Study of Factors Affecting the Implementation of BIM: An Evaluation of Risk Variability at Construction Stages

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Abstract - *Building information modeling is new innovative approach towards building designing, construction and management and one of the important fields related to it i.e. quantity surveying. Quantity surveyor plays an important role in constriction industries such as preparation of bill of quantity, preparation of final accounts etc. BOQ prepared by the quantity surveyor is generally used to analyze the budgeted cost of the entire construction project and during the contracting procedures. In this study various risks involved in adoption of BIM for construction and management. In this study various risk factors are analyzed which has more impact on adoption of BIM in construction industry.*

Key Words: *BIM, BOQ, quantity surveyor, construction and management.*

1. INTRODUCTION

Building Information Modeling (BIM) is one of the most visible aspects of a deep and fundamental change that is rapidly transforming the global construction industry. It is the platform that brings about collaboration between project stakeholders and improvement of project outcomes. (Abubakar, MuIbrahim, Yahaya Makarfi,Bala, K)1

The lifecycle management of construction project based on BIM is analyzed thoroughly, and thought that the usage of BIM may solve the problem of information demand in the lifecycle management of construction project, and changes the way of information transmission and accumulation. (Chen Baoping, Wu Wei, He Xin)2

Building Information Modelling (BIM) is widely seen as a catalyst for innovation and productivity in the construction industry. BIM can assist a more sustainable construction process that in turn may contribute to eradicating poverty in developing countries.(Nam Buiab*, Christoph Merschbrockb, Bjørn Erik Munkvolda)3

Therefore, it becomes imperative to empirically assess the measures to improve the implementation of BIM among AEC firms. It is against this backdrop that four different AEC firms were considered in this study. (Babatunde, Solomon Olusola)4

Recently Building Information Modeling (BIM) has been widely used to manage building information throughout the project life-cycle more effectively and efficiently. (Kim, Seong-ah,Chin, Sangyoon,Yoon, Su-won,Shin, Tae-hong,Kim, Yea-sang)5

Building information modeling (BIM) is considered as a key innovation in the construction industry with promises of significant benefits. (Gogoi, Arnab Kumar)6

An approach for enhancing the production efficiency of bill of quantities (BQ) used on construction projects is presented. (Wong, AndyWong, Francis K W)7

The use of building information modeling (BIM) has provided a means of increasing total project quality, providing accurate quantity take-offs, and improving scheduling, consequently diminishing total project `contingencies and costs. (Bynum, Patrick Issa, Raja R A Asce, F Olbina, Svetlana)8

The ability to utilize BIM to virtually construct a building prior to construction of the actual building provides an effective means to check its constructability in the real world. (Bynum, Patrick Issa, Raja R A Asce, F Olbina, Svetlana)9

In recent years, many governments and authorities have openly accepted BIM within the construction industry to provide the required information exchange between stakeholders. An alternative methodology is not in the vicinity that could provide the required benefits. (Coates, Paul) 10

Building Information Modeling (BIM) systems have the potential to revolutionize current practices and to automate the measurement of quantities from construction drawings. (Olatunji, O A Sher, W Gu,N)11

The classification system used to organize the measurements is another major issue. Many practices use different systems and so practitioners often have trouble with the mapping of each others' documents since either the elements and the measurements are defined in a different way. The lack of an official standard is one of the main contributors to this situation (Monteiro, AndréMartins, João Poças)12

In the traditional paper-based, detailed estimating process, the time spent on quantity takeoff can be broken down into three categories: 1) identifying items and their interrelationships on the drawings and specs (by marking and searching drawings and specs); 2) finding dimensions (reading directly or inferring from other drawings); and 3) calculating and aggregating the quantities, lengths, areas, and volumes of the identified items.(Shen, Zhigang)13

The support needed for BIM expansion comes from more professionals trained in BIM applications.(Wong, Kam-din Andy)14

This proposes an offer for the completion of works according to the project specifications. As well as determine and analyze the material requirements for site organization.

