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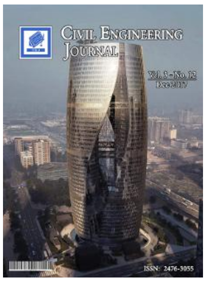

Testing a Measurement Model of BIM Potential Benefits in Iraqi Construction Projects

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Abstract

Building Information Modeling (BIM) is an integrated and comprehensive system for all that related to the construction project, which includes a set of effective policies, procedures, and computer applications that increase the performance of the project during its life cycle. The objective of this research develops a clear concept about the BIM adoption in Iraq through investigating potential benefits that can be obtained through its application in construction projects also build a measurement model for these benefits. The research methodology was based on quantitative approach which adopted by conducting a questionnaire directed to professionals in the field of construction projects in the public and private sectors supported by personal interviews with respondents either individually or in groups. Three hundred copies of the forms were distributed to the companies, firms and engineering departments of the various ministries of the state. After the data was obtained, two software (SPSS and SmartPLS) was used for analyzing the data and constructing the measurement model. The results showed of all the benefits constructed within three key components. The first is knowledge support for management in term of (costs, data, processes), the second is effective design performance and the third is effective construction performance and all these components were modeled as a measurement model.

Keywords: BIM; Benefits; SmartPLS; CFA Analysis; EFA Analysis.

1. Introduction

The construction industry has witnessed a paradigm shift that will achieve the highest productivity, efficiency, quality, sustainability, and the value of infrastructure and reduce the costs of the life cycle as well reduce time [1]. This is consistent with what Azhar [2] said says about construction industry tends to adopt techniques that reduce the cost of the project, increase the productivity and quality of the project and reduce the project time.

One of these techniques is building information modeling (BIM) which is a technological and procedural shift in the construction industry [3]. Actually, the evolution of computer science as well as information technology has caused a positive change in the processes of most industries [4].

BIM is an advanced process and tool consisting of a combination of virtual aspects, systems and concepts facilitated within a unified environment [5]. It includes the application and keeps of integrated digital representation of different information across different project stages [6] .There are many BIM applications[7] which can be used to support

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constructability, scheduling, analysis, cost estimating and sequencing[8]. Building Information Modeling as a new paradigm has a great potential for integration into the life cycle of construction projects [9, 10].

One of the main benefits of BIM is the accurate geometrical representation of building parts within an integrated information environment [11]. Furthermore, the BIM reduces the duration and cost of the project, improves maintenance management and increases the value of the building [6].

On the other hand, the BIM as a new phenomenon seeks to renew the practices of the construction industry, so it is subject to several challenges facing its application [12].

For the implementation of BIM, this requires good planning and a coordinated approach with considerations for implementation and innovation management [13].

2. Research Background

The benefits of BIM have been studied previously by a number of researchers. CRC Construction Innovation [11] indicates that the accurate representation of the building within an informative environment is one of the most important benefits of BIM and this study was interested in showing the benefits of BIM through its application in a project, but discussed the benefits within a certain stage of the project. Through BIM visualization, it is possible to see the design in detail in a more comprehensive way [14]. This visualization is not confined to the form of the building only, but also helps to understand the sequence of project activities within the duration of the project overall. Recently, the BIM has provided a great service to designers of complex buildings such as buildings with free form surfaces where they can be represented and visualize their design with more efficient way [15] and this study has reviewed several of the previously published BIM implementation plans, it has not been shown in detail in the study of the benefits of PIM, which is one of the important drivers of PIM implementation.

Azhar [16] indicates through its study which dealt with very important aspects of the application of BIM that the design processes have become more efficient by using the BIM, which gave the possibility of dealing with the intelligent environment design allows to simulate the model quickly and benchmark the performance. In a related context, different design alternatives are available for study faster by the BIM, giving the possibility to make informed decisions regarding different alternatives and to study multiple scenarios of the building [17].

Another significant concept in the BIM is that it deals with objects rather than three-dimensional forms, but it has its own characteristics and materials. In this way, the environment is flexible, so a change in a one location automatically followed by changes in the objects which are associated with this change [18]. On the other hand, the BIM allows easy and quick extraction of any sections and plans of the building without the need to draw them [16, 19]. These benefits were studied only for a specific phase of the project, which is the design phase.

One of the key benefits offered by BIM is the integration of stakeholders during different project phases and the imposition of a cooperative working environment among them to expand area of interest. Furthermore Holness [20] explains through its study which integrating between (BIM) and intelligent document technology that the feature of clash detection in BIM helps to detect conflicts in the early stages before the actual construction and as a result, the orders of change, which arises largely due to errors design will be avoided. BIM also has high accuracy in estimating quantities and costs [21].

The use of BIM in projects enhances the productivity and quality of the project and saves time and money. All these factors are the focus of customer satisfaction in executing a successful project [22, 23], but studying such factors requires their actual application to a construction project to demonstrate these benefits as numerical values.

BIM presents opportunities for contractors to simulate and analyze work in a virtual environment for improving safety performance and identifying problems before they occur according to this workers and staff can avoid the risks and manage the site in optimist way. On the other hand, about the supplier, the BIM provides a service to him by informing him with accurate data about the quantities of materials at an early stage so that he can put the appropriate quantity at the right time without delay. This point serves the work site also because it regulates the arrival of quantities in a timely manner not less than the need and no more than the need [24]. Through the database provided by the BIM, the operation and maintenance of the building became easier than before through the BIM model, one click on any part or equipment giving full details about it this is what Sebastian [25] said it through its study, but it has been study only the hospital construction projects and what the BIM is doing for them.

Through BIM, there is quality in completeness and storage of project data, sharing and utilizing them at any stage of the project [26]. For sustainability, BIM has provided services in the area of sustainable design, including the possibility of analyzing the building's energy, reducing construction waste and managing it and other aspects [27].

3. Research Methodology

This paper studies potential benefits of BIM in Iraqi construction project. The research includes three basic stages which can be summarized in the following points:

1. The first stage: Involves highlighting the problem of the research, defining the aim from this research, setting clear objectives within the research plan.
2. The second stage: This stage involves the See of previous literature on this topic and collect information from various sources such as books, papers, thesis, reports and others
3. Third stage: The design of the questionnaire, which includes the preparation of the main parts and the items and questions of each part after completing the draft of the questionnaire as a primary form through the following steps:
   a) Arbitration: the questionnaire was presented to several experts from inside and outside Iraq, to express their views about the validity of the paragraphs of the questionnaire and the extent of its clarity and then respond to the views of experts and the amendment to the light of their observations.
   b) The questionnaire was distributed to the whole sample
   c) After that questionnaire data was organized and prepared for statistical analysis.
   d) The last stage is the discussion of what has been obtained from the results and build the conclusions.

