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Factors Affecting BIM Adoption in the Yemeni Construction Industry: A Structural Equation Modelling Approach

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Abstract: The construction sector is one of Yemen's most important economic pillars. Building information modelling (BIM) is a new information technology implementation that can create an intelligent digital design of buildings to support a variety of tasks and provides a wide range of benefits throughout the project life cycle. However, BIM is not widely embraced in Yemeni construction firms. Compared with other countries, Yemen presents a unique case for BIM adoption due to the ongoing war in the country, which will assist in rapid rebuilding processes. Thus, a complete and systematic investigation of the factors affecting BIM adoption in the Yemeni construction industry is required. This study utilises five categories of impacting factors: Technology, Process, Policy, People, and the Environment to model the strategic implementation for BIM in the Yemeni construction industry. A random sample was used to achieve homogeneity and increase the consistency and quality of data. Purposive sampling was used to choose participants for the framework validation. The data were analysed using partial least squares structural equation modelling (PLS-SEM), and the key factors influencing BIM adoption were determined and modelled. The results show multivariate results indicate a high correlation within the measurement model for all factors affecting BIM adoption in Yemen. In addition, the developed model was deemed to fit because the analysis result of the model's coefficient of determination test (R^2) is BIM adoption having 0.437, Environment at 0.589, and People having 0.310, demonstrating high acceptance. Moreover, the results reveal a high correlation between policy and people (>0.50), while the environment significantly affected BIM adoption (0.304). Overall, the model illustrated how various factors influence BIM adoption. The created framework highlights the importance of understanding BIM adoption concepts and challenges in the Yemeni construction industry. It is believed that this study highlights the BIM implementation in developing countries such as Yemen and the possibility of implementing the proposed method in other countries to develop their own BIM implementation strategy.

Keywords: building information modelling; BIM adoption; construction industry; technology factors; Yemen; partial least square; PLS; SEM

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1. Introduction

Construction industries worldwide use building information modelling (BIM) to plan, build, and monitor their projects. The BIM adoption rate is increasing in several countries in the public and private construction sectors [1]. However, BIM has not been studied adequately for building project management, and there is a lack of extensive evaluations that objectively analyse the advancements in BIM applications in the construction sector [2]. Succar [3] discusses the BIM framework's fields, stages, and lenses. BIM competencies include implementation maturity, activity domain, level/scope, and requirements assessment. Adopting BIM requires professionals and organisations, not software or technology; three knowledge models are described (i.e., in Technology, Process, and Policy developments).

The significance, drivers, obstacles, and factors for government policies on BIM adoption methods need to be determined and implemented [4]. The project lifecycle benefits greatly from BIM. These advantages are, nevertheless, compromised by challenges and the construction industry's failure to integrate BIM technology properly [5]. The primary elements influencing BIM adoption in the global construction sector are processes, people, and technology [6]. Babatunde [7] highlighted the barriers to BIM adoption and implementation in the Nigerian construction sector and discovered that enterprises are still underperforming in BIM adoption and implementation. Therefore, further work is needed to deepen the BIM adoption and acceptance strategies. The unpleasant precedent predicted by building professionals since BIM's inception in Malaysia has prompted more profound research into BIM adoption [8].

Despite several attempts to analyse and model the BIM framework in the construction industry, current research has flaws in how it views BIM as a separate technical and administrative process rather than a working process that is supposed to be instantaneous or simultaneous and emergent. The BIM knowledge framework, practical implementation at the industry level, BIM application, and BIM acceptance are some of the frameworks proposed to disperse BIM application in the construction sector [8]. Numerous studies looked at technical integration, the usage of BIM tools, and model-sharing concerns, which dwell on a technical aspect of BIM technology. However, this research was limited to the use of BIM in the building sector in general. There is a shortage of in-depth examination of the obstacles and success factors for effective BIM deployment among local organisations or at the organisational level in building projects [9].

The Yemeni construction industry experienced noticeable growth in early 2011. After the war started in 2015, there was a considerable decline in the construction industry, and many projects were suspended. In early 2016, people got used to the instability within the war environment and started to adopt the new norms of life, resulting in the unsustainable building of their houses despite the shortage of materials and machinery. Additionally, ongoing projects were funded by different non-governmental agencies and the Social Fund for Development [9].

Complexity, instability, and time constraints are among the significant issues affecting project delivery in the construction industry. Yemen's construction industry is no exception [10–13]. Using 2D CAD for many years has not enhanced collaboration or project performance. Yemen's construction sector is growing. Yemeni construction industry stakeholders are working to improve construction efficiency. Still, the sector has technical obstacles, such as a lack of acceptable building materials, labour construction technology and a lack of BIM awareness and knowledge [12]. Therefore, techniques for BIM application in the Yemeni construction sector should be studied to improve project cooperation and performance [12,13].

There are limited studies on BIM in the Yemen construction industry, and construction stakeholders are resistant to embracing changes, which encourages traditional building practices linked with incorrect planning and monitoring resulting in cost overruns, schedule overruns, low quality, and project failure [12]. Ineffective regulation and law, limited utilisation of local construction technology, inadequate financial structure, and incorrect use of local building resources were other problems [13]. An extensive review of the relevant literature shows that most construction industries in Yemen still use 2D CAD. Holistic research on BIM adoption, especially in Yemen, is absent. This research integrated and examined BIM implementation aspects across the building process to produce an effective and complete implementation plan in Yemen. For effective BIM adoption, local organisations and the entire building industry need in-depth analyses of the challenges and success factors.

This study fills this gap and narrows the scope by focusing on the Yemeni industry scenario. Moreover, this study investigated the extent of BIM adoption in construction projects, particularly among local organisations in Yemen, and has contributed to the body of knowledge due to the limited literature on BIM adoption in the Yemeni construction industry. It also examines the factors affecting BIM adoption, knowledge, and awareness in the Yemeni construction sector. As a result of the thorough literature review, in-depth discussion during the interviews, and factor analysis evaluation, new factor groupings are also identified. In addition, the study also created an SEM model that detailed the correlations between the factors that influence the adoption of BIM. The model helps to better understand how independent factors impact the adoption of BIM. The created framework is an excellent example of the significance of understanding the BIM adoption ideas and challenges and assessing the elements and BIM technology motivators to accomplish effective adoption in building projects. Other researchers might use the suggested approach to evaluate its value in promoting BIM adoption in construction projects.

2. Literature Review

The need for BIM in the construction industry became apparent after reviewing papers and studies. A substantial amount of information on BIM, including definitions and relevance to the construction industry, has been published in the academic and non-academic literature. Some frameworks suggested for implementing BIM in the construction industry include the BIM knowledge framework, industry-level implementation, and BIM acceptance. Other studies investigated the concerns of model sharing, BIM tool use, and technology integration. Most construction industries in underdeveloped nations are BIM infant industries that struggle with adoption and implementation [14]. Therefore, BIM infants are confronted with obstacles varying from innovative features to internal and exterior settings. As noted in several developed nations, the lack of official backing for BIM in most countries is a substantial barrier.

Recent research by [15] in "macro-BIM adoption: comparative market analysis" contributes to comparative market research. That paper offers suggestions for newly adopting countries seeking to deploy macro-BIM. In this expanding industry, precedent is crucial for education and acceptability. This study evaluated BIM adoption trends in the United States, the United Kingdom, and Australia to serve as a model for early adopting countries. The study demonstrates: government engagement increases BIM adoption; government mandates enable widespread BIM adoption and integrate a country's industry into the global marketplace; the ruling also supports BIM research and training, which leads to revenue development through training and workforce export; diffusion dynamics vary throughout time based on a country's propensity to absorb innovation; and the dynamics also alter as the culture and regulations of a sector evolve.

Moreover, the study by [16] evaluates and defines the usefulness and inefficiency of BIM technology in construction infrastructure projects and presents a comparative and exhaustive examination of academic literature and industry reports. Its implementation provides a framework solution to profit and utilise BIM to overcome inefficiencies and obstacles. The study intended to develop a method for identifying difficulties. The excessive nature of BIM (acronyms and competing acronyms) also results in a gap. People need a framework for applying an objective emphasis on BIM methodology, requirements, goal achievement, and agreed-upon measurements, as well as an objective focus on what to deploy and when (standards and technology) concerning the project's aims and advantages.

Information collecting relies on the expert analysis provided by conventional storage. The Internet of Things (IoT) and smart devices generate vast quantities of live data from several sources; hence, IoT–BIM integration is essential. Replace semantic information with internal conditions to construct Service-Oriented-Architecture (SOA). Connect static to real-time models using SOA. It is crucial to develop two-way communication to imitate human thought. Cloud computing is required for IoT device connectivity. Integrating BIM with Internet of Things (IoT) real-time data enhances construction and operational efficiency and produces high-fidelity BIM models. The study addresses IoT concerns connected to BIM. Cloud computing eliminates interoperability problems. The document investigates and identifies new BIM–IoT application areas, followed by enhanced procedures [17].

Due to country-specific socio-cultural, economic, and legal conditions, marketing and implementing BIM for building projects varies. Cambodia's building sector's BIM adoption is unknown. This study investigates BIM industry obstacles. Detailed survey responses and professional architects and contractors. In the final datasets, 13 key drivers were identified. The use of technology enhances project visibility, and technology alters project timelines. The future of an industry is influenced by the information stakeholders share. Technology adoption's is the most significant obstacle that pushes toward industrial resistance to change, especially, reluctance towards inadequate BIM conversion from 2D to 3D, which is expensive. Study implementation can adapt and apply technology to improve Cambodia's construction progress and project success through socio-cultural, economic, and regulatory parallels [17].

Enegbuma [18] conducted a study in Malaysia to investigate BIM adoption, focusing on BIM interpretation (factors influencing BIM) and sources for successful BIM adoption. This collaborative approach mediated the interaction between strategic IT planning and BIM adoption. It identified the factors that have the most significant impact on BIM perception in Malaysia. Another development was made in Singapore by Attarzadeh and Tiong [19], likely to interest many researchers and industries looking to implement the BIM technique. This study was to see what factors impact BIM adoption and application in the AEC sector in Singapore. The study results aid AEC firms in ensuring BIM acceptance during the project life cycle. The study also recommended that government agencies develop standard, comprehensive functional guidelines, models, and BIM public libraries for various areas to promote new technologies.

Similarly, Rosli et al. [8] investigated the link between numerous constructs that influence BIM adoption. The Structural Equation Modelling (SEM) model fit indices and the association strength within the components were used to investigate this link. It is advised to employ ongoing BIM-friendly policy formulation, individuals, procedures, and technology to primarily address the issues impacting BIM adoption in the worldwide construction sector. Hosseini et al. [20] introduced some results of a study effort in Australia where they employed a questionnaire survey to target SMEs in the construction sector. The research provides the most up-to-date information on BIM in Australia's small- and medium-sized enterprises. It offers and expands upon a framework based on the innovation diffusion concept (IDT).

Yemen has suffered and is continuously experiencing mass structural destruction from a war that has been happening for many years. Many vital structures have been destroyed, and reconstruction is inevitable [21]. Usually, the reconstruction of destroyed buildings, such as hospitals, schools, universities, factories, highways, etc., requires a substantial amount of time, money, and effort. An effective and efficient construction approach such as building information modelling (BIM) is essential for rebuilding efficiency and cost-effectiveness.

Gamil et al. [9] noticed that Yemen's construction industry had substantially declined and failed. The sector's growth has been halted, and most projects have collapsed. Several factors have played a significant role in the industry's downfall. It is problematic because the study views BIM as a discrete technical and administrative procedure rather than an interactive, continuous, and emergent working process. Alaghbari [22] indicates that construction project costs and time overruns are caused by various factors, including poor labour productivity.

Moreover, according to Kassem [13], the economics of Yemen prepends on heavily the gas sector. Any active building project has a unique set of risk concerns. As a result, external risk factors have the most significant impact on Yemen's oil industry. The greatest risk indicators for cost and schedule overruns were those related to project management. According to Dahmas [21], Yemen's construction industry is pressured to reduce production time and project costs. Yemen needs to use concurrent engineering (CE) to speed up the reconstruction of its facilities. CE focuses on the design stage and gets it done right the first time. However, delays in implementing construction projects, especially public projects, have become common in Yemen.