1.1 Building information modeling part of quantity survey

Building information modeling is an integrated digital process providing coordinated, reliable information about a project throughout all phases, from design through construction and into operation. BIM technology & collaboration techniques will be incorporated into QS modules for:

1) Enhance the learning experience
2) Up to date industry methods & techniques
3) Development of QS specific skills
    a) Visualization – 3d viewing
    b) Quantification
    c) Data Scheduling & pricing
    d) Multi disciplinary work based projects

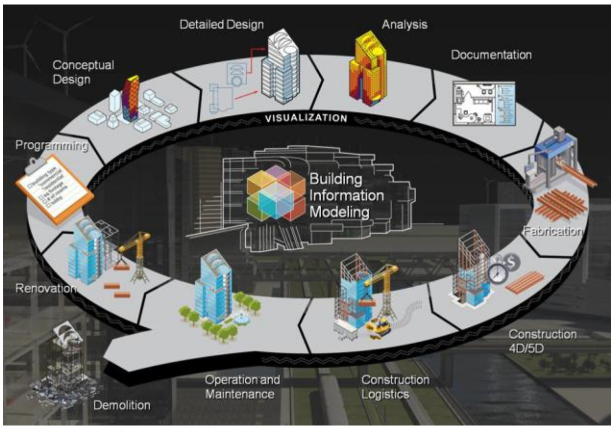

Figure 1 Applications of BIM in quantity surveying

1.2 Scope of work

- There are various problems occurs during the preparation of BOQ with paper based drawings and specifications to quantity surveyor.
- BIM implementation for BOQ serves as a useful alternative to addressing construction sector issues and offer solutions in order to increase the productivity, efficiency, quality, reduced cost etc. in construction project.

1.3 Problem statement

- Conceptual level estimates are limited by time and yet they need to be as accurate as possible.
- Increasing the speed of the estimating process allows an estimator to bid more jobs, which helps the company acquire more work. Performing quantity takeoffs is considered the most time-consuming portion of an estimate.
- Because of this estimators need more efficient methods to perform accurate quantity takeoffs. Thus, BIM provide more accuracy and improves performance of quantity surveyor to prepare BOQ.

1.4 Objective

- To study application of BIM in quantity surveying practice.
- To study the factors influencing in adoption of BIM in quantity surveying.
- To identify the risk and variability in construction cost.

2. Literature review

Chen Baoping, et.al analyzed the time and accuracy of performing quantity takeoffs when using building information modeling (BIM) through a comparison study using Revit (BIM software) and On-Center's OST. Participants of the study were asked to perform a quantity takeoff using both Revit and OST. Their resulting data was then, analyzed comparing both the time and accuracy of each item taken off. Seong-Ah Kim et.al includes the criterion as needed in the stage of detailed estimation for 3D model based quantity take off and its limitations. To overcome the limits the finished modeling method that allows drawing many materials at once on the basis of geometric constraints.

O.A. Olatunji, et.al had investigated the budgetary reliability of the BOQ in procuring building projects using secondary data from completed building projects.

O.A. Olatunji et.al explores the relationship between BIM systems and the roles of quantity surveyors in the construction industry. We argue that BIM challenges traditional roles of quantity surveyors and their relevance to the construction industry. Zhigang Shen et.al Aim of this research report was to study the influence of BIM on the quantity surveying profession.

Zhigang Shen, et.al concluded that the BIM-assisted estimate demonstrated better performance over traditional estimating methods for the entry-level user. Both the visualization and aggregation functions of the BADE tool had significant impact on the performance of the detailed estimate.

Kam-din Andy Wong, et.al provided a review of BIM in tertiary education in the AEC disciplines. A number of universities around the world are offering courses for various applications of BIM. Kevin Thomas et.al aims, to allow construction industry professionals to enhance their existing skills in order to improve project delivery through the use of Building Information Modeling and Management and foster leadership, decision making, strategic thinking and communication.

Patrick Bynum, et.al investigate how BIM has been adopted in Nigeria and determine to what extent it has helped in improving collaboration among stakeholders in Nigerian construction industry. The method adopted is that of the structured questionnaire. Abbas M.Abd shows that the energy modeling leading to analyze of building project performance and this can help in optimization of buildings overall design with respect to energy efficiency.

Arnab Kumar Gogoi, et.al explore the real potential of BIM in QS. It also checks expansions of QS roles, challenges of Quantity Surveying by BIM.

Mu'awiya Abubakar, et.al presents the process of feeding information to the model based on selected construction works design software. S. Arunkumar et,al shows that though there are lots of benefits of BIM, there are a lot of barriers quoted by professionals which prevent them in implementing BIM.