Figure 1 illustrates the research plan.

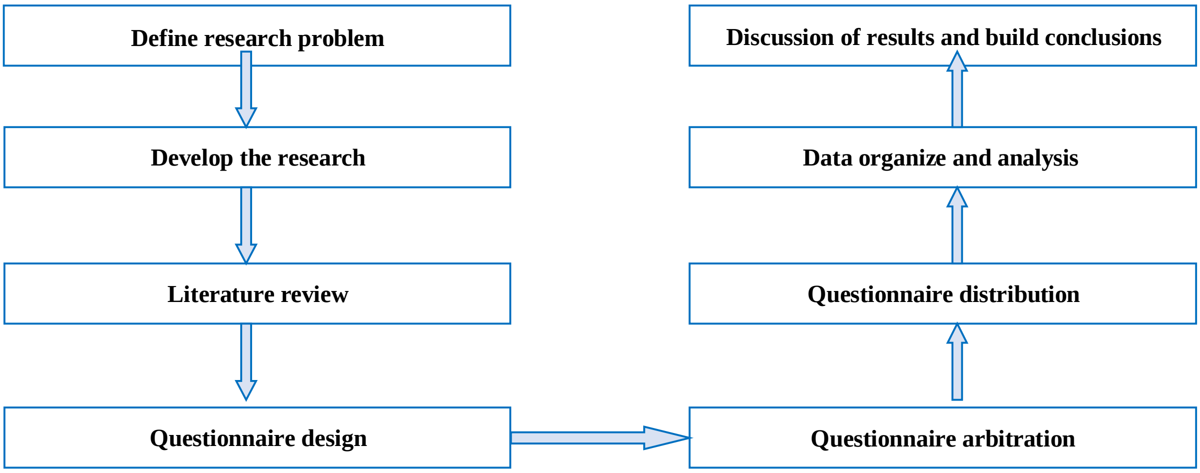

Figure 1. Research Plan

The data were collected using the field survey through the design of a special questionnaire for this purpose as it mentioned previously, and this questionnaire distribute to the professionals working in the Iraqi construction sector in both public and private sectors (in Diyala Governorate as a case study). Respondents explained their views in a set of items in the questionnaire, where 300 questionnaires were distributed, and the total return was 273 be response rate 87.7%. with 11 incompletes, so the final number of forms is 262 forms. The questionnaire included two main parts: the first part is the personal information regarding the respondent including (gender, age, academic qualification, specialization, group and work experience). The second part included 24 items shown in Table 1 representing the BIM potential benefits which used in questionnaire and designed by the five- Likert scale [28] as follow:

1. Extremely high benefit;
2. High benefit;
3. Moderate benefit;
4. Low benefits;
5. Extremely low benefit.

After the collection of the questionnaires, they were arranged, unloaded and analysed using the Statistical Packaging for Social Science (SPSS) software version 24 and SmartPLS version 3.2.6 to execute exploratory factor analysis and confirmatory factor analysis to build the measurement model.

Table 1. BIM Potential Benefits

No.	Item
B1	The ability to visualize the building with different details from different angles and better representation for complex buildings details
B2	Increased design efficiency by the ability to simulate the design model
B3	Digital Virtual Construction enables rapid analysis of various performance scenarios related Building
B4	Link cost, time and other variables to the unified design model
B5	Facilitate cooperation between the different stockholder of the project such as the owner, designer, contractor, and others to expand the area of interest in several aspects
B6	Improving the productivity of estimating the quantities of the project
B7	Support decision-making by providing a reliable database for all parts of the project
B8	Saving on the cost of the project
B9	The high flexibility offered by the BIM design so that the change in a particular location of the design followed by automatic change in all variables associated with it
B10	Detection of design errors and conflicts between different disciplines at early time and minimizing rework
B11	Enhance customer satisfaction
B12	Analysis of the building in terms of energy
B13	visualize the scheduling of the project this has a role in facilitating the coordination project processes and steps to reach an expected result
B14	Provide high-quality and fast data documentation system
B15	Minimize construction waste and manage it well
B16	Develop risk management and minimize risks as well as site safety planning and reduce accidents
B17	Improved construction communication management
B18	Increase the delivery speed and finish of the project
B19	Easy and quick access to any details or sections of the building
B20	Increase productivity and quality of the project
B21	Minimize change orders
B22	Increased efficiency of procurement by processing accurate quantitative data as well as identify the plan and times of purchase
B23	Better maintenance management and technical accessories during the life of the building
B24	Enhanced location logistics plans and better site equipment management

4. Factor Analysis (FA)

Factor analysis is a systematic statistical method which aims at reducing a large number of observed variables to a smaller number of non-observed variables (factors) [29-31] and is present in the SPSS under the name of "Dimension Reduction" which reduces and summarizes the variables to certain factors [31].

Factor analysis has become one of the most widely statistical methods used in several fields such as philosophy, public health, social sciences, political science, administration, education, etc. [30]. There are two type of factor analysis (exploratory and confirmatory).

4.1. Exploratory Factor Analysis (EFA)

It is used to detect the structure in which variables are organized within a number of factors [32] In other words, there is no idea about how the variables will be distributed on the factors.

The studied variables must be subject to a set of characteristics with certain conditions to have true EFA. These characteristics will be clarified with their condition:

1- KMO value (Sufficient sample size) : KMO value is (Kaiser-Meyer-Olkin) value which determines whether the size of the sample is suitable for the EFA, KMO value range is from 0 to 1 and the sample size is sufficient and the value of the KMO is acceptable if it exceeds 0.6 [31].

2- Bartlett's test of sphericity (Sufficient correlation): This gives an indication whether or not the items are sufficiently related to each other to carry out the EFA. The test is considered successful if its Sig. value is less than 0.05 [31].

3- Correlation matrix: This matrix includes all the correlation coefficients between each of the two items involved in the analysis and the use of the FA requires the existence of correlation not less than 0.3 and not exceed 0.9 [29, 33].

4- Communalities: These represent the percentage of variance interpreted by a given item cross the extracted factors [34]. This value preferably more than 0.4, but it does not exceed 1 [35].

5- Eigenvalue: This contributes to determining the number of factors because one of the most rules for determining the factors is the Kaiser rule. According to this rule the factors that have Eigenvalue more than 1 will be selected, which contribute to the interpretation part of the variance is higher than 1, and higher Eigenvalue mean higher importance of this factor [34].