3. Methodology

3.1. Identifying and Evaluating the Factors That Affect the Adoption of BIM

This study aims to identify the factors influencing the adoption of BIM in Yemen's construction industry. The initial technique for conducting research is to go through several sources, such as scholarly journal articles, conference proceedings, and books, to determine all aspects of the concepts [23]. This study conducted intensive research of the previous literature to study the adoption of BIM in the construction industry. Two essential techniques are employed to extract and filter the components from the literature: similarity analysis and frequency analysis. Analysis of similarity is a technique used to avoid duplication of variables with similar meanings and distinct phrases; it also aids in establishing a collection of factors that differ in terms of purpose and intent [24]. Frequency analysis is the number of repetitions from the various literature sources of BIM adoption in the construction industry [19]. The list of factors connected to the construction industry is given to five Yemeni professionals; each has over 20 years of experience working in Yemen's construction industry. Using expert opinion in Yemen's construction industry proved extremely valuable in identifying the most critical challenges of implementing BIM in Yemen [3]. Then, the experts were asked to classify these components conceptually into categories, and ambiguous elements were improved. Figure 1. Summarises all stages of the methodology.

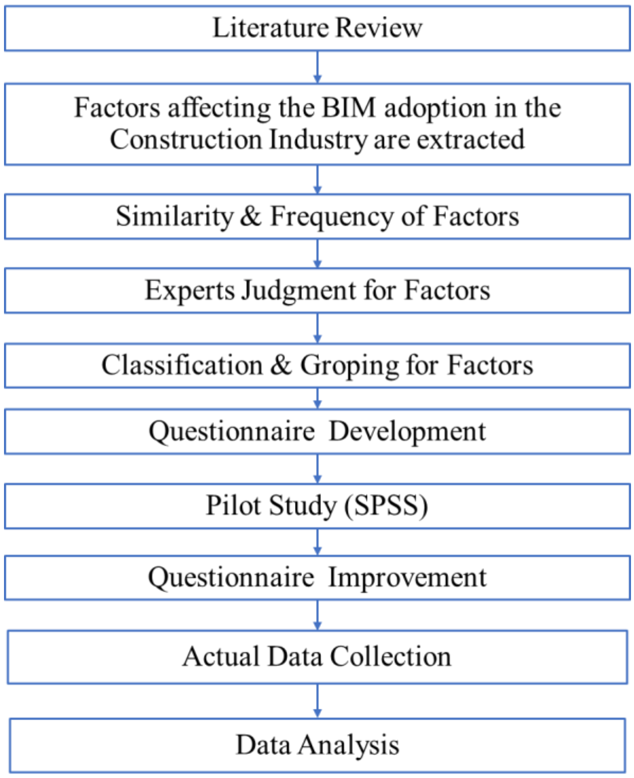

Figure 1. Research method.

A random sample was used to achieve homogeneity and increase the consistency and quality of data. Purposive sampling was used to choose participants for the expert's evaluation depending on criteria such as years of experience within the Yemeni construction industry, BIM experience, organisation size, and job description. Table 1. lists the final assessment items for these constructs.

Table 1. Assessment of the factors that influence BIM adoption in the Yemeni construction industry.

Code	**Category 1: Technology (TEC)**	**References**
TEC01	Lack of full automation in the construction industry	[8,18,25,26]
TEC02	Lack of BIM knowledge within the project	[27–33]
TEC03	Visualisation of construction sequences	[6,24,34–39]
TEC04	Trialability (Possibility of risk reduction with the try-out before adopting BIM in practice, and trying out various BIM features in my work to verify its effects)	[6,24,29,34–36]
TEC05	The usefulness of digital transfer of data	[24,26,40–42]
Code	**Category 2: Process (PR)**	**References**
PR01	Information availability and sharing	[35,41,42]
PR02	Providing guidance on the use of BIM	[40,42]
PR03	The leadership of senior management	[18,42–45]
PR04	Contractual sharing norm	[35,41,42]
PR05	Shared norms and collective expectations diffused through information exchange activities	[35,42]
PR06	Shared liability between project participants	[41–46]
PR07	Production of drawings and schedules	[27,47,48]
PR08	Desire to speed up the design process	[24,42]
PR09	Collaboration (project) management tools	[42]
PR10	Standard and rules	[42]
PR11	Companies' collaboration experience with project partners	[27,42,47,49,50]
PR12	Developing data exchange standards	[24,41,42,45,46,51,52]
PR13	Greater collaboration with consultants and other project team members	[46]
Code	**Category 3: Policy (PL)**	**References**
PL01	Financial resources of the organisation	[6,35,42,47,53,54]
PL02	Regulation and policy	[35,42,47,55]
PL03	Organisational readiness	[6,8,26,29,34,35,46,55–59]
PL04	Weak legal institutions	[60,61]
PL05	Guidance on the use of BIM	[40,42]
PL06	The increased demand for design and building	[42,47,51]
PL07	Lack of government incentives	[29,33,41,45,51,62]
PL08	Lack of construction codes	[9,22,24,53,57,63,64]
Code	**Category 4: People (PPL)**	**References**
PPL 01	Lack of skills and knowledge of one of the partners	[65–70]
PPL 02	Lack of cooperative concept	[4,18,21,24,26,41,71–75]
PPL 03	Lack of BIM expertise	[29,32,41]
PPL 04	Lack of top management support	[28,74–81]
PPL 05	Errors by a design team in construction projects	[13,33,56,82–85]
PPL 06	Weak supervision and control	[50,86–90]
PPL 07	Lack of demand by clients	[20,32,33,45,47,53,62,84,91–94]

Table 1. *Cont.*

Code	Category 5: Environment (ENV)	References
ENV 01	Security of information on project data	[22,24,42,46,51,52,54,62,94,95]
ENV 02	Poor Internet connectivity	[50,64,96]
ENV 03	Allows coordination and collaboration between disciplines	[46,47,51,53,57,97]
ENV 04	BIM readiness by project consultants.	[50,64,96]
ENV 05	Poor economic condition	[5,13,55]
ENV 06	Method of communication between the team	[18,20,24,26,32,35,36,41,52,92]
ENV 07	Market demand, size, and competition increase	[98–101]
ENV 08	Risk management	[2,34,72,102–107]
ENV 09	Facility management and building operation	[17,108,109]
Code	**Intention to Adopt the BIM**	**References**
ADBIM1	Encourage the staff to use BIM in regular workflow, even without BIM being the official workflow process at the organisation	[94]
ADBIM2	Implement BIM in future projects, regard less of its implementation level	[94]
ADBIM3	Invite other partner organisations to use BIM for project communication purposes	[94]

3.2. Questionnaire Design

A questionnaire is a comprehensive set of instruments presenting respondents with questions to answer by choosing responses that match their ideas [110]. This study uses the literature review results and expert interviews to improve the questionnaire design. The factors affecting the adoption of BIM in the construction industry were extracted and then categorized into groups. Using a Likert-style scale, these factors determine the elements' degree of importance and seriousness.

A pilot study observes the perspectives and feedback of construction industry experts. It also aids in identifying issues, evaluating questions for clarity, confirming quality, and validating measurement scales. The second objective of the pilot research is to assess and improve the questionnaire's content [111]. This study surveyed 30 Yemeni construction professionals for a pilot study to examine the internal accuracy of the questionnaire regarding data evaluation and assess the variables' importance.

3.3. Data Collection

Surveys are often used to collect research field sample data. Despite a poor response rate and bias, they can examine essential topics. This survey is based on earlier research that led to government guidelines, suggestions, and principles for determining research data requirements [112]. A two-part quantitative questionnaire was developed and utilised for data collection. The first part comprised respondents' demographic information, including their age, education, position, BIM experience, and work experience. Table 2 shows that most participants have more than ten years of experience in the construction industry, and their career is strongly tied to civil/structural engineering. There were more designers or consultants in the research than in the public sector, with fewer participants. The rest are in the private sector and (Mix) public and private.

Table 2. Factors affecting demographics.

		Frequency	Percent %
Qualification	High School	1	0.4
	Diploma	5	2.1
	Bachelor	137	58.3
	Masters	58	24.7
	PhD	34	14.5
Specialisation	Designer or Consultant	160	68.1
	Contractor/Construction	64	27.2
	Client	11	4.7
Organisation	Public	35	14.9
	Private	94	40
	Public and Private (Mix)	106	45.1
Profession	Architecture	33	14
	Civil/Structural Engineering	147	62.6
	Electrical Engineering	13	5.5
	Mechanical Engineering	2	0.9
	Project Management	14	6
	Construction Management	11	4.7
	Quantity Surveying	3	1.3
	Technical in panning team	5	2.1
	Others	7	3

The second part of the questionnaire had 45 items (see Table 1 for details). Using a Likert scale of 1 to 5, the respondents' attitudes and comprehension of BIM adoption factors in the Yemeni construction industry were evaluated (1: strongly disagree; 2: disagree; 3: neutral; 4: agree; and 5: strongly agree). The online surveys were open to a broad public. The most efficient method of communication during the COVID-19 pandemic was online; hence, the Ministry of Public Works and Highways and Yemeni Engineers Syndicates (YES) were contacted repeatedly to distribute the survey to all registered engineers. Access to the study was permitted for four months. Despite receiving 235 survey responses, the intended sample size for the study was 475 people. The questionnaire was answered by 49% of the respondents that participated in the study. A quantitative technique was used to investigate the factors affecting BIM adoption in the Yemeni construction industry.

3.4. Structural Equation Modelling (SEM)

A measurement model (confirmatory factor analysis) and a structural model are combined in the SEM test. In formulas, all evaluation component connections are specified. Since SEM captures the structure of latent variable relationships, the measuring method must be validated. Scale reliability is the dependability of an internal element. It is computed using Cronbach's alpha coefficient, with a minimum value of 0.70 and a higher value suggesting more accurate measurement scales for latent variables. The analyses include concept validity, reliability, convergent and discriminant validity, and structural model evaluation.

Estimating and quantifying relationships for interactions among components/latent variables distinguishes structural equation modelling from other data analysis methodologies [113]. Over the last decade, SEM has captivated the interest of a rising number of scholars in psychology, social science, and strategic management [114]. SEM is used to explain a wide range of empirical data to evaluate the validity of statistical models' underlying ideas. On the other hand, the researcher employs the SEM technique to estimate a specific model. Hypotheses can be tested using SEM, including both latent and observable variables. SEM's aggregate topographies of factor analysis and multiple regression are used to examine the structural properties of both theoretical and measurement models.

Many academics have resorted to SEM as an alternative to first-generation data analysis approaches, such as regression analysis and defining multi-layer correlations between dependent and independent variables [115]. SEM concurrently examines structural models and data. It concurrently models several dependent and independent variables. SEM must be understood before usage. PLS-SEM and CB-SEM are examples of methods. Smart-PLS software created a conceptual measurement model for examining observable characteristics. PLS replicates the model by calculating and measuring item loading, reliability, and validity. To estimate PLS model parameters, first, solve the measurement model's blocks, then compute the structural model's path coefficients [116]. Even though individual item reliability was satisfactory, construct reliability was nevertheless advised for observing group item reliability within the same construct. The internal relationship between items belonging to the exact constructions is more remarkable, as seen by construct-level dependability [117]. The commonly used "Average Variance Extracted" strategy was used in this study to examine convergent validity [118]. This method is considered comparable to that of Fornell and Lacker. The HTMT number must be less than 0.90 [119].

Because PLS does not need distribution assumptions, bootstrapping was utilised to generate t statistics and confidence ranges. Route estimates based on the inner path model or hypothetical relations demonstrated the correct connection. It was utilised to assess each framework path. PLS bootstrap was used to determine structural model hypotheses. According to research, the path coefficient must be at least 0.1 for a model to have an effect. The mediating analysis uses a rigorous bootstrapping method. Some scholars believe that mediation analysis diminishes the significance of the direct impact. Inadequate sample size or predictive ability may limit the detection of a relevant direct correlation. As a result, the mediation analysis is the most important part of observing the indirect impact [120].

