errors in decision-making. BIM adoption in countries where it is not yet extensively established and required by regulations can be tricky as diverse private and public sectors develop their own BIM guidelines and frameworks. As a result, adopting BIM in the industry becomes more difficult as stakeholders must familiarize themselves with the different BIM guidelines of each project. Therefore, it is critical to develop national BIM standards as one of the GIs for enhancing BIM adoption.

A digital transformation strategy is a comprehensive plan for utilizing digital solutions to improve the physical parts of an organization in engineering, manufacturing, and service. Digital transformation in the AEC industry offers the opportunity to integrate practices and resources, leading to new methods, skillsets, and monetary resources. Prior works show that a digital transformation plan in the UK could enhance BIM adoption [50]. Therefore, policymakers might create a plan for digital transformation for enhancing BIM adoption. A BIM mandate is a set of enforced policies requiring BIM for specific projects. BIM allows governments to develop responsibly by extracting the most social, economic, and environmental value from limited resources. Thus, certain countries are making BIM mandatory, as many sources suggest that BIM plays an important role in the AEC industry [88]. Therefore, a BIM mandate is an effective initiative for enhancing BIM adoption [89]. Since 2016, the UK has mandated BIM for all publicly funded projects [90], putting it at the forefront of the continent regarding BIM adoption. Furthermore, the US is the most advanced country in BIM adoption, with a 72% adoption rate [91]. However, without a mandate, stakeholders may have less incentive to embrace BIM, resulting in limited collaboration among different parties. This can result in communication issues, errors, and omissions, as well as a less coordinated approach to design and construction. Therefore, one of the GIs for enhancing BIM adoption is mandating BIM, which leads to improvements in the construction process, resulting in better-quality projects, higher efficiency, and greater transparency.

Market demand affects both businesses and customers as it affects how much is made and how competition works in the market. One of the main challenges hindering BIM adoption is market demand [92]. BIM adoption in the AEC industry may be boosted by increasing market demand [93]. By educating clients, policymakers might increase the market demand for BIM. Clients have a significant role in BIM demand; teaching them about the benefits of BIM can assist in boosting demand from other stakeholders. Thus, BIM adoption in the AEC industry may expand with market demand. The increased use and demand for BIM can be attributed to several factors, including governmental regulations, clients demanding BIM, and a competitive setting. These can be met by having trained BIM professionals. BIM professionals help to increase project quality by optimizing processes and working efficiently, reducing rework time and expense, and decreasing waste in a collaborative setting. BIM training benefits both individual users and large organizations. An incompetent individual may create errors in the BIM model, such as incorrect measurements, missing details, or inaccurate representations of the building's features. These mistakes can cause problems and errors during the construction process, which can cause delays and higher costs. As a result, developing programs to improve BIM competencies is critical to ensuring the success of BIM projects.

In most countries, the high price tag associated with BIM is a major roadblock to its widespread use. BIM-related direct costs such as software licensing, the cost of hiring BIM professionals, and employee training programs can influence stakeholders. As a result, project stakeholders are hesitant to adopt BIM as it has significant financial implications. Financial support from the government could help AEC organizations optimize the transition to BIM. The financial burden on stakeholders can then be reduced, and BIM adoption in countries can be encouraged. Furthermore, governments may provide grants or subsidies to organizations or individuals to assist with the costs of BIM adoption. These grants or subsidies may pay for training, software, hardware, or consulting services. Therefore, financial aid can encourage BIM adoption. In order to encourage the industry to begin BIM adoption as an innovative method to deliver projects, prior works have stressed the significance of spreading information about the adoption process, its benefits, and its challenges. By raising awareness, organizations are encouraged to adopt BIM.

In contrast, ref. [94] attributed the delayed adoption to a lack of awareness. BIM is meant to improve efficiency in the construction process. However, without awareness of its benefits, organizations may continue to rely on inefficient, traditional methods. Therefore, raising awareness is necessary to overcome the challenges of BIM adoption.

### 5.2. Organizational Strategies

The second construct extracted from the EFA was organizational strategies. This construct is related to organizational efforts for enhancing BIM adoption, which consists of five GIs: ST09, ST11, ST10, ST08, and ST12.

The introduction of BIM is having an impact on AEC education. Numerous educational institutions have begun integrating BIM into educational programs to meet industry demand for professionals with BIM skills [95]. Bridging the gap between industry and academia by equipping graduates with BIM skills is one of the benefits of incorporating BIM into educational programs. According to [96], BIM is an effective teaching tool for estimation and quantity take-off skills, as well as for design comprehension skills and the understanding of construction materials, methods, and processes. Furthermore, BIM education can help organizations overcome a dearth of qualified BIM professionals by producing BIM-ready personnel [72]. Therefore, it is essential to have educational programs incorporating BIM to better prepare graduates for the job and satisfy industry demands.