6- Factor extraction: Many techniques are designed to extract factors, including (Principal Components Analysis PCA, Unweighted Least Squares, Generalized least squares, Maximum likelihood, Principal axis factoring, Alpha factoring and Image factoring) , But the most common way is Principal Components Analysis PCA [31].

7- Factor rotation: Rotation of elements is the process of making the extracted factors more susceptible to understanding and explanation. This process does not result in any change in the underlying solution in terms of mathematics and one of the most important methods of factor rotation is the orthogonal rotation – Varimax [31].

8- Factor naming: After the EFA is done, the extracted factors are anonymous so each factor should be named according to the variables that are Contributed on it

4.2. Confirmatory Factor Analysis (CFA)

It is the second type of factor analysis which deals with the previously explored model of measurement to accept or reject the model [36].

Schumacker [37] indicates that the CFA is a type of Structural Equation Modeling (SEM), which is known as a statistical technique for creating statistical models, which tend towards the confirms of these models rather than the explores of them.

The confirmatory factor analysis was done by building and testing a second order measurement model according to hypothesized models shown in Figure 2 for each BIM potential benefits items. SmartPLS version 3 (latest version) software was used.

According to Hair [38] the second order model is also called Higher Order Construct (HOC). The model type is reflective- formative model. Hair [38] distinguished between the criteria for examining the model in the case of reflective and formative.

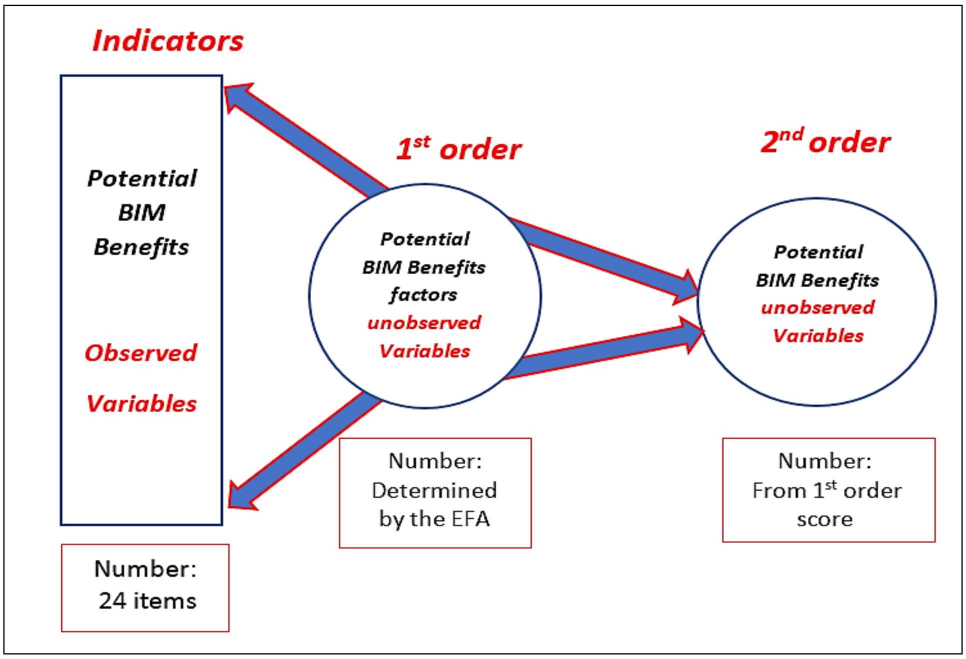

Figure 2. Hypothesized BIM Potential Benefits Model

The assessment process of Second order reflective- formative model includes two stages:

4.2.1. Stage One: Assess Lower Order Model (Reflective)

When construct causes indicators and the indicators are interchangeable this mean that construct is reflective [38]. The assessment of the reflective model includes two basic criteria: the first is the achievement of convergent validity and the second is the achievement of discriminant vanity [38] .Convergent validity means to what extent there is a positive correlation between the indicators of one construct. Achieving convergent validity requires three main criteria [38]:

1. Factor loading: also called (indicator reliability). It is the amount of variance extracted from this indicator in the construct. If the value of Factor loading is equal or higher than 0.7 it is good. If it is between 0.4-0.7 the effect of its deletion on the model should be checked if it changes the values of other criteria. If it does not, then it is not excluding from the model. Values below 0.4 values are unacceptable and should be excluded.
2. Average Variance Extracted (AVE): it is a measure of the extent to which constructs are interpreted for the variation of their indicators. The value of AVE must be higher than 0.5 to be considered acceptable.
3. Composite Reliability (CR): it is a more advance measure rather than alpha-Cronbach to measure internal consistency because it considers the differing of factor loading.

Discriminant validity is a measure of the extent to which one construct distinguishes from the rest of the constructs and the detection of whether constructs are supposed to fall into one construct because there is no differentiation between them [38].

The most recent method of assessing discriminant validity is the method of Heterotrait _Monotrait [39] a newly discovered method mentioned also by [40] and incorporated into the SmartPLS software. Based on this method, the value of HTMT index which is extracted from model must be less than 0.9 according to HTMT0.9 [39].

4.2.2. Stage Two: Assess Higher Order Model (Formative)

When indicators causes construct and the indicators is not interchangeable this mean that construct is formative [38] The assessment of the formative model includes two basic criteria: the first is the assess of Collinearity issues and the second is to assess of outer weight [38].

1. Collinearity issues: When the correlation between the two indicters of the Formative is a high correlation model indicating that there are Collinearity issues and to examine the model according to this case, a special coefficient of tolerance called VIF (variance inflation factor) must between (0.2 – 5).
2. Outer weights: The evaluation of the outer weights gives an indication of the relevance and contribution of the indicators of the formative model. For the purpose of evaluating this point, the results of the bootstrapping should be evaluated for each of the indicters. The P-value of the outer weights must be statistically significant (less than 0.05 for significant level 5%) t statistic must be also statistically significant (greater than 1.96 for significant level 5%).

Bootstrapping refers to a large number of (subsamples) extracted from the (original sample) and it is recommended to use 5,000 subsamples [38]. Figure 3 demonstrates the concept of bootstrapping.