4. Results and Findings

This research method investigates BIM acceptance and usage, as well as how the perspectives of BIM drivers, advocates, and early adopters may be utilised to develop a contextualised BIM adoption framework. The conceptual framework supports fundamental research methodologies. This model integrates Policy, Process, Technology, People, and the Environment for BIM adoption in Yemen's construction industry.

In this study, eleven hypotheses were formulated based on the theoretical model illustrated in Figure 2; the potential for BIM's further adoption in the construction sector:

H1. *Environment (ENV) has a significant effect on BIM adoption (ADBIM).*

H2. *People (PPL) have a significant effect on BIM adoption (ADBIM).*

H3. *Policy (PL) has a significant effect on BIM adoption (ADBIM).*

H4. *Policy (PL) has a significant effect on Environment (ENV).*

H5. *Policy (PL) has a significant effect on People (PPL).*

H6. *Process (PR) has a significant effect on BIM adoption (ADBIM).*

H7. *Process (PR) has a significant effect on Environment (ENV).*

H8. *Process (PR) has a significant effect on People (PPL).*

H9. *Technology (TEC) has a significant effect on BIM adoption (ADBIM).*

H10. *Technology (TEC) has a significant effect on Environment (ENV).*

H11. *Technology (TEC) has a significant effect on People (PPL).*

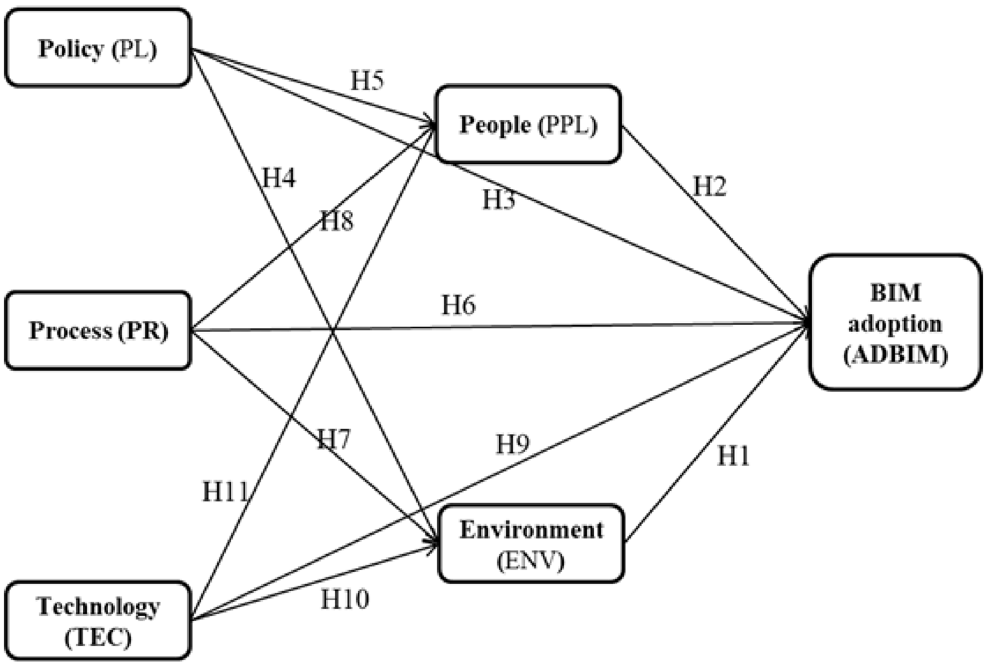

Figure 2. The hypotheses of the research.

A partial least square estimate technique was used to investigate the theoretical model. The measurement and the structural model parameters were estimated using Smart PLS 3.0.

4.1. Experts' Assessment of the Factors

Establishing a model for final variables focuses this investigation on defining features that benefit the Yemeni construction industry. Expert opinion was precious in identifying the most crucial issues in implementing BIM. Table 3 illustrates the respondent's demography, indicating that 40% of the experts are above 55 years, while those between 36–45 years represent 60%. Moreover, respondents that spent more than 20 years in the industry represent 60%, whereas those between 11 to 15 years represent 40%.

Table 3. Demographic characteristic analysis for the experts.

Demographic Characteristics	Frequency	%
Age group:		
Above 55 years	2	40%
36–45 years	3	60%
Experience in the construction industry:		
Above 20 years	3	60%
11 to 15 years	2	40%
Qualification:		
PhD	5	100%
Organisation:		
Private	2	40%
Private (Mix)	3	60%
Job description:		
Commercial Buildings; Industrial Buildings	2	40%
Governmental Buildings; Roads and Transportation; Water and Sanitation Projects	1	20%
Residential Buildings	2	40%

One hundred percent of the respondent have a Ph.D. The majority projects undertaken by the respondents are residential and commercial buildings, with 40% each. Respondents from the private sector represent 40%.

4.2. Pilot Survey

The pilot survey is aimed to test the questionnaire's accuracy, completeness, and ease of understanding by the respondent. It helps uncover flaws, assess whether questions are straightforward, and check to measure scales' reliability and validity. The pilot research helped improve the questionnaire's content and find unclear or complicated questions. After explaining and clarifying questions to the respondents, the researcher collected 30 complete responses from the respondents who were emailed the pilot study questionnaire.

Reliability Test: This section calculates the first Cronbach alpha values based on five BIM adoption factors affecting the construction industry. SPSS is used to calculate Cronbach's alpha; the result of the original Cronbach's alpha value is less than the minimum [121]. Using Cronbach's alpha, which ranges from 0 to 1, a reliability analysis determines if the data obtained are consistent. If Cronbach's alpha value is less than 0.3, the reliability is poor, and the data cannot be trusted. A higher Cronbach's alpha implies better internal consistency in the data [122]. The data have a high and respectable level of consistency if Cronbach's alpha value exceeds 0.7. The pilot study's Cronbach alpha is shown in Table 4.

Table 4. Cronbach Alpha (Pilot Study) Constant factors affecting BIM adoption.

Construct	No of Items	Cronbach Alpha Value
Technology (TEC)	5	0.838
Proses (PR)	13	0.825
Policy (PL)	8	0.826
People (PPL)	7	0.925
Environment (ENV)	9	0.800
The extent of BIM adoption in the Yemeni construction industry (All Categories)	42	0.930

All the items are trustworthy, and the real test is internally consistent according to the overall model's Cronbach alpha value being substantially higher than 0.7.

4.3. Assessment of Measurement Model

Figure 3 shows the model development. The first stage in examining the model is to evaluate the measurement model, which involves assessing Cronbach's alpha and composite reliability for construct reliability, convergent and discriminant reliability, and discriminant validity for composite and discriminant validity. The outer model, also known as the measurement model, is used in factor analysis to determine how loaded observed variables are on their underlying construct. To confirm the underlying relationship between the observable variables and the hidden components, an outer model/CFA is advised. Figure 3 shows each item's factor loadings/outer loadings, and the Cronbach alpha (CA) for each constant derived using the PLS-Algorithm. Moreover, Table A1 indicates some descriptive analyses resulting from Smart PLS.

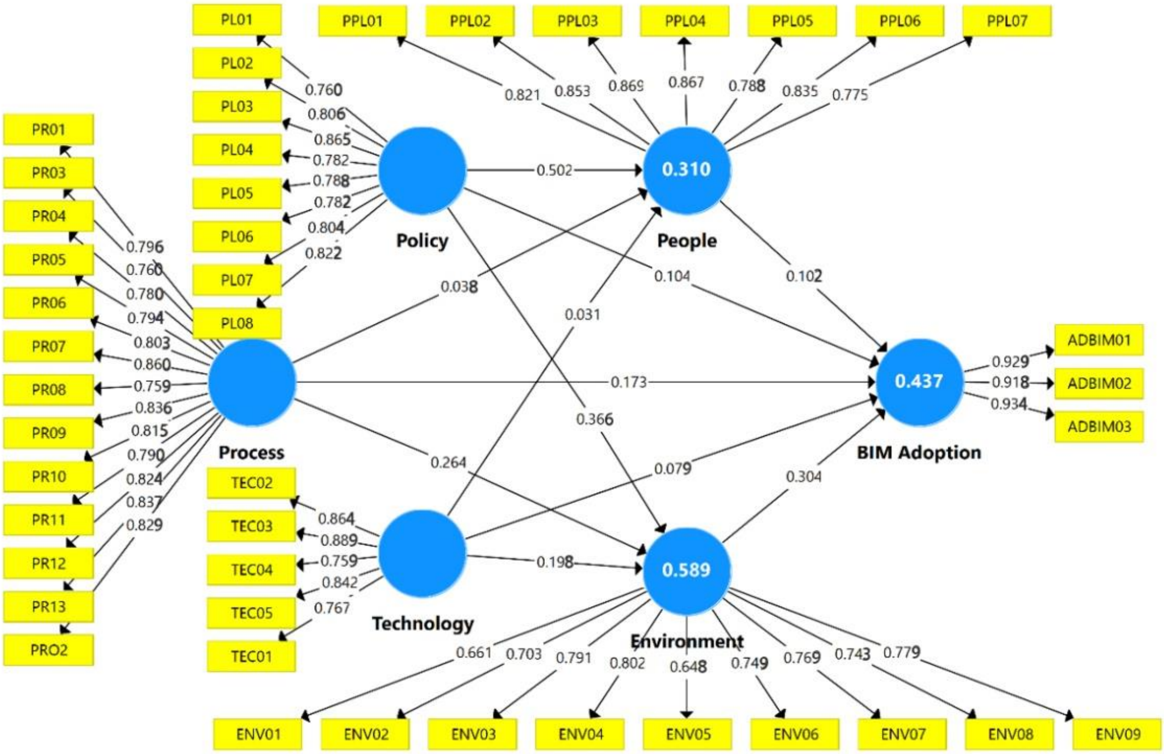

Figure 3. Factor loadings/outer loadings of each item calculated through the PLS algorithm.

4.3.1. Validity and Reliability of Constructs

The construct validity and reliability findings demonstrate that the absolute correlation between the construct and its measuring items is between 0.661 to 0.934, which is higher than the minimum threshold criteria.

4.3.2. Convergent Validity

The Average Variation Extracted (AVE) for each latent variable was more significant than the required threshold of 0.5 (50 percent), indicating that each construct could explain more than half of the variance to its measuring items on average, as shown in Table 5.

Table 5. Internal Consistency and Convergence Validity Results.