With any BIM project, it is critical to establish how BIM is executed. Hence, BIM adoption guidelines should be developed at an organizational level. One of the most important things organizations can do for enhancing BIM adoption is to draft suitable BIM guidelines that may be included in contracts [97]. In addition, BIM guidelines provide a standardized approach for BIM adoption within an organization, ensuring consistency in the use of BIM software and processes, leading to better collaboration and communication between team members. Therefore, one of the steps that policymakers can take for enhancing BIM adoption is developing guidelines. Furthermore, BIM legal difficulties are regarded as challenges that must be addressed appropriately. In [98], it was pointed out that one of the challenges is the requirement of developing contractual arrangements to achieve positive BIM results. BIM contractual frameworks provide clarity and consistency regarding BIM expectations and the responsibilities of all parties involved in a construction project. This helps avoid misunderstandings and disputes arising due to a lack of clarity in BIM project requirements. Therefore, it is crucial to develop a BIM contractual framework as one of the GIs for enhancing BIM adoption.

Organizations can begin BIM adoption with pilot projects, measure their outcomes, and realize benefits that can be scaled up to an organizational level. A successful pilot project serves as a model for encouraging the project stakeholders to adopt BIM in the future. In addition, a pilot project can assist staff in comprehending BIM tools while determining their internal training and development needs. As the transition is difficult, it is preferable to provide the team with advanced skill sets to prepare them for complex BIM projects in the future. Ref. [51] proved that initiating pilot projects to realize BIM benefits was the primary GI for enhancing BIM adoption in the Finnish AEC industry. Therefore, as one of the GIs for enhancing BIM adoption, organizations should initiate pilot projects to exploit potential evidence-based benefits.

According to [99], one of the obstacles associated with BIM adoption is the shortage of professionals who received formal training in BIM. To address this, a BIM institute might be constructed to provide education and training to AEC professionals for upskilling and reskilling. This can help to promote and enhance BIM adoption in the industry. Furthermore, a BIM institute can also conduct research to further the use of BIM, resulting in new insights, innovations, and best practices that can improve the outcome of projects, lower costs, and increase sustainability. Therefore, another GI for enhancing BIM adoption is creating a BIM institute for fresh graduates.

## 6. Conclusions

This study examines the GIs that policymakers could use for enhancing BIM adoption in Saudi Arabia. Twelve potential GIs for enhancing BIM adoption are presented based on data from semi-structured interviews with BIM professionals and a systematic literature review of published articles. The mean ranking, normalization, EFA, and FSE techniques were then used to examine the 101 surveys completed by AEC professionals. From the analysis, out of the twelve potential GIs, there are five critical GIs for enhancing BIM adoption. The critical GIs include developing programs for improving BIM competencies, developing programs to increase BIM awareness and understanding, developing programs to integrate BIM into education curricula and academia, developing BIM-related contractual frameworks, and providing financial aid to reduce the cost of BIM adoption. The EFA results indicate that the underlying GIs are national policies and organizational strategies. The study addresses GIs for enhancing BIM adoption in Saudi Arabia. This study can help researchers, practitioners, and policymakers boost BIM adoption. The study's key theoretical contribution is a better grasp of the GIs necessary for enhancing BIM adoption. Prior works have identified GIs for enhancing BIM adoption in other countries, including China, Turkey, and Nigeria. Hence, it is critical to use caution while implementing GIs in different countries, as the initiatives may function differently and need specific changes to meet the needs and regulations of each nation. Therefore, GIs tailored to each country are required to fill the BIM adoption gaps in their respective industries.

This study addresses the knowledge gap by investigating GIs for enhancing BIM adoption in Saudi Arabia. It outlines critical GIs for enhancing BIM adoption and evaluates the effectiveness of every GI. Therefore, academics and researchers could employ the findings to propose frameworks for better BIM adoption. Furthermore, the results pave the way for future innovations, such as digital twins, which allow stakeholders to monitor the status of their assets or systems in real-time and make any necessary adjustments.

While this study certainly has its benefits, it also has limitations. To begin, a possible limitation of the study is the small number of survey respondents ($n$ = 101). However, this study can be replicated in the future with a larger sample size. Second, the outcomes greatly depend on the local situation in each country. As a result, the conclusions should be applied with caution and suitable modifications to other countries. Third, the broader range of data gathering across various countries and locations allows for comparisons and insights into the impact and applicability of the results. Fourth, this study did not tabulate GIs according to countries, as a comprehensive literature review is necessary for avoiding misrepresenting the efforts of any governments. Future research can consider employing an SLR to comprehensively compare the GIs between countries. Nevertheless, the research will have some limitations due to language barriers from the existence of non-

English publications and limited access to government documents, which could potentially cause misinformation. Therefore, the research should be completed with great caution. Finally, future research can expand the study by employing more advanced statistical analysis techniques, such as structural equation modeling. As a result, it will be easier to comprehend every GI with an established causal relationship. However, the study's findings still provide significant knowledge about GIs that can enhance BIM adoption in Saudi Arabia.

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