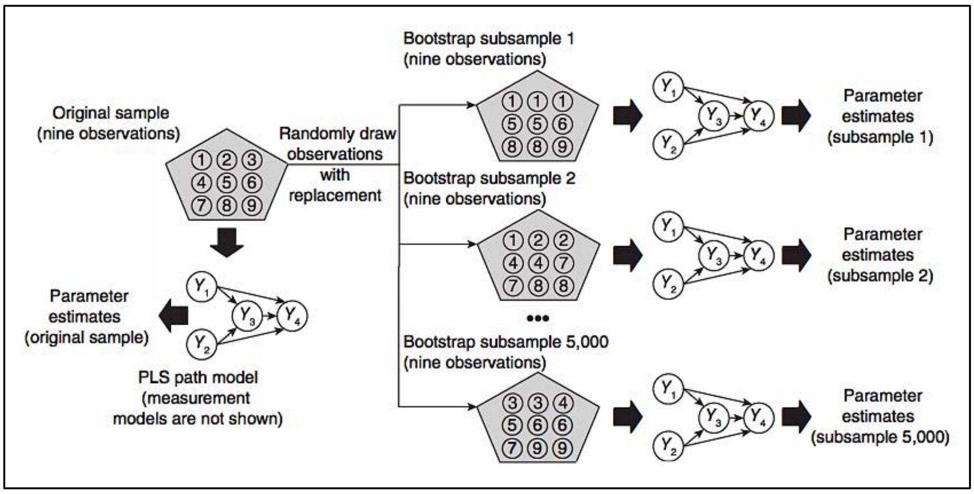

Figure 3. The Concept of Bootstrapping [38]

Figure 4 shows a brief description of the 2nd order reflective-formative assessment in SmartPLS.

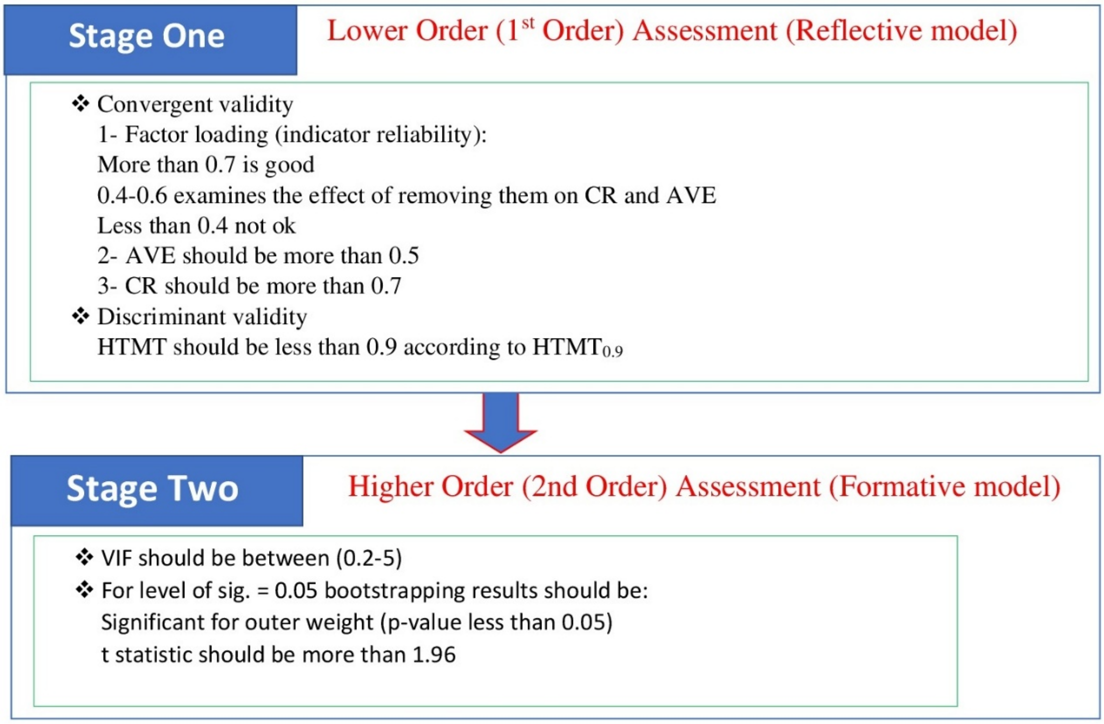

Figure 4. 2nd Order Reflective-Formative Assessment

5. Results and Discussion

5.1. General Information for Respondents

The demographic characteristics of target respondents shown in Table 2

Table 2. The Respondent's Profile

Information about	Categories	Percentage
Work sector	Public sector	79%
	Private sector	14%
	Public and private together	7%
Gender	Male	69%
	Female	31%
Age	20-30 years	25%
	31-40 years	51%
	41-50 years	18%
	More than 51 years	6%
Academic qualification	Diploma	3%
	Bachelor	80%
	Master	10%
	Ph.D.	10.6%
	Other	1%
Specialization	Architect	4%
	Civil Eng.	52%
	Electrical Eng.	24%
	Mechanical Eng.	12%
	Other	8%
Group (Job)	Designer	14%
	Consultant	9%
	Project manager	10%
	Site engineer	50%
	Contractor	12%
	Other	5%
Practical experience	Less than 5 years	30%
	5-10 years	24%
	11-15 years	17%
	16-20 years	17%
	More than 20 years	12%

5.2. EFA Analysis

As mentioned earlier the FA aims at reducing the number of observed variables to a smaller number of non-observed variables (factors). For the items allocated to measure the potential benefits of BIM which is 24 items, The EFA will show the structure under which these items are grouped into certain factors. The following results represent the results obtained from EFA:

5.2.1. KMO Value and Bartlett's Test

KMO value refers to the adequacy of the sample size and the value of Bartlett's test indicating the adequacy of the correlation, which are important conditions that must be met before the application of the EFA. Table 3 shows the results of these tests.

Table 3. KMO and Bartlett's test results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.890
Bartlett's Test of Sphericity	**Approx. Chi-Square**	2513.995
	df	253
	Sig.	0.00

The results showed that KMO value is good because the minimum allowed is 0.6, also the value of Bartlett's Test is significant because of it less than 0.05. Thus, the data are appropriateness to completion other steps of the EFA.

5.2.2. Correlation Matrix

The correlation coefficients between the items varied and greater than 0.3 and not exceed 0.9 that which gives an impression of variation in the general data structure to conduct EFA.

5.2.3. Communalities

The common values (Communalities) obtained from the EFA ranged from 0.407 to 0.735. As previously mentioned, the values of the common represent the contribution of the variable in the interpretation of the variance in extracted factors. Since the values obtained are greater than 0.4 and not more than 1, they are acceptable values.