Constructs/Items	Code	F. L	CA	CR	AVE
BIM Adoption	**AD-BIM**		**0.918**	**0.948**	**0.859**
Encourage employees to utilise BIM in their daily work, even if it is not the organisation's formal workflow process	ADBIM 01	0.929			
Implement BIM in future projects, no matter how advanced it is	ADBIM 02	0.918			
Invite additional collaborative partners to utilise BIM for project communication	ADBIM 03	0.934			
Environment Factors	**ENV**		**0.896**	**0.916**	**0.548**
Security of information on project data	ENV 01	0.661			
Poor Internet connectivity	ENV 02	0.703			
Allows coordination and collaboration between disciplines.	ENV 03	0.791			

Table 5. *Cont.*

Constructs/Items	Code	F. L	CA	CR	AVE
BIM readiness by project consultants.	ENV 04	0.802			
Poor economic condition	ENV 05	0.648			
Method of communication between the team	ENV 06	0.749			
Market demand, size, and competition increase	ENV 07	0.769			
Risk management	ENV 08	0.743			
Facility management and buildings operation	ENV 09	0.779			
People Factors	**PPL**		**0.925**	**0.940**	**0.690**
Lack of skills and knowledge of one of the partners	PPL 01	0.820			
Lack of cooperative concept	PPL 02	0.854			
Lack of BIM expertise	PPL 03	0.871			
Lack of top management support	PPL 04	0.868			
Errors by the design team in construction projects	PPL 05	0.789			
Weak supervision and control	PPL 06	0.834			
Lack of demand by clients	PPL 07	0.773			
Policy Factors	**PL**		**0.920**	**0.935**	**0.643**
Financial resources of the organisation	PL01	0.760			
Regulation and policy	PL02	0.806			
Organisational readiness	PL03	0.866			
Strong legal institutions	PL04	0.782			
Guidance on the use of BIM	PL05	0.788			
The increased demand for design and building	PL06	0.782			
Government incentives	PL07	0.804			
Construction codes	PL08	0.822			
Process Factors	**PR**		**0.955**	**0.960**	**0.651**
Information availability and sharing	PR01	0.796			
Guiding the use of BIM	PR02	0.829			
The leadership of senior management	PR03	0.760			
Contractual sharing norm	PR04	0.780			
Information-sharing activities disseminate shared norms and community expectations	PR05	0.794			
Shared liability between project participants	PR06	0.803			
Production of drawings and schedules	PR07	0.860			
Desire to have the design process go faster	PR08	0.759			
Collaboration (project) management tools	PR09	0.836			
Standard and rules	PR10	0.815			
Collaboration experience of companies with project partners	PR11	0.790			
Creating data interchange standards	PR12	0.824			
Greater collaboration with consultants and other project team members.	PR13	0.837			
Technology Factors	**TEC**		**0.882**	**0.914**	**0.682**
Full automation in the construction industry	TEC01	0.767			

Table 5. *Cont.*

Constructs/Items	Code	F. L	CA	CR	AVE
BIM knowledge within the projects	TEC02	0.864			
Visualisation of construction sequences	TEC03	0.889			
Trialability (possibility of risk reduction by experimenting with BIM before implementing it in practice and experimenting with various BIM features in my work to validate their impact)	TEC04	0.759			
The usefulness of digital transfer of data	TEC05	0.842			

Hints: (AVE) Average Variance Extracted; (CA) Cronbach's alpha; (CR) Composite reliability.

4.3.3. Measurement of Discriminant Validity

Table 6 shows that the square roots of the AVE are more significant than their comparable inter-correlations. As a consequence, the validity and reliability of the measurement model is established.

Table 6. Discriminant Validity—Fornell and Lacker Criterion.

Constructs	BIM Adoption	Environment	People	Policy	Process	Technology
BIM Adoption	0.927					
Environment	0.614	0.740				
People	0.447	0.560	0.831			
Policy	0.585	0.730	0.556	0.802		
Process	0.588	0.721	0.481	0.837	0.807	
Technology	0.532	0.665	0.424	0.726	0.763	0.826

The diagonal represents the square root of AVE, while the off-diagonal values are correlations between latent variables.

As shown in Table 7, the discriminant findings demonstrate that most of the Heterotrait–Monotrait (HTMT) values are less than 0.9, which is extremely good and meets the discriminant validity criteria since the value is less than 0.90.

Table 7. Heterotrait–Monotrait Ratio Results (HTMT).

Constructs	BIM Adoption	Environment	People	Policy	Process	Technology
BIM Adoption						
Environment	0.668					
People	0.483	0.622				
Policy	0.631	0.797	0.596			
Process	0.623	0.770	0.509	0.893		
Technology	0.587	0.738	0.463	0.803	0.828	

4.4. The Structural Model's Assessment

The structural model is a theoretical model that analyses the inner path model using structural equations. Statistical measures such as path coefficient, predictive relevance (Q^2), effect size (f^2), and coefficient of determination (R^2) were used to verify the structural model. Once the measurement model was fit, the structural model's validity was evaluated. The next step was to create a causal route between independent (exogenous) and dependent (endogenous) variables to develop a linear covariance connection. The path coefficient, coefficient of determination (R^2) for the endogenous prediction relevance (Q^2), variable, effect size (f^2), and multicollinearity were used to evaluate the structural model in this study [123].

4.4.1. Coefficient of Determination (R^2)

The coefficient of determination (R^2) is the most significant criterion for assessing structural models and determining R^2 values. If the R^2 value is 0.26 or higher, effective results are expected. It is moderate if the R^2 value is between 0.13 and 0.25, and it is weak if the R^2 value is between 0.02 and 0.12 [124]. The R^2 results are presented in Table 8, with BIM adoption having 0.437, Environment at 0.589, and People having 0.310, demonstrating high acceptance.

Table 8. Result of R-square.

Endogenous Variables	R Square	R Square Adjusted
BIM Adoption	0.437	0.424
Environment	0.589	0.584
People	0.310	0.301

4.4.2. Effect Size (f^2)

The f^2 measures the influence of a predictive construct on an endogenous construct. According to [125], R^2 looks at how much one external construct helps explain a particular endogenous component. Significant, medium, and minor impact sizes are defined by f^2 values of 0.35, 0.15, and 0.02. Table 9 shows that policy on people and the environment has significant effects considering a value of 0.103 and 0.092, respectively. Other values indicate medium and small size effects.

Table 9. F-square Result.

Exogenous Variables	BIM Adoption	Environment	People
BIM Adoption			
Environment	0.062		
People	0.012		
Policy	0.005	0.092	0.103
Process	0.013	0.042	0.001
Technology	0.004	0.037	0.001

4.4.3. Result of Multicollinearity (Inner VIF)

The presence of two or more independent but highly connected entities is referred to as multicollinearity. It is a multicollinearity problem if there are common indicators across multiple constructs. Before moving further with model testing, we strongly suggest the researcher looks at multicollinearity [126]. The variables are assumed to have a collinearity problem when the correlation coefficient values are more than 0.9. The Variance Infant Tolerance (VIF) can detect collinearity concerns instead of the correlation coefficient. The VIF value in Smart-PLS must not be greater than five, indicating that the variables in the model are not collinear. This investigation did not consider multicollinearity because the inner VIF values were less than 5. Table 10 shows that the maximum VIF is 4.196, and the lowest is 1.561, indicating no multicollinearity at the site as the VIF is less than 10.

Table 10. Multicollinearity—Inner VIF Values.

Exogenous Variables	BIM Adoption	Environment	People
BIM Adoption			
Environment	2.630		
People	1.567		
Policy	4.102	3.559	3.559
Process	4.196	4.022	4.022
Technology	2.644	2.547	2.547

4.4.4. Predictive Relevance (Q^2 Value)

The Q^2 value was calculated using a blindfolding test to measure the model's predictive effectiveness. The blindfolding Q^2 test assesses endogenous variables' predictive capabilities and the structural model's predictive abilities. It is also a sample process strategy for assessing cross-validation in a model. The model is accurate in its predictions. The model's predictive significance is insufficient if the Q^2 value is more than zero [47]. As shown in Table 11, because the Q^2 values are more than zero, the model establishes a good fit and vital predictive significance. All matters are greater than zero ranging from 0.210 to 0.672, which indicates that the model is significant.

Table 11. Predictive Relevance Results.

Endogenous Variables	CCC Q^2 (=1-SSE/SSO)	CCR Q^2 (=1-SSE/SSO)
BIM Adoption	0.672	0.350
Environment	0.433	0.314
People	0.583	0.210
Policy	0.540	
Process	0.586	
Technology	0.522	

(CCC), Construct cross-validated communality; (CCR), construct cross-validated redundancy.

4.5. Analysis of Direct Effect Path Coefficients

The path coefficient results, as shown in Table 12 and Figure 4, indicate that the most significant path (t = 5.276) was found between Policy (PL) and People (PPL), which Policy (PL) and Environment (ENV) follow, and then Environment (ENV) and BIM adoption (ADBIM) with *t* values of 4.050 and 2.889, respectively, with all having *p* significance values of 0.000. The minor significance paths are those between Process (PR) and BIM adoption, Process and People, Technology (TEC) and BIM adoption (ADBIM), and Technology and People, all having a P-value above 0.05, and hence their hypotheses are not supported.

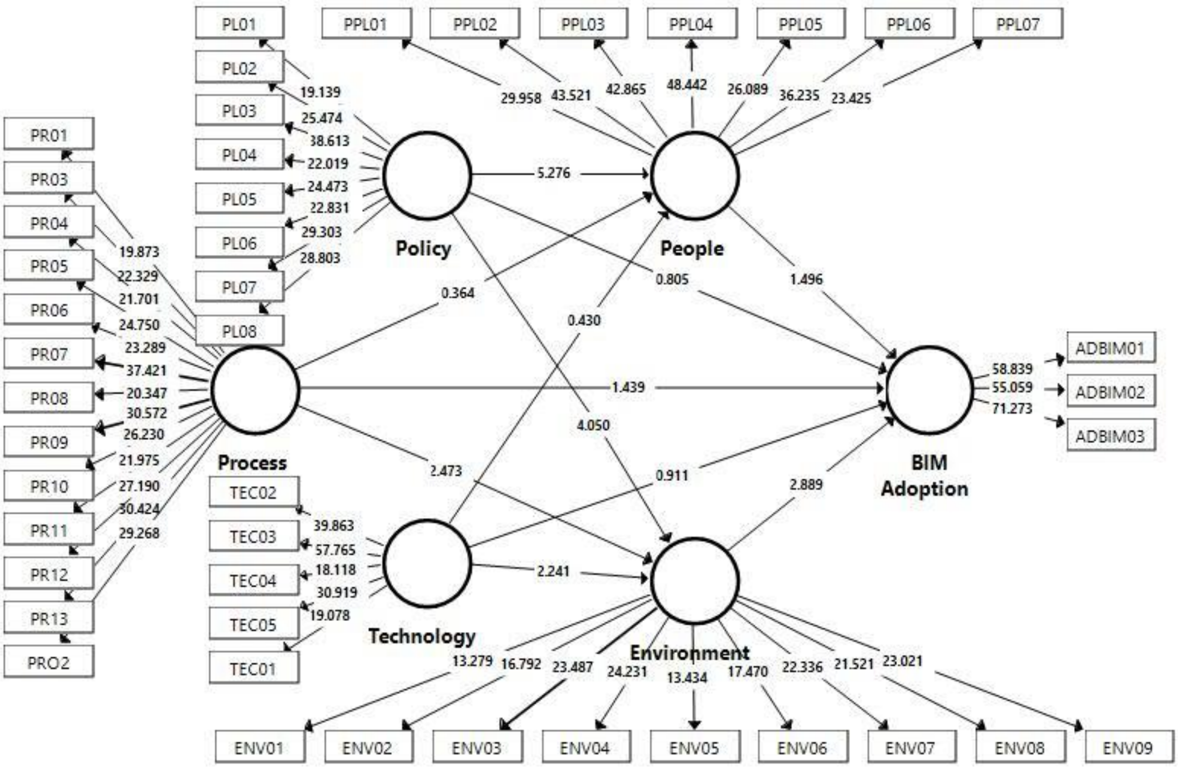

Figure 4. Path coefficient (T-values relative).

Table 12. Path Coefficient Result.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	*p* Values	Decision
Environment → BIM Adoption	0.304	0.304	0.105	2.889	0.004	Significant
People → BIM Adoption	0.102	0.097	0.068	1.496	0.135	Not Significant
Policy → BIM Adoption	0.104	0.107	0.129	0.805	0.421	Not Significant
Policy → Environment	0.366	0.365	0.090	4.050	0.000	Significant
Policy → People	0.502	0.503	0.095	5.276	0.000	Significant
Process → BIM Adoption	0.173	0.169	0.120	1.439	0.151	Not Significant
Process → Environment	0.264	0.257	0.107	2.473	0.014	Significant
Process → People	0.038	0.036	0.104	0.364	0.716	Not Significant
Technology → BIM Adoption	0.079	0.079	0.087	0.911	0.363	Not Significant
Technology → Environment	0.198	0.205	0.088	2.241	0.025	Significant
Technology → People	0.031	0.034	0.071	0.430	0.668	Not Significant

Significant: $p < 0.05$.

Table 12 shows the study's path coefficient results, which show that five hypotheses were supported and six were not, with a *p*-value of less than 0.05 for the supported hy potheses.