5.2.4. Factors Extracting

To extract the factors, the principal components method PCA and the Kaiser rule were used. Three factors were extracted according to Kaiser's rule. The eigenvalue of the extracted factors should be greater than 1. The ratio of total explained variance is 54.861 to the three factors of the first factor (43.985), the second factor (6.724) and the third factor (4.152).

The Cattell's scree plot is one of the outputs of EFA and it confirms the application of Kaiser's rule in selecting the number of factors where the eigenvalue at 1 value gives three factors. Figure 5 shows Cattell's scree plot.

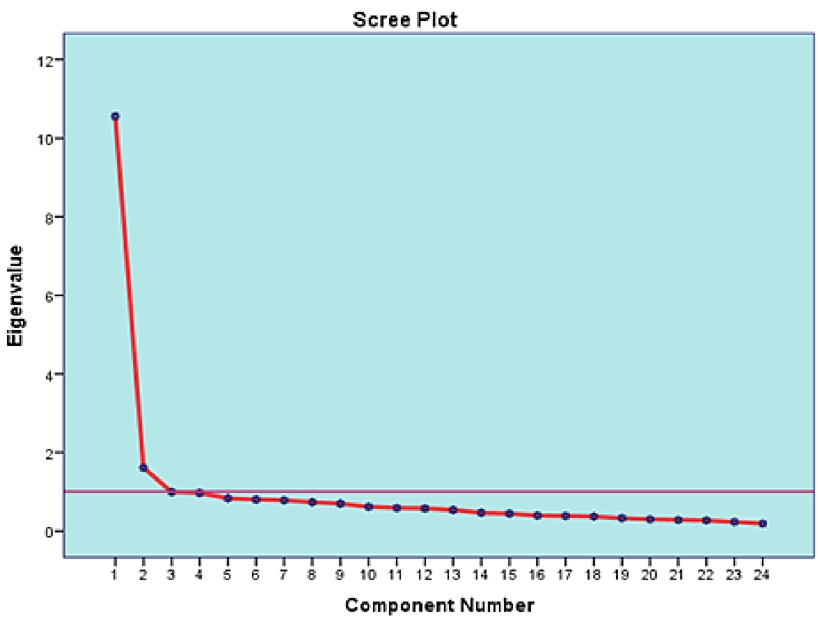

Figure 5. The Cattell's Scree Plot

5.2.5. Explanation of Factors

Factor rotation helps to understand the distribution of variables on the extracted factors. Varimax with Kaiser Normalization used as a rotation method and Table 4 shows the results of the rotation of the three factors. It was found that the highest loading value for each variable on a given factor within the acceptable limits [41] stated that if the sample size exceeded 250 and did not exceed 350 the lowest acceptable load is 0.35.

Table 4. Rotated Component Matrix

No.	Component		
	1	2	3
B1	0.335	0.546	0.296
B2	0.223	0.785	0.139
B3	0.119	0.655	0.262
B4	0.224	0.505	0.417
B5	0.221	0.665	0.162
B6	0.390	0.556	0.162
B7	0.611	0.342	0.218
B8	0.479	0.440	0.223
B9	0.564	0.234	0.185
B10	0.372	0.524	0.218
B11	0.474	0.393	0.172
B12	0.608	0.315	0.261
B13	0.622	0.317	0.180
B14	0.562	0.356	0.246
B15	0.393	0.325	0.422
B16	0.486	0.207	0.593
B17	0.633	0.199	0.297
B18	0.344	0.208	0.714
B19	0.223	0.182	0.807
B20	0.303	0.164	0.781
B21	0.183	0.059	0.735
B22	0.636	0.092	0.438
B23	0.713	0.148	0.318
B24	0.685	0.174	0.309

5.2.6. Naming of Factors (Components)

One of the EFA analysis advantages is the possibility of giving a name to the extracted factors and this name must be based on the items contained in the factor. Table 5 shows the names of each factor.

Table 5. BIM Potential Benefits Factor Naming

No.	items	Name
BF1	B7, B8, B9, B11, B12, B13, B14, B17, B22, B23, B24	knowledge support for management in term of (costs, data, processes)
BF2	B1, B2, B3, B4, B5, B6, B10	Effective design performance
BF3	B15, B16, B18, B19, B20, B21	Effective construction performance

5.3. Confirmatory Factor Analysis (CFA)

The confirmatory factor analysis (CFA) was executed using the measurement model in the SmartPLS 3.2.6 software. Afthanorhan [42] indicates that Smart PLS provides reliable and valid results in the CFA analysis. The model is second order model as shown Figure 5 which illustrates the model before executing analysis.

The repeated indicators approach used for the repeated items [43] . According to this approach the main latent variable (BIM Potential Benefits) includes all indicators of its latent variables (BF1, BF2, BF3). Latent variables (BF1, BF2, BF3) set as reflective while latent variable (BIM potential benefits) set as formative.

The assessment of measurement model for the potential benefits of BIM as mentioned consists of two stages:

5.3.1. Assessment of 1st Order (Reflective Model)

The first stage (reflective model) was assessed by two criteria: convergent validity and discriminant validity.

5.3.1.1. Convergent Validity

Convergent validity has been assessed by three basic criteria as previously mentioned to these criteria are (factor loading , AVE and CR) .Factor loading As shown in Figure 7, which represents the results of the PLS algorithm for BIM potential Benefits model the loading factor values ranged between 0.631 and 0.819, 18 from 24 indicators loaded above 0.7 and the remaining six are within the range (0.4-0.7) and there is no unacceptance factor loading (0.4) .As [38] indicated that the value of CR and AVE should be checked if it is below the required limits for indicating the effect of deleting (0.4-0.7) factor loading of the factors on them if they are less than required. In Table 6, which shows the values of the measurement model results, the results of CR and VIF are basically more than the required limits. Therefore, no indicators from the model should be deleted, Therefore the Factor loading for BIM potential benefits is verified and within the required limits.