4.6. Indirect (Mediation) Effect Analysis

The bootstrapping results for the indirect effect are shown in Table 13, where the bootstrapping analysis was used to indicate the indirect effect of PL, PR, and technology (TEC) on BIM adoption (ADBIM). The mediation impact of independent variables on dependent variables was statistically significant using PL, PR, and TEC. The findings of the mediation analysis show that two of the three mediating hypotheses were supported, while the third was not. The mediating path Policy (PL) → Environment (EMV) is significant, having a $p = 0.000$ and t = 4.050. Moreover,, Policy (PL) → People (PL) is significant with $p = 0.000$ and t = 5.276, Environment → BIM adoption is significant with $p = 0.004$ and t = 2.889, and Process → Environment is significant with $p = 0.025$ and t = 2.241.

Table 13. Mediation Result.

Hypothesis	OS	SM	SD	T	*p* Values	Decision	Mediation
Policy (PL) → BIM adoption (ADBIM)	0.162	0.155	0.055	2.964	0.003 *	Sig.	Full Mediation
Process (PR) → BIM adoption (ADBIM)	0.083	0.076	0.046	1.804	0.045 *	Sig.	Full Mediation
Technology (TEC) → BIM adoption	0.063	0.064	0.039	1.604	0.109	Not Sig.	No Mediation

Significant; * $p < 0.05$.

4.7. Hypotheses Testing Result

The summary of the hypotheses testing is presented in Table 14, which shows that five hypotheses are accepted and six are rejected. This indicates Environment, People, and Policy are the most influencing factors on BIM adoption in the Yemeni construction industry. It also shows that other factors, such as Technology and Process, can be crucial in achieving the said objectives. The findings conform with the studies conducted by previous researchers.

Table 14. Hypotheses Results.

No.	Hypotheses	Results
H1	ENV has a significant effect on ADBIM	Accepted
H2	PPL have a significant effect on ADBIM	Rejected
H3	PL has a significant effect on ADBIM	Rejected
H4	PL has a significant effect on ENV	Accepted
H5	PL has a significant effect on PPL	Accepted
H6	PR has a significant effect on ADBIM	Rejected
H7	PR has a significant effect on ENV	Accepted
H8	PR has a significant effect on PPL	Rejected
H9	TEC has a significant effect on ADBIM	Rejected
H10	TEC has a significant effect on ENV	Accepted
H11	TEC has a significant effect on PPL	Rejected

The path between policy (PL) and Environment is the next meaningful relationship (ENV). It was discovered via structural equation modelling evaluating this link that there is a sizeable direct relationship between Policy and People. The Environment mediates the relationship between increased BIM adoption in the Yemeni construction industry. Previous studies have repeatedly emphasised this desired transformation.

5. Discussion

The structural equation model path analysis shows that the five variables, Policy, Process, Technology, People, and Environment, affect BIM adoption. Specifically, the relationship between Policy and People was found to be the most significant (t-values = 5.276, p-values = 0.000; significant), the relationship between Policy and the Environment was shown to be the second most important (t-values = 4.050, p-values = 0.000; significant). Following that, in terms of the significance of the association, the Process (which is an independent variable) and the Environment (which acts as a mediator) come in with t-values = 2.473 and p-values = 0.014; significant). Only the direct affect environment has a significant active impact on the rate of BIM adoption (t-values = 2.89, p-values = 0.004; significant). Consequently, the other direct-effect constants do not contribute considerably to the relationships. The relationship between Technology and the Environment was the last one to reach the significant level (t-values = 2.241, p-values = 0.025; significant). The other correlations lack statistical significance because the p-value is more than 0.05, and the t has a considerably lower value. As shown in Figure 5, the BIM adoption model includes two mediation paths: PL and PR→PPL→ADBIM and PR and TEC→ENV→ADBIM. In the first path, PPL acts as a link between PL→ADBIM. Such findings indicate that the construction industry's comprehensive understanding of policy BIM implementation factors (particularly construction codes) encourages the People (PPL) with a positive attitude to implement BIM in an existing workflow; this will eventually influence the organisation's decision to adopt BIM. Rogers' (2003) innovation process has five stages: agenda-setting, decision-making, implementation, and evaluation. Diffusion theory argues that organisations start implementing innovations by identifying issues and suggesting solutions. After analysing the innovation's viability, a decision can be taken about its implementation. This study focuses on initiation and decision stages, not a five-stage process. The analysis results indicate that the Yemeni construction industry shows fewer considerations of negative factors, including People (PPL). This reveals that the Yemeni construction industry idealises the BIM adoption process. Such results are not limited to Yemen. For instance, a study conducted in Qatar [127] revealed that more than half of the interviewees understood BIM to be the collaboration, cooperation, and digital data management that modifies the traditional manner of work. Despite this, most respondents (71%) stated that the industry lacks a sufficient understanding of BIM. Another mediation path identified in this study is from TEC and PR to ENV and eventually to ADBIM. Organisations whose teams have better capabilities in using BIM tools and processes tend to advance more in understanding the work environment, which will finally contribute to BIM adoption. Based on the above logic, conventional organisations with a lack of focus on improving personnel's technical knowledge and simplifying the way of work are less likely to adopt BIM. The establishment of a suitable environment is profoundly affected by process (PR) or technology (TEC). The stronger the BIM process or experiences of staff on technology, the more influential the environment the Yemeni construction industry will establish [26]. Moreover, a test of the hypothesised components suggests that the model can explain 24.6% of BIM adoption based on the sample size. The most significant influence of Technology was on Processes, confirming the belief that technology facilitates strategic innovation and alters traditional business processes. Non-challenge attitudes of the authorities toward adopting BIM are eminent in developing countries. The construction industry's stakeholders in most developing countries are still in the early stage of BIM adoption and implementation. Hence, they face numerous issues ranging from qualities of innovation inside and outside environments. Small- and medium-scale construction organisations contributing significantly to Yemen's development are the most affected due to their peculiar nature. The industry faces insufficient human resources, limited resources, and a lack of technological innovation, which has always been a significant setback to BIM adoption and implementation. This study appraises the factors affecting BIM adoption in the Yemeni construction industry using a structural equation modelling approach. Factors affecting BIM adoption were identified, reviewed, and synthesised into groups. Professionals within the Yemeni construction industry were consulted to determine the relationship among the factors affecting BIM adoption using the structural equation modelling (SEM) technique. As a result, Yemeni construction experts can investigate, examine, pinpoint, and assess the challenges associated with implementing BIM in construction projects. This study fills a gap and narrows the scope by focusing on the Yemeni construction industry scenario. A schematic relationship model of effective BIM adoption was also developed in the research. The government of Yemen is making several efforts to promote BIM among local groups. As a result, there is an opportunity to investigate, examine, identify, and assess the constraints of poor BIM adoption in construction projects among Yemeni construction professionals. In Yemen, almost all projects struggle to accomplish their goals. The government should use this study's results to enhance the construction sector's state. This is necessary to investigate the previous projects to identify the leading causes of issues and draw lessons for new initiatives. The Yemeni government should use the results of this study to enhance the state of the construction sector currently [63]. This systematic research on BIM adoption in the Yemeni construction industry has increased the literature and describes the research's originality. The research filled the knowledge gap regarding identifying and evaluating barriers to and impacts on BIM adoption in Yemeni construction projects. The overall results of this study are anticipated to boost and succeed in BIM adoption.

The research's findings are essential for the construction sector for the reasons listed below. Firstly, review the variables influencing the adoption of BIM in the construction industry. Secondly, research the elements influencing BIM adoption in the Yemeni construction industry. Investigate the level of BIM adoption, awareness, and knowledge in the Yemeni construction industry. Finally, the study created a framework for enhancing BIM adoption in the Yemeni construction industry. This framework can be used as a visual aid to comprehend the requirements for BIM adoption and potential obstacles. The research has paved the way for further study in various fields, including an international application. The findings of this research can be expanded and updated to support and improve construction practices in other countries.

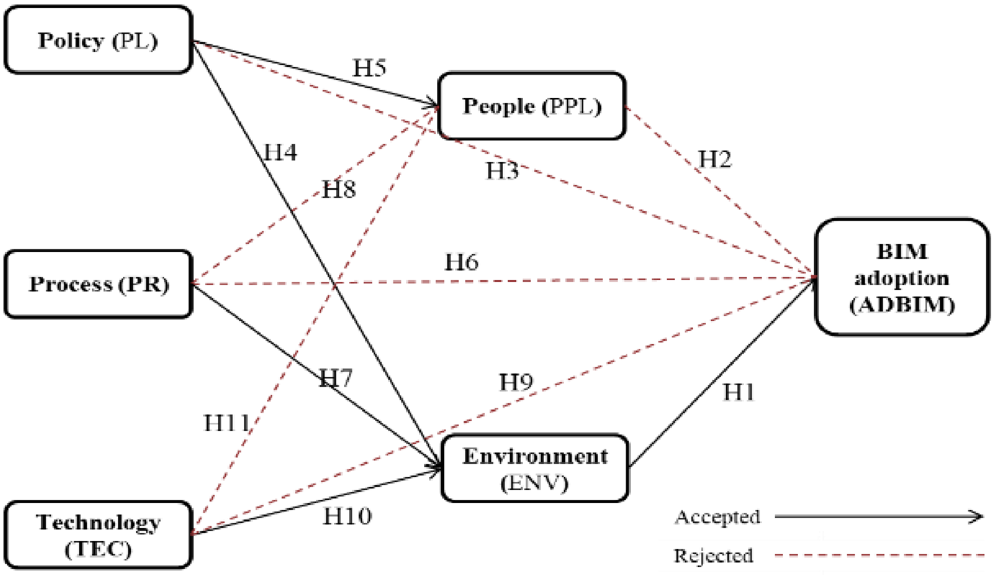

Figure 5. The final hypotheses of the research.

6. Conclusions

This study looks at the factors that drive BIM adoption in the construction sector. Its purpose is to provide an integrated framework for BIM adoption in the Yemeni construction industry, where additional research is needed. Making information more accessible to project members is an awareness factor that is more significant among the responses received. Structural equation modelling was employed, and essential factors loading was observed, which led to the development of the BIM adoption framework, which was successfully validated. This study's framework is represented diagrammatically with essential information embedded within. The findings show that the most critical factor for BIM adoption in the Yemeni construction industry is Policy, which would include regulation and policy, organisational readiness, government incentives, and construction codes. Visualisation of a sequence is the most significant technological factor toward BIM adoption. Greater collaboration between consultants and contractors is the most significant process factor. In contrast, BIM adoption is a policy-driven factor that lacks top management support as a people factor in addition to examining BIM adoption determinants and awareness in the Yemeni construction industry in order to establish a strategy that enables the development of a practical framework to proceed smoothly.

This research contributes originally to knowledge and the Yemeni construction industry. According to the literature review, there has never been academic research in Yemen on BIM adoption for the construction industry that has raised or increased the literature on sustainable construction. The study framework will provide consultants and contractors with a systematic and realistic technique for encouraging collaboration and consultation in the BIM adoption decision-making process. The findings of this study contribute to a better understanding of the factors affecting BIM adoption in the Yemeni construction industry. It is believed that these factors will help the construction industry improve the effectiveness of BIM implementation, achieve full benefits, and maximise the advantages for each project stakeholder with the existing tools and technologies available. A research framework is developed as the main contribution of this research, in which are attributes for BIM adoption in the construction industry. Particular attention is given to the challenging requirements of the Yemen construction industry, together with the need for government support for BIM adoption and implementation across all disciplines throughout the project lifecycle.

This study is extensive, and the findings are valuable to construction stakeholders. Nonetheless, there are certain drawbacks to this study. The literature supporting BIM adoption in the Yemeni construction sector was limited. As a result, this study could provide a solution to bridging this gap. Furthermore, it investigated BIM adoption factors in the Yemeni construction sector and built a strategy that allows for the smooth development of a practical framework. The framework's design and development were limited to Yemen, and possibly other countries needed to be studied. The usefulness of this study remains, however, because it does not detract from the limitations but allows for future research.