Table 6. Convergent validity results for BIM potential benefits model

Construct	Items	Factor Loading	Construct Reliability (C_R)	Average Variance Extracted (AVE)
BF1	B23	0.767	0.919	0.508
	B24	0.755		
	B7	0.738		
	B12	0.736		
	B22	0.734		
	B13	0.722		
	B14	0.715		
	B17	0.708		
	B8	0.684		
	B9	0.634		
	B11	0.631		
BF2	B2	0.801	0.881	0.515
	B5	0.718		
	B6	0.716		
	B10	0.703		
	B1	0.700		
	B4	0.695		
	B3	0.686		
BF2	B20	0.819	0.902	0.606
	B18	0.816		
	B19	0.816		
	B16	0.809		
	B21	0.705		
	B15	0.693		

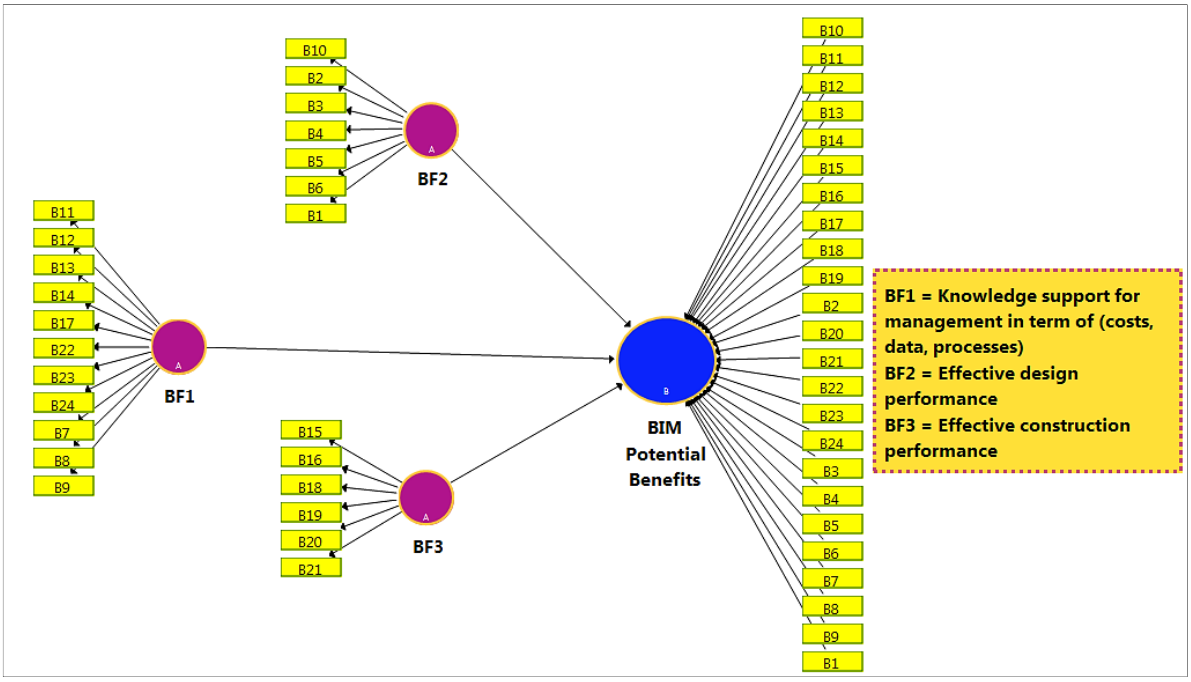

Figure 6. BIM potential benefit measurement model before analysis

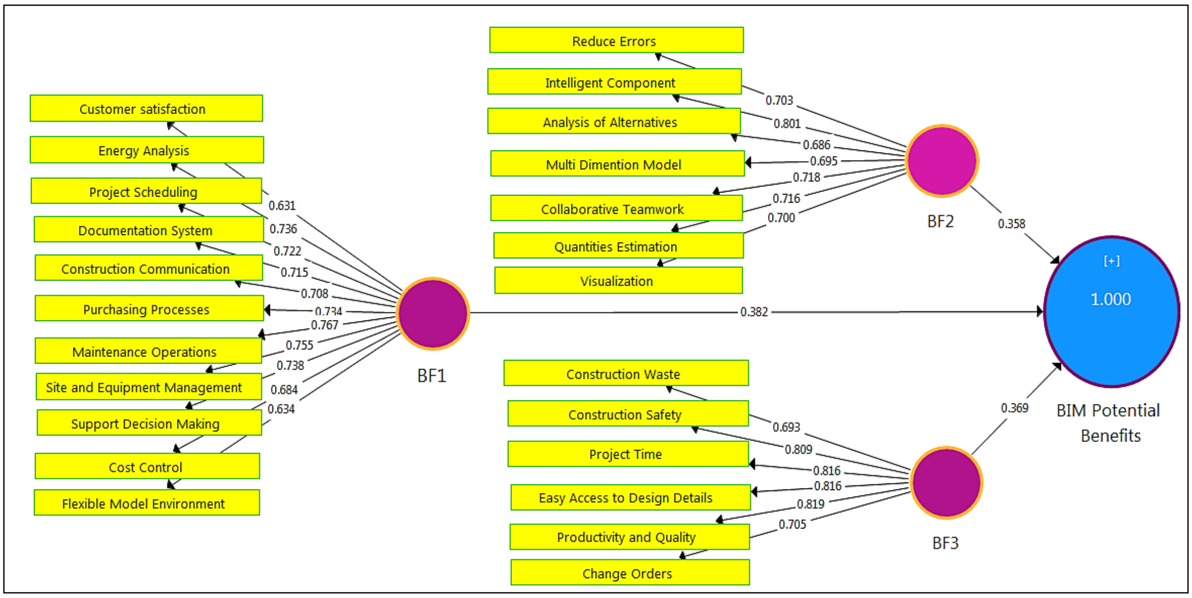

Figure 7. BIM potential benefits measurement model after PLS algorithm calculation

5.3.1.2. Discriminant Validity

The second criterion in evaluating the first stage of the model is the discriminant validity. The method of Heterotrait-Monotrait was used for assessing the discriminant Validity of the model. In accordance with the HTMT0.9 criterion, the results of discriminant validity in table 7 are considered acceptable results because it is less than 0.9. Therefore, the model has a discriminant validity between its three factors.

Table 7. Discriminant Validity Results for BIM Potential Benefits Model

	BF1	BF2	BF3
BF1			
BF2	0.829		
BF3	0.886	0.748	

5.3.2. Assessment of 2nd Order (Formative Models)

The assessment of the second order formative model includes two basic criteria, as mentioned earlier. The first criterion is VIE value, which examines the model relative to the issue of collinearity. The second criterion measures the relevance and significance of outer weights by using p-value and t statistic value. Table 8 represents the results of the second order reflective model assessment.

Table 8 Second Order Validity Results

2nd order construct	1st order construct	VIF	Outer weight	Standard Deviation	t statistic	P_Value
BF1	BIM Potential Benefits	3.329	0.382	0.007	54.19***	0.000
BF2		2.166	0.358	0.005	78.53***	0.000
BF3		2.693	0.369	0.006	59.27***	0.000

NS = not significant
*$p < 0.10$
** $p < 0.05$
*** $p < 0.01$

The results of the second order formative model assessment criteria are within acceptable limits as all VIF values are between 0.2-5, P-values are less than 0.05 and finally t statistic values are higher than 1.96.

6. Conclusions

There is no measurement model for BIM application benefits. The measurement model was developed during this study. The results showed that the benefits of BIM were made up of three main components. The first component is "knowledge support for management in term of (costs, data, processes)" Which is concerned with the benefits that contribute to supporting the project management well to reach a successful project.

The second factor is "Effective design performance" and the third is "Effective construction performance" It was explained how to use items in the lower and higher orders as a hierarchal component models. No items have been removed from any construct (BF1, BF2 and BF3) where all items are subject to the statistical criteria of the model and no item penetrates these criteria and this gives an indicator from a purely quantitative perspective that the model provided an advanced validation tool for study results.

7. References

[1] Arayici, Y., et al. Towards Implementation of Building Information Modelling in the Construction Industry. in Fifth International Conference on Construction in the 21st Century (CITC-V). 2009. Istanbul, Turkey. doi: 10.13140/2.1.3776.6080.

[2] Azhar, S., et al. Building Information Modeling (BIM): A new Paradigm for Visual Interactive Modeling and Simulation for Construction Projects. in Proc., First International Conference on Construction in Developing Countries. 2008.

[3] Succar, B., Building Information Modelling Framework: A Research and Delivery Foundation for Industry Stakeholders. Automation in construction, 2009. 18(3): p. 357-375.doi: 10.1016/j.autcon.2008.10.003.

[4] Chan, C.T., Barriers of Implementing BIM in Construction Industry from the Designers' Perspective: A Hong Kong Experience. Journal of System and Management Sciences, 2014. 4(2): p. 24-40.

[5] Azhar, S., M. Khalfan, and T. Maqsood, Building Information Modelling (BIM): Now and Beyond. Construction Economics and Building, 2015. 12(4): p. 15-28.doi: 10.5130/ajceb.v12i4.3032.

[6] Eastman, C.M., et al., BIM handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors. 2nd Edition ed. 2011, United States: John Wiley & Sons. doi: 10.5130/ajceb.v12i3.2749.

[7] Arayici, Y., C. Egbu, and S. Coates, Building Information Modelling (BIM) Implementation and Remote Construction Projects: Issues, Challenges, and Critiques. Journal of Information Technology in Construction, 2012. 17(Management of remote construction sites and the role of IT Systems): p. 75-92.

[8] Memon, A.H., et al., BIM in Malaysian Construction Industry: Status, Advantages, Barriers and Strategies to Enhance The Implementation Level. Research Journal of Applied Sciences, Engineering and Technology, 2014. 8(5): p. 606-614.doi: 10.19026/rjaset.8.1012.

[9] Chen, L. and H. Qu, Evaluation for "Economics and Legislative Factors Influence the Design Team and Contractor Throughout a Building Project From Inception to Completion". Journal of System and Management Sciences, 2011. 1(6): p. 94-108.

[10] Nagalingam, G., H.S. Jayasena, and K. Ranadewa. Building Information Modelling and Future Quantity Surveyor's Practice in Sri Lankan Construction Industry. in The Second World Construction Symposium. 2013.

[11] CRC Construction Innovation, Adopting BIM for Facilities Management: Solutions for Managing The Sydney Opera House, in Cooperative Research Center for Construction Innovation. 2007: Brisbane, Australia.

[12] Kekana, C.O. Aigbavboa, and W.D. Thwala. Building Information Modelling (BIM): Barriers in Adoption and Implementation Strategies in the South Africa Construction Industry. in International Conference on Emerging Trends in Computer and Image Processing. 2014. Thailand.

[13] Smith, D.K. and M. Tardif, Building Information Modeling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers. 1st Edition ed. 2009, United States: John Wiley & Sons. doi: 10.1002/9780470432846.

[14] Ahmad, M.A., Peter Demian , and Andrew D.F Price. BIM Implementation Plans: A Comparative Analysis. in In: Smith, S. D., (Ed). 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK: Association of Researchers in Construction Management. 2012.

[15] Yamazaki, Y., et al., 3D/BIM applications to large-scale complex building projects in Japan. International Journal of High-Rise Buildings, 2014. 3(4): p. 311-323.

[16] Azhar, S., Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. Leadership and Management in Engineering, 2011. 11(3): p. 241-252.doi: 10.1061/(asce)lm.1943-5630.000012.

[17] Schade, J., T. Olofsson, and M. Schreyer, Decision ‐ making in a model ‐ based design process. Construction management and Economics, 2011. 29(4): p. 371-382.doi: 10.1080/01446193.2011.552510.

[18] Nawari, N.O. and M. Kuenstle, Building information modeling: Framework for structural design. 2015: CRC Press. doi: 10.1201/b18355.

[19] Hergunsel, M.F., Benefits of Building Information Modeling for Construction Managers and BIM Based Scheduling. 2011.

[20] Holness, G., Building Information Modeling: Future Direction of the Design and Construction Industry. ASHRAE Journal, August 2006, 2006. 48(8): p. 38-46.

[21] Nassar, K. The Effect of Building Information Modeling on the Accuracy of Estimates. in The sixth annual AUC research conference. Cairo: The American University. 2010. Retrieved from http://ascpro.ascweb.org/chair/paper/CPRT155002010.pdf.

[22] Arayici, Y., et al., Technology adoption in the BIM implementation for lean architectural practice. Automation in Construction, 2011. 20(2): p. 189-195.doi: 10.1016/j.autcon.2010.09.016.

[23] Barlish, K. and K. Sullivan, How to Measure the Benefits of BIM—A Case Study Approach. Automation in construction, 2012. 24: p. 149-159.doi: 10.1016/j.autcon.2012.02.008.

[24] Linderoth, H.C., Understanding Adoption and Use of BIM as the Creation of Actor Networks. Automation in construction, 2010. 19(1): p. 66-72.doi: 10.1016/j.autcon.2009.09.003.

[25] Sebastian, R., Changing Roles of the Clients, Architects and Contractors Through BIM. Engineering, Construction and Architectural Management, 2011. 18(2): p. 176-187.doi: 10.1108/09699981111111148.