The following recommendations for improving BIM adoption were derived from the findings of this study:

- This study aimed to create a BIM adoption model in Yemen that could be expanded to include the operational and destruction steps and investigations into nations other than Yemen. More research may be conducted to examine the parameters of their impact on different types of infrastructure.
- The built environment curriculum in Yemeni tertiary institutions should be studied to include BIM education to produce a stream of BIM-oriented professionals.
- Similar to other developed countries, the Yemeni government should adopt construction policies to promote the use of BIM on every construction project. These policies would stimulate the implementation of BIM in Yemen.
- Due to the high cost of BIM infrastructure, the government might implement a loan scheme to aid construction companies in acquiring it.
- It would be interesting to investigate the level of BIM adoption in developed and developing nations. As a result, benchmark data and best practices for addressing problems with worldwide BIM adoption should be established.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. MV Descriptive (from Smart PLS).

No.		Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness	Number of Observations Used
1	ADBIM01	4.000	4.000	1.000	5.000	1.023	1.603	−1.320	235.000
2	ADBIM02	3.885	4.000	1.000	5.000	1.031	0.911	−1.103	235.000
3	ADBIM03	4.021	4.000	1.000	5.000	1.000	1.751	−1.329	235.000
4	ENV01	3.485	4.000	1.000	5.000	1.077	−0.290	−0.568	235.000
5	ENV02	3.523	4.000	1.000	5.000	1.211	−0.341	−0.771	235.000
6	ENV03	3.749	4.000	1.000	5.000	1.092	0.614	−1.027	235.000
7	ENV04	3.902	4.000	1.000	5.000	1.041	1.265	−1.191	235.000
8	ENV05	3.672	4.000	1.000	5.000	1.248	−0.317	−0.814	235.000
9	ENV06	3.813	4.000	1.000	5.000	0.931	1.269	−1.018	235.000
10	ENV07	3.796	4.000	1.000	5.000	1.044	0.605	−0.982	235.000
11	ENV08	3.706	4.000	1.000	5.000	1.049	0.150	−0.790	235.000
12	ENV09	3.762	4.000	1.000	5.000	1.008	0.980	−1.039	235.000
13	PL01	3.715	4.000	1.000	5.000	1.076	0.640	−1.001	235.000

Table A1. *Cont.*

No.		Mean	Median	Min	Max	Standard Deviation	Excess Kurtosis	Skewness	Number of Observations Used
14	PL02	3.753	4.000	1.000	5.000	1.035	0.607	−0.905	235.000
15	PL03	3.851	4.000	1.000	5.000	1.031	1.077	−1.128	235.000
16	PL04	3.681	4.000	1.000	5.000	1.078	0.090	−0.793	235.000
17	PL05	3.974	4.000	1.000	5.000	0.993	1.145	−1.129	235.000
18	PL06	3.800	4.000	1.000	5.000	1.063	0.824	−1.068	235.000
19	PL07	3.800	4.000	1.000	5.000	1.166	0.080	−0.949	235.000
20	PL08	3.991	4.000	1.000	5.000	1.126	1.005	−1.261	235.000
21	PPL01	3.528	4.000	1.000	5.000	1.153	−0.561	−0.612	235.000
22	PPL02	3.498	4.000	1.000	5.000	1.165	−0.509	−0.597	235.000
23	PPL03	3.570	4.000	1.000	5.000	1.227	−0.734	−0.595	235.000
24	PPL04	3.609	4.000	1.000	5.000	1.265	−0.509	−0.729	235.000
25	PPL05	3.455	4.000	1.000	5.000	1.142	−0.584	−0.511	235.000
26	PPL06	3.532	4.000	1.000	5.000	1.186	−0.556	−0.585	235.000
27	PPL07	3.477	4.000	1.000	5.000	1.168	−0.514	−0.564	235.000
28	PR01	3.996	4.000	1.000	5.000	1.033	1.827	−1.388	235.000
29	PR03	3.791	4.000	1.000	5.000	1.021	0.640	−0.950	235.000
30	PR04	3.723	4.000	1.000	5.000	1.042	0.264	−0.835	235.000
31	PR05	3.817	4.000	1.000	5.000	0.974	0.909	−0.931	235.000
32	PR06	3.889	4.000	1.000	5.000	1.000	1.028	−1.085	235.000
33	PR07	4.085	4.000	1.000	5.000	1.011	2.233	−1.514	235.000
34	PR08	3.877	4.000	1.000	5.000	1.043	0.605	−1.020	235.000
35	PR09	3.898	4.000	1.000	5.000	0.953	1.794	−1.218	235.000
36	PR10	3.813	4.000	1.000	5.000	1.043	0.946	−1.089	235.000
37	PR11	3.826	4.000	1.000	5.000	0.980	1.052	−0.980	235.000
38	PR12	4.000	4.000	1.000	5.000	0.932	2.222	−1.303	235.000
39	PR13	4.132	4.000	1.000	5.000	1.012	2.016	−1.456	235.000
40	PRO2	3.889	4.000	1.000	5.000	1.058	1.215	−1.209	235.000
41	TEC01	3.672	4.000	1.000	5.000	1.103	0.389	−0.970	235.000
42	TEC02	3.864	4.000	1.000	5.000	1.051	1.254	−1.229	235.000
43	TEC03	3.936	4.000	1.000	5.000	1.048	1.369	−1.256	235.000
44	TEC04	3.783	4.000	1.000	5.000	1.035	1.016	−1.152	235.000
45	TEC05	3.911	4.000	1.000	5.000	1.058	0.830	−1.100	235.000

References

1. Manzoor, B.; Othman, I.; Gardezi, S.; Harirchian, E. Strategies for Adopting Building Information Modeling (BIM) in Sustainable Building Projects—A Case of Malaysia. *Buildings* **2021**, *11*, 249. [CrossRef]
2. Baarimah, A.O.; Alaloul, W.S.; Liew, M.S.; Kartika, W.; Al-Sharafi, M.A.; Musarat, M.A.; Alawag, A.M.; Qureshi, A.H. A bibliometric analysis and review of building information modelling for post-disaster reconstruction. *Sustainability* **2022**, *14*, 393. [CrossRef]
3. Succar, B. Building information modelling framework: A research and delivery foundation for industry stakeholders. *Autom. Constr.* **2009**, *18*, 357–375. [CrossRef]
4. Sacks, R.; Eastman, C.; Lee, G.; Teicholz, P. Facilitators of BIM Adoption and Implementation. In *BIM Handbook*; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2018; pp. 323–363.
5. Ahmed, S. Barriers to Implementation of Building Information Modeling (BIM) to the Construction Industry: A Review. *J. Civ. Eng. Constr.* **2018**, *7*, 107–113. [CrossRef]
6. Elghdban, M.G.; Azmy, N.B.; Bin Zulkiple, A.; Al-Sharafi, M.A. A Systematic Review of the Technological Factors Affecting the Adoption of Advanced IT with Specific Emphasis on Building Information Modeling. *Recent Adv. Intell. Syst. Smart Appl.* **2020**, *29*, 29–42.
7. Babatunde, S.O.; Udeaja, C.; Adekunle, A.O. Barriers to BIM implementation Barriers and ways forward to improve its adoption in the Nigerian AEC firms. *Int. J. Build. Pathol. Adapt.* **2020**, *39*, 48–71. [CrossRef]
8. Enegbuma, W.I.; Aliagha, G.U.; Ali, K.N. Effects of Perceptions on BIM Adoption in Malaysian Construction Industry. *J. Teknol.* **2015**, *77*, 1–6. [CrossRef]
9. Gamil, Y.; Rahman, I.A.; Nagapan, S.; Nasaruddin, N.A.N. Nasaruddin. Exploring the failure factors of Yemen construction industry using PLS-SEM approach. *Asian J. Civ. Eng.* **2020**, *21*, 967–975. [CrossRef]

10. Mishmish, M.; El-Sayegh, S.M. Causes of claims in road construction projects in the UAE. *Int. J. Constr. Manag.* **2016**, *18*, 26–33. [CrossRef]
11. El-Sayegh, S.M.; Mansour, M.H. Risk assessment and allocation in highway construction projects in the UAE. *J. Manag. Eng.* **2015**, *31*, 04015004. [CrossRef]
12. Issa, U.H.; Farag, M.A.; Abdelhafez, L.M.; Ahmed, S.A. A risk allocation model for construction projects in Yemen. *Civ. Environ. Res.* **2015**, *7*, 78–89.
13. Kassem, M.A.; Khoiry, M.A.; Hamzah, N. Risk factors in oil and gas construction projects in developing countries: A case study. *Int. J. Energy Sect. Manag.* **2019**, *13*, 846–861. [CrossRef]
14. Saka, A.B.; Chan, D.W.M.; Siu, F.M.F. Drivers of sustainable adoption of building information modelling (BIM) in the nigerian construction small and medium-sized enterprises (SMEs). *Sustainability* **2020**, *12*, 3710. [CrossRef]
15. Hamma-Adama, M.; Kouider, T. Comparative Analysis of BIM Adoption Efforts by Developed Countries as Precedent for New Adopter Countries. *Curr. J. Appl. Sci. Technol.* **2019**, *36*, 1–15. [CrossRef]
16. Pidgeon, A.; Dawood, N. BIM Adoption Issues in Infrastructure Construction Projects: Analysis and Solutions. *J. Inf. Technol. Constr.* **2021**, *26*, 263–285. [CrossRef]
17. Altohami, A.; Haron, N.; Ales@alias, A.; Law, T. Investigating approaches of integrating BIM, IoT, and facility management for renovating existing buildings: A review. *Sustainability* **2021**, *13*, 3930. [CrossRef]
18. Enegbuma, W.I.; Aliagha, U.G.; Ali, K.N. Preliminary building information modelling adoption model in Malaysia A strategic information technology perspective. *Constr. Innov.* **2014**, *14*, 408–432. [CrossRef]
19. Attarzadeh, M.; Nath, T.; Tiong, R.L.K. Identifying key factors for building information modelling adoption in Singapore. *Inst. Civ. Eng. Manag. Procure. Law* **2015**, *168*, 220–231.
20. Hosseini, M.; Banihashemi, S.; Chileshe, N.; Namzadi, M.O.; Udaeja, C.; Rameezdeen, R.; McCuen, T. BIM adoption within Australian Small and Medium-sized Enterprises (SMEs): An innovation diffusion model. *Constr. Econ. Build.* **2016**, *16*, 71–86. [CrossRef]
21. Dahmas, S.; Li, Z.; Liu, S. Solving the difficulties and challenges facing construction based on concurrent engineering in Yemen. *Sustainability* **2019**, *11*, 3146. [CrossRef]
22. Alaghbari, W.; Al-Sakkaf, A.A.; Sultan, B. Factors affecting construction labour productivity in Yemen. *Int. J. Constr. Manag.* **2017**, *19*, 79–91. [CrossRef]
23. Bahamid, R.A.; Doh, S.I.; Al-Sharafi, M.A.; Rahimi, A.R. Risk Factors Influencing the Construction Projects in Yemen from Expert's Perspective. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *712*, 012007. [CrossRef]
24. Shirowzhan, S.; Sepasgozar, S.M.E.; Edwards, D.J.; Li, H.; Wang, C. BIM compatibility and its differentiation with interoperability challenges as an innovation factor. *Autom. Constr.* **2020**, *112*, 103086. [CrossRef]
25. Enegbuma, W.I.; Aliagha, G.U.; Ali, K.N.; Badiru, Y.Y. CConfirmatory strategic information technology implementation for building information modelling adoption model. *J. Constr. Dev. Ctries.* **2016**, *21*, 113–129.
26. Enegbuma, W.I.; Aliagha, U.G.; Ali, K.N. Measurement of Theoretical Relationships in Building Information Modelling Adoption in Malaysia. In Proceedings of the 31st International Symposium on Automation and Robotics in Construction and Mining (ISARC), Sydney, Australia, 9–11 July 2014.
27. Pickup, J. BIM Adoption & Precast Concrete: Design and Implementation of a Strategic Guide. Bachelor's Thesis, University of Sydney, Sydney, Australia, 2013.
28. Elhendawi, A.; Omar, H.; Elbeltagi, E.; Smith, A. Practical approach for paving the way to motivate BIM non-users to adopt BIM. *Int. J. BIM Eng. Sci.* **2019**, *2*, 1–22. [CrossRef]
29. Ahuja, R.; Sawhney, A.; Jain, M.; Arif, M.; Rakshit, S. Factors influencing BIM adoption in emerging markets–the case of India. *Int. J. Constr. Manag.* **2018**, *20*, 65–76. [CrossRef]
30. Alhumayn, S.A. Developing A Framework for BIM Implementation in the Saudi Arabian Construction Industry. Ph. D. Thesis, University of Wolverhampton, Wolverhampton, UK, 2018.
31. Sodangi, M.; Fouad, A.; Muhammad, S. Building Information Modeling: Awareness Across the Subcontracting Sector of Saudi Arabian Construction Industry. *Arab. J. Sci. Eng.* **2017**, *43*, 1807–1816. [CrossRef]
32. Enshassi, A.; Ayyash, A.; Choudhry, R.M. BIM for construction safety improvement in Gaza strip: Awareness, applications and barriers. *Int. J. Constr. Manag.* **2016**, *3599*, 249–265.
33. Gamil, Y.; Rahman, I.A.R. Awareness and challenges of building information modelling (BIM) implementation in the Yemen construction industry. *J. Eng. Des. Technol.* **2019**, *17*, 1077–1084. [CrossRef]
34. Hochscheid, E.; Halin, G. Generic and SME-specific factors that influence the BIM adoption process: An overview that highlights gaps in the literature. *Front. Eng. Manag.* **2019**, *7*, 119–130. [CrossRef]
35. Ahmed, A.L.; Kawalek, J.P.; Kassem, M. A comprehensive identification and categorisation of drivers, factors, and determinants for BIM adoption: A systematic literature review. In *Computing in Civil Engineering*; American Society of Civil Engineers (ASCE): Reston, VA, USA, 2017; pp. 220–227.
36. Ahmed, A.; Kawalek, P.; Kassem, M. A Conceptual Model For Investigating BIM Adoption by Organisations. In Proceedings of the Joint Conference on Computing in Construction (JC3), Heraklion, Greece, 4–12 July 2017; Volume 1, pp. 447–455.
37. Muhammad, H.; Shehzad, F.; Ibrahim, R.B.; Fadhil, A.; Anwar, K.; Shawkat, S. Recent developments of BIM adoption based on categorization, identification and factors: A systematic literature review. *Int. J. Constr. Manag.* **2020**, *17*, 1–13.

38. Shehzad, H.M.F.; Ibrahim, R.B.; Yusof, A.F.; Khaidzir, K.A.M. Building Information Modeling: Factors Affecting the Adoption in the AEC Industry. In Proceedings of the 2019 6th International Conference on Research and Innovation in Information Systems (ICRIIS), 2–3 December 2019; pp. 1–6.
39. Ahmed, A.L.; Kassem, M. A unified BIM adoption taxonomy: Conceptual development, empirical validation and application. *Autom. Constr.* **2018**, *96*, 103–127. [CrossRef]
40. Zhang, L.; Chu, Z.; Song, H. Understanding the Relation between BIM Application Behavior and Sustainable Construction: A Case Study in China. *Sustainability* **2019**, *12*, 306. [CrossRef]
41. Oesterreich, T.D.; Teuteberg, F. Behind the scenes: Understanding the socio-technical barriers to BIM adoption through the theoretical lens of information systems research. *Technol. Forecast. Soc. Chang.* **2019**, *146*, 413–431. [CrossRef]
42. Ahmed, S.H.; Suliman, S.M. A structure equation model of indicators driving BIM adoption in the Bahraini construction industry. *Constr. Innov.* **2019**, *20*, 61–78. [CrossRef]
43. Gurevich, U.; Sacks, R. Longitudinal Study of BIM Adoption by Public Construction Clients. *J. Manag. Eng.* **2020**, *36*, 05020008. [CrossRef]
44. Gu, N.; London, K. Understanding and facilitating BIM adoption in the AEC industry. *Autom. Constr.* **2010**, *19*, 988–999. [CrossRef]
45. Rogers, J.; Chong, H.Y.; Preece, C. Adoption of Building Information Modelling technology (BIM): Perspectives from Malaysian engineering consulting services firms. *Eng. Constr. Archit. Manag.* **2015**, *22*, 424–445. [CrossRef]
46. Alsaeedi, F.; Lafta, M.J.; Ahmed, A. State of Building Information Modelling (BIM) adoption in Iraq. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *737*, 012007. [CrossRef]
47. Ayinla, K.; Adamu, Z. Bridging the digital divide gap in BIM technology adoption. *Eng. Constr. Archit. Manag.* **2018**, *25*, 1398–1416. [CrossRef]
48. Patil, S.D. Application of BIM for Scheduling and Costing of Building Project. *Int. J. Res. Appl. Sci. Eng. Technol.* **2018**, *6*, 1609–1615. [CrossRef]
49. Khan, S.U.; Niazi, M.; Ahmad, R. Factors influencing clients in the selection of offshore software outsourcing vendors: An exploratory study using a systematic literature review. *J. Syst. Softw.* **2011**, *84*, 686–699. [CrossRef]
50. Ogunlana, S.; Charoenngam, C.; Herabat, P.; Hadikusumo, B.H.W. International Symposium on Globalisation and Construction Proceedings CIB W107 (Construction in Developing Economies) and CIB TG23 (Culture in Construction) Joint Symposium Sponsored by Edited by [Internet]. academia.edu. 2004. Available online: https://www.academia.edu/download/3477348/cib5911.pdf#page=394 (accessed on 24 August 2022).
51. Herr, C.M.; Fischer, T. BIM adoption across the Chinese AEC industries: An extended BIM adoption model. *J. Comput. Des. Eng.* **2018**, *6*, 173–178. [CrossRef]
52. Oraee, M.; Hosseini, M.R.; Edwards, D.J.; Li, H.; Papadonikolaki, E.; Cao, D. Collaboration barriers in BIM-based construction networks: A conceptual model. *Int. J. Proj. Manag.* **2019**, *37*, 839–854. [CrossRef]
53. Almuntaser, T.; Sanni-Anibire, M.O.; Hassanain, M.A. Adoption and implementation of BIM–case study of a Saudi Arabian AEC firm. *Int. J. Manag. Proj. Bus.* **2018**, *11*, 608–624. [CrossRef]
54. Kassem, M.A.; Khoiry, M.A.; Hamzah, N. Evaluation of Risk Factors Affecting on Oil and Gas Construction Projects in Yemen. *Int. J. Eng. Technol.* **2019**, *8*, 6–14.
55. Succar, B.; Kassem, M. Macro-BIM adoption: Conceptual structures. *Autom. Constr.* **2015**, *57*, 64–79. [CrossRef]
56. Yuan, H.; Yang, Y. BIM Adoption under Government Subsidy: Technology Diffusion Perspective. *J. Constr. Eng. Manag.* **2020**, *146*, 04019089. [CrossRef]
57. Ma, G.; Jia, J.; Ding, J.; Shang, S.; Jiang, S. Interpretive structural model based factor analysis of BIM adoption in Chinese construction organizations. *Sustainability* **2019**, *11*, 1982. [CrossRef]
58. Banawi, A. *Barriers to Implement Building Information Modeling (BIM) in Public Projects in Saudi Arabia*; Springer: Berlin/Heidelberg, Germany, 2018; Volume 3, pp. 119–125.
59. Researcher, A. BIM: A Technology Acceptance Model In Peru. *J. Inf. Technol. Constr.* **2020**, *25*, 99–108.
60. Republic of Yemen. National Report Habitat III. In Proceedings of the Third United Nations Conference on Housing and Sustainable Urban Development-HABITAT III, Quito, Ecuador, 17–20 October 2016; pp. 1–67. Available online: http://habitat3.org/wp-content/uploads/Yemen-National-Report-September-2016.pdf (accessed on 24 August 2022).
61. Sultan, B.; Alaghbari, W. Political instability and the informal construction sector in Yemen. *Int. J. Civ. Eng. Technol.* **2018**, *9*, 1228–1235.
62. Delgado JM, D.; Oyedele, L.; Ajayi, A.; Akanbi, L.; Akinade, O.; Bilal, M.; Owolabi, H. Robotics and automated systems in construction: Understanding industry-specific challenges for adoption. *J. Build. Eng.* **2019**, *26*, 100868. [CrossRef]
63. Gamil, Y.; Rahman, I.A.; Nagapan, S.; Alemad, N. Qualitative Approach on Investigating Failure Factors of Yemeni Mega Construction Projects. *MATEC Web Conf.* **2017**, *103*, 03002. [CrossRef]
64. Gamil, Y.; Rahman, I.A. Assessment of critical factors contributing to construction failure in Yemen. *Int. J. Constr. Manag.* **2018**, *20*, 429–436. [CrossRef]
65. McCuen, T.L. BIM and Cost Estimating: A Change in the Process for Determining Project Costs. *Build. Inf. Model. Appl. Pract.* **2015**, 63–81.