[26] Forbes, L.H. and S.M. Ahmed, Modern construction: lean Project Delivery and Integrated Practices. 1st Edition ed. 2010, United States: CRC Press. doi: 10.1201/b10260.

[27] Love, P.E., et al., From Justification to Evaluation: Building Information Modeling for Asset Owners. Automation in construction, 2013. 35: p. 208-216.doi: 10.1016/j.autcon.2013.05.008.

[28] Likert, R., A Technique for the Measurement of Attitudes. Archives of psychology, 1932. 144(55): p. 1-55.

[29] Field, A., Discovering Statistics Using SPSS. 4th Edition ed. 2009, United States: SAGE Publications. doi: 10.1002/bjs.7040.

[30] Tabachnick, B.G. and L.S. Fidell, Using Multivariate Statistics. 5th Edition ed. 2013, United Kingdom: Pearson Education.

[31] Pallant, J., SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS. 6th Edition ed. 2016, Australia: Allen & Unwin. doi: 10.1111/1753-6405.12166.

[32] Norris, M. and L. Lecavalier, Evaluating the Use of Exploratory Factor Analysis in Developmental Disability Psychological Research. Journal of autism and developmental disorders, 2010. 40(1): p. 8-20.doi: 10.1007/s10803-009-0816-2.

[33] Yong, A.G. and S. Pearce, A Beginner's Guide to Factor Analysis: Focusing on Exploratory Factor Analysis. Tutorials in quantitative methods for psychology, 2013. 9(2): p. 79-94.doi: 10.20982/tqmp.09.2.p079.

[34] Mertler, C.A. and R.V. Reinhart, Advanced and Multivariate Statistical Methods: Practical Application and Interpretation. 6th Edition ed. 2016, United Kingdom: Routledge. doi: 10.4324/9781315266978.

[35] Baggio, R. and J.E. Klobas, Quantitative Methods in Tourism: A handbook. 1st Edition ed. Vol. 48. 2011, United Kingdom: Channel View Publications. doi: 10.21832/baggio6195.

[36] Brown, T.A., Confirmatory Factor Analysis for Applied Research. 2nd Edition ed. 2014, United States: Guilford Publications. doi: 10.1198/tas.2008.s98.

[37] Schumacker, R.E. and R.G. Lomax, A Beginner's Guide to Structural Equation Modeling. 4th Edition ed. 2015, United Kingdom: Taylor & Francis. doi: 10.1080/10705511.2011.607726.

[38] Hair, J.F., et al., A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). 2nd Edition ed. 2014, United States: SAGE. doi: 10.1080/1743727x.2015.1005806.

[39] Henseler, J., C.M. Ringle, and M. Sarstedt, A New Criterion for Assessing Discriminant Validity in Variance-Based Structural Equation Modeling. Journal of the Academy of Marketing Science, 2015. 43(1): p. 115-135.doi: 10.1007/s11747-014-0403-8.

[40] Hair, J.F., et al., A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). 3rd Edition ed. 2016, United States: SAGE. doi: 10.1108/IMDS-04-2016-0130.

[41] Joseph, F., et al., Multivariate Data Analysis: A Global Perspective (7th (Global Edition) ed.). 7th Edition ed. 2010, United States: Prentice Hall.

[42] Afthanorhan, W., A comparison of partial least square structural equation modeling (PLS-SEM) and covariance based structural equation modeling (CB-SEM) for confirmatory factor analysis. International Journal of Engineering Science and Innovative Technology, 2013. 2(5): p. 198-205.

[43] Wilson, B. and J. Henseler. Modeling reflective higher-order constructs using three approaches with PLS path modeling: a Monte Carlo comparison. 2007. ANZMAC. Retrieved from https://research.utwente.nl/en/publications/modeling-reflective-higher-order-constructs-using-three-approache.

Appendix: Questionnaire

Part I: Personal information (information about the person completing the questionnaire)

Name (Optional):

Work sector:

- ☐ Public
- ☐ Private
- ☐ Public and Private together

Gender:

- ☐ Male
- ☐ Female

Age:

- ☐ 20-30 years
- ☐ 31-40 years
- ☐ 41-50 years
- ☐ More than 51

Academic qualification:

- ☐ Diploma
- ☐ Bachelor
- ☐ Master
- ☐ Ph.D.
- ☐ Other

Specialization:

- ☐ Architect
- ☐ Civil Engineer
- ☐ Electrical Engineer
- ☐ Mechanical engineer
- ☐ Other

Belong to any group:

- ☐ Designer
- ☐ Consultant

- ☐ Project Manager
- ☐ Site engineer
- ☐ Contractor
- ☐ Other (specify Please)

Practical experience:

- ☐ Less than two years
- ☐ From 2 to 5 years
- ☐ From 5 to 10 years
- ☐ More than 10 years

Part II: Potential Benefits of BIM Application

As you know the current situation of the Iraqi construction sector, your assessment of the benefits mentioned below, which is produced by the application of BIM

Please tick (√) under the column you see fit

No.	Item	Extremely High Benefit	High Benefit	Moderate Benefit	Low Benefit	Extremely Low Benefit
1	The ability to visualize the building with different details from different angles and better representation for complex buildings details					
2	Increased design efficiency by the ability to simulate the design model					
3	Digital Virtual Construction enables rapid analysis of various performance scenarios related Building					
4	Link cost, time and other variables to the unified design model					
5	Facilitate cooperation between the different stockholder of the project such as the owner, designer, contractor, and others to expand the area of interest in several aspects					
6	Improving the productivity of estimating the quantities of the project					
7	Support decision-making by providing a reliable database for all parts of the project					
8	Saving on the cost of the project					
9	The high flexibility offered by the BIM design so that the change in a particular location of the design followed by automatic change in all variables associated with it					
10	Detection of design errors and conflicts between different disciplines at early time and minimizing rework					
11	Enhance customer satisfaction					

12	Analysis of the building in terms of energy					
13	visualize the scheduling of the project this has a role in facilitating the coordination project processes and steps to reach an expected result					
14	Provide high-quality and fast data documentation system					
15	Minimize construction waste and manage it well					
16	Develop risk management and minimize risks as well as site safety planning and reduce accidents					
17	Improved construction communication management					
18	Increase the delivery speed and finish of the project					
19	Easy and quick access to any details or sections of the building					
20	Increase productivity and quality of the project					
21	Minimize change orders					
22	Increased efficiency of procurement by processing accurate quantitative data as well as identify the plan and times of purchase					
23	Better maintenance management and technical accessories during the life of the building					
24	Enhanced location logistics plans and better site equipment management					