66. Yahya Al-Ashmori, Y.; Bin Othman, I.; Bin Mohamad, H.; Rahmawati, Y.; Napiah, M. Establishing the Level of BIM implementation-A Case Study in Melaka, Malaysia. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *601*, 012024. [CrossRef]
67. Awwad, K.A.; Shibani, A.; Ghostin, M. Exploring the critical success factors influencing BIM level 2 implementation in the UK construction industry: The case of SMEs. *Int. J. Const.r Manag.* **2022**, *22*, 1894–1901. [CrossRef]
68. CIDB. BIM Guide 1: Awareness. Construction Industry Development Board Malaysia. 2016. Available online: http://www.mybimcentre.com.my (accessed on 24 August 2022).
69. Joblot, L.; Paviot, T.; Deneux, D.; Lamouri, S. Automation in Construction Building Information Maturity Model specific to the renovation sector. *Autom. Constr.* **2019**, *101*, 140–159. [CrossRef]
70. Kassem, M.; Vukovic, V.; Dawood, N.; Hafeez, M.A.; Chahrour, R.; Naji, K. Approaches for Assessing BIM Adoption in Countries: A Comparative Study within Qatar. *World Build. Congr.* **2016**, *1*, 695–705.
71. Ahmed, S.; Dlask, P.; Shaban, M.; Selim, O. Possibility of applying bim in syrian building projects. *Eng. Rural. Dev.* **2018**, *17*, 524–530.
72. Babatunde, S.O.; Perera, S.; Ekundayo, D.; Adeleye, T.E. An investigation into BIM-based detailed cost estimating and drivers to the adoption of BIM in quantity surveying practices. *J. Financ. Manag. ofof Prop. Constr.* **2019**, *25*, 61–81. [CrossRef]
73. Li, P.; Zheng, S.; Si, H.; Xu, K. Critical Challenges for BIM Adoption in Small and Medium-Sized Enterprises: Evidence from China. *Adv. Civ. Eng.* **2019**, *2019*, 9482350. [CrossRef]
74. Alemayehu, S.; Nejat, A.; Ghebrab, T.; Ghosh, S. A multivariate regression approach toward prioritizing BIM adoption barriers in the Ethiopian construction industry. *Eng. Constr. Archit. Manag.* **2021**, *29*, 2635–2664. [CrossRef]
75. Qin, X.; Shi, Y.; Lyu, K.; Mo, Y. Using a tam-toe model to explore factors of building information modelling (BIM) adoption in the construction industry. *J. Civ. Eng. Manag.* **2020**, *26*, 259–277. [CrossRef]
76. Shi, Q.; Ding, X.; Zuo, J.; Zillante, G. Automation in Construction Mobile Internet based construction supply chain management: A critical review. *Autom. Constr.* **2016**, *72*, 143–154. [CrossRef]
77. Chien, K.-F.; Wu, Z.-H.; Huang, S.-C. Identifying and assessing critical risk factors for BIM projects: Empirical study. *Autom. Constr.* **2014**, *45*, 1–15. [CrossRef]
78. Lancashire, C. *Implementation of the Lean Approach in Sustainable Construction: A Conceptual Framework by Oyedolapo Ogunbiyi*; University of Central Lancashire: Preston, UK, 2014.
79. Ding, Z.; Zuo, J.; Wu, J.; Wang, J.Y. Key factors for the BIM adoption by architects: A China study. *Eng. Constr. Archit. Manag.* **2015**, *22*, 732–748. [CrossRef]
80. Bui, N.; Merschbrock, C.; Munkvold, B.E. A review of Building Information Modelling for construction in developing countries. *Procedia Eng.* **2016**, *164*, 487–494. [CrossRef]
81. Saka, A.B.; Chan, D.W.M. Profound barriers to building information modelling (BIM) adoption in construction small and medium-sized enterprises (SMEs): An interpretive structural modelling approach. *Constr. Innov.* **2020**, *20*, 261–284. [CrossRef]
82. Aigbavboa, C.; Thwala, W. *The Construction Industry in the Fourth Industrial Revolution*; Springer: Berlin/Heidelberg, Germany, 2020.
83. Liao, L.; Teo Ai Lin, E.; Low, S.P. Assessing building information modeling implementation readiness in building projects in Singapore: A fuzzy synthetic evaluation approach. *Eng. Constr. Archit. Manag.* **2019**, *27*, 700–724. [CrossRef]
84. Aibinu, A.; Venkatesh, S. Status of BIM Adoption and the BIM Experience of Cost Consultants in Australia. *J. Prof. Issues Eng. Educ. Pract.* **2014**, *140*, 04013021. [CrossRef]
85. Antwi-Afari, M.F.; Li, H.; Pärn, E.A.; Edwards, D.J. Critical success factors for implementing building information modelling (BIM): A longitudinal review. *Autom. Constr.* **2018**, *91*, 100–110. [CrossRef]
86. Al-Fadhali, N.; Zainal, R.; Kasim, N.; Dodo, M.; Kim-Soon, N.; Hasaballah, A.H.A. The desirability of Integrated Influential Factors (IIFs) Model of internal stakeholder as a panacea to project completion delay in Yemen. *Int. J. Constr. Manag.* **2017**, *19*, 128–136. [CrossRef]
87. Al-Fadhali, N.; Mansir, D.; Zainal, R. Validation of an integrated influential factors (IIFs) model as a panacea to curb projects completion delay in Yemen. *J. Sci. Technol. Policy Manag.* **2019**, *10*, 793–811. [CrossRef]
88. Alaghbari, W.; Sultan, B. Delay Factors Impacting Construction Projects in Sana' a-Yemen. *PM World J.* **2018**, *VII*, 1–28.
89. Purushothaman, K.; Ahmad, R. Integration of Six Sigma methodology of DMADV steps with QFD, DFMEA and TRIZ applications for image-based automated inspection system development: A case study. *Int. J. Lean Six Sigma* **2022**, *13*, 1239–1276. [CrossRef]
90. Li, C.Z.; Hong, J.; Xue, F.; Shen, G.Q.; Xu, X.; Mok, M.K. Schedule risks in prefabrication housing production in Hong Kong: A social network analysis. *J. Clean. Prod.* **2016**, *134*, 482–494. [CrossRef]
91. Cao, Y.; Zhang, L.H.; McCabe, B.; Shahi, A. The Benefits of and Barriers to BIM Adoption in Canada. *Int. Symp. Autom. Robot. Constr.* **2019**, *36*, 152–158.
92. Hong, Y.; Hammad, A.W.; Sepasgozar, S.; Nezhad, A.A. BIM adoption model for small and medium construction organisations in Australia. *Eng. Constr. Archit. Manag.* **2018**, *26*, 154–183. [CrossRef]
93. Ullah, K.; Lill, I.; Witt, E. An overview of BIM adoption in the construction industry: Benefits and barriers. In Proceedings of the 10th Nordic Conference on Construction Economics and Organization, Tallinn, Estonia, 7–8 May 2019; Emerald Publishing Limited: Bingley, UK, 2019; Volume 2, pp. 297–303. Available online: https://www.emerald.com/insight/content/doi/10.1108/S2516- (accessed on 24 August 2022).

94. Doan, D.T.; Ghaffarianhoseini, A.; Naismith, N.; Ghaffarianhoseini, A.; Zhang, T.; Tookey, J. Examining Green Star certification uptake and its relationship with Building Information Modelling (BIM) adoption in New Zealand. *J. Environ. Manag.* **2019**, *250*, 1–11. [CrossRef] [PubMed]
95. Fitriani, H.; Budiarto, A.; Ajayi, S.; Idris, Y. Implementing BIM in architecture, engineering and construction companies: Perceived benefits and barriers among local contractors in palembang, Indonesia. *Int. J. Constr. Supply Chain Manag.* **2019**, *9*, 20–34. [CrossRef]
96. Zafar, I.; Shen, G.; Ahmed, S.; Yousaf, T. Stakeholders Responsibilities for Time Overrun Risks of Highway Projects in Terrorism Affected Areas. In Proceedings of the 13th International Postgraduate Conference (IPGRC 2017), London, UK, 19–21 February 2017; pp. 504–515.
97. Hore, A.; Kuang, S.; McAuley, B.; West, R.P. Development of a Framework to Support the Effective Adoption of BIM in the Public Sector: Lessons for Ireland. In *Conference Papers; by the School of Multidisciplinary Technologies at ARROW@TU Dublin, Hong Kong, China, 17–21 June 2019*; Technological University Dublin: Dublin, Ireland, 2019; pp. 1–17. Available online: https://arrow.tudublin.ie/schmuldistcon/25%0Ahttps://arrow.tudublin.ie/schmuldistcon/25 (accessed on 24 August 2022).
98. Hong, Y.; Hammad, A.W.A.; Akbarnezhad, A. Impact of organization size and project type on BIM adoption in the Chinese construction market. *Constr. Manag. Econf.* **2019**, *37*, 675–691. [CrossRef]
99. Kassem, M.; Succar, B. Macro BIM adoption: Comparative market analysis. *Autom. Constr.* **2017**, *81*, 286–299. [CrossRef]
100. Bew, M.; Underwood, J. Delivering BIM to the UK Market. In *Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies*; IGI Global: Hershey, PA, USA, 2010; pp. 30–64.
101. Construction, M.H. The Business Value of BIM for Construction in Major Global Markets. In *Smart Market Report*; McGraw Hill Construction: Bedford, MA, USA, 2014.
102. Alhumayn, S.A.; Saka, A.B.; Chan, D.W.M. A Scientometric Review and Metasynthesis of Building Information Modelling (BIM) Research in Africa. *Buildings* **2019**, *9*, 85.
103. Fadhil, A.; Khaidzir, K.; Husain, O. The Evolution of Technology Adoption Theories in Building Information Modelling Research Building Information Modelling Adoption: Systematic Literature Review. In Proceedings of the 5th International Conference of Reliable Information and Communication Technology 2020, London, UK, 26–28 July 2020; Yemeni Scientists Reseaarch Group & (ISSIRG) in Universiti Teknologi Malaysia (Malaysia): Johor Bahru, Malaysia, 2020; pp. 1–12.
104. Hochscheid, E.; Halin, G. Micro BIM adoption in design firms: Guidelines for doing a BIM implementation plan. *Proc. Creat. Constr. Conf.* **2019**, *119*, 864–871.
105. Hochscheid, E.; Halin, G. A model to approach BIM adoption process and possible BIM implementation failures. In Proceedings of the Creative Construction Conference 2018, CCC 2018, Ljubljana, Slovenia, 30 June–3 July 2018; Diamond Congress Ltd.: Budapest, Hungary, 2018; pp. 257–264.
106. Prabhakaran, A.; Mahamadu, A.-M.; Mahdjoubi, L.; Andric, J.; Manu, P.; Mzyece, D. An investigation into macro BIM maturity and its impacts: A comparison of Qatar and the United Kingdom. *Archit. Eng. Des. Manag.* **2021**, *17*, 496–515. [CrossRef]
107. Van Tam, N.; Diep, T.N.; Toan, N.Q.; Quy, N.L.D. Factors affecting adoption of building information modeling in construction projects: A case of Vietnam. *Cogent Bus. Manag.* **2021**, *8*, 1918848. [CrossRef]
108. Liu, Z. Feasibility Analysis of BIM Based Information System for Facility Management at WPI. Master's Thesis, Worcester Polytechnic Institute, Worcester, MA, USA, 2010.
109. Kang, T.W.; Hong, C.H. A study on software architecture for effective BIM/GIS-based facility management data integration. *Autom. Constr.* **2015**, *54*, 25–38. [CrossRef]
110. Vriens, R.G.M. *The Handbook of Marketing Research: Uses, Misuses, and Future Advances*; Sage: New York, NY, USA, 2006.
111. Bhattacherjee, A. *Social Science Research: Principles, Methods, and Practices*, 2nd ed.; Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License; University of South Florida Tampa: Tampa, FL, USA, 2012.
112. Fellows, R.; Liu, A.M.M. Use and misuse of the concept of culture. *Constr. Manag. Econ.* **2013**, *31*, 401–422. [CrossRef]
113. Weston, R.; Gore, P.A. A brief guide to structural equation modeling. *Couns. Psychol.* **2006**, *34*, 719–751. [CrossRef]
114. Chin, W.W. The partial least squares approach to structural equation modeling. *Mod. Methods Bus. Res.* **1998**, *295*, 295–336.
115. Haenlein, M.; Kaplan, A.M. A beginner's guide to partial least squares analysis. *Underst. Stat.* **2004**, *3*, 283–297. [CrossRef]
116. Latan, H.; Noonan, R.; Matthews, L. Partial least squares path modeling. In *Basic Concepts, Methodol*; Springer: Berlin/Heidelberg, Germany, 2017; Volume 3.
117. Bagozzi, R.P.; Baumgartner, H. The evaluation of structural equation models and hypothesis testing. *Princ. Mark. Res.* **1994**, *1*, 386–422.
118. Tabachnick, B.G.; Fidell, L.S. *Using Multivariate Statistics*, 5th ed.; Allyn Bacon: Boston, MA, USA, 2007.
119. Henseler, J.; Ringle, C.M.; Sarstedt, M. A new criterion for assessing discriminant validity in variance-based structural equation modeling. *J. Acad. Mark. Sci.* **2015**, *43*, 115–135. [CrossRef]
120. Hayes, A.F. *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*; Guilford publications: New York, NY, USA, 2017.
121. Kim, H.; Ionides, E.; Almirall, D. A sample size calculator for SMART pilot studies. *SIAM Undergrad. Res.* **2016**, *9*, 229. [CrossRef]
122. Sürücü, L.; Maslakçi, A. Validity and reliability in quantitative research. *Bus. Manag. Stud. An Int. J.* **2020**, *8*, 2694–2726. [CrossRef]
123. Götz, O.; Liehr-Gobbers, K.; Krafft, M. Evaluation of structural equation models using the partial least squares (PLS) approach. In *Handbook of Partial Least Squares*; Springer: Berlin/Heidelberg, Germany, 2010; pp. 691–711.

124. Cohen, A. Comparison of correlated correlations. *Stat. Med.* **1989**, *8*, 1485–1495. [CrossRef]
125. Shmueli, G.; Sarstedt, M.; Hair, J.F.; Cheah, J.-H.; Ting, H.; Vaithilingam, S.; Ringle, C.M. Predictive model assessment in PLS-SEM: Guidelines for using PLSpredict. *Eur. J. Mark.* **2019**, *53*, 2322–2347. [CrossRef]
126. Hair, J.F.; Anderson, R.E.; Babin, B.J.; Black, W.C. *Multivariate Data Analysis: A Global Perspective*; Pearson: Bergen, NJ, USA, 2010.
127. Vukovic, V.; Hafeez, M.A.; Chahrour, R.; Kassem, M.; Dawood, N. BIM Adoption in Qatar: Capturing High Level Requirements for Lifecycle Information Flow. In Proceedings of the 15th International Conference on Construction Applications of Virtual Reality (CONVR), Banff, AB, Canada, 5–7 October 2015; pp. 1–11.