Solomon Olusola Babatunde, et.al highlighted that there are several design coordination issues that affect the efficiency of not only the design but also the construction process. Lean and BIM if implemented simultaneously can help resolve these issues, however there are major gaps in research when it comes to real-world examples and how they achieve this integration.

3. Methodology

The diagrammatic process of experimental investigation given as below:

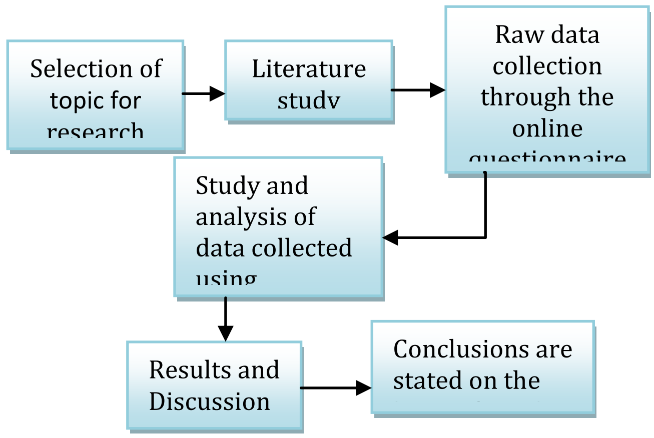

Figure 2 Flow chart of methodology adopted for the research work

4. Data Collection and Data Analysis

This study is primarily carried out through the use of secondary data. Interviews are analyzed by using thematic and documentary methods to complement survey responses on factors influenced in adoption of BIM.

4.1 Modes of data collection

- Some of the data collected from personal interview, questionnaire survey and literature study.
- This study is basically done on the basis of availability of secondary data.
- For this study data is obtained through the questionnaire survey amongst the civil engineers and quantity surveyors.

4.2 Structure of Questionnaire Survey

- Section 1, consist the demographic information of individual who is willing to fill the questionnaire form.
- Section 2, consist the list of 20 factors and individual has to select an appropriate answers if the risks are involved or not as per their opinion.

- There are some of the responses collected through questionnaire represented in pie chart as given below:

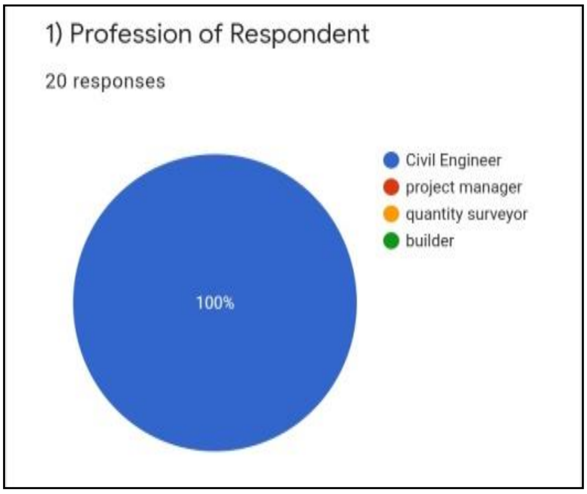

Figure 3 Pie Chart Shows Profession of Responden

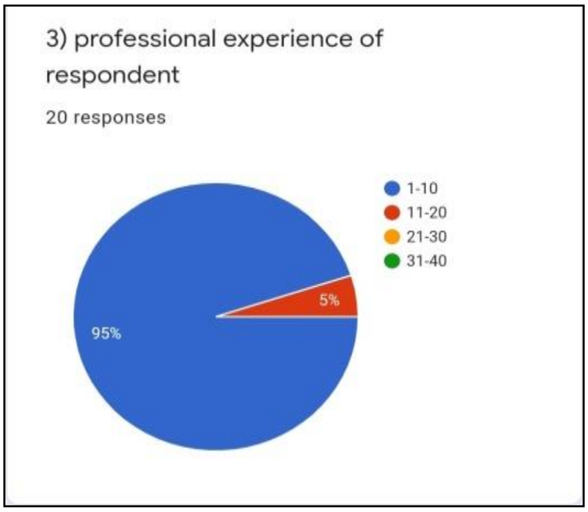

Figure 3 Pie chart shows professional experience of respondent

- For this study, quantitative and qualitative both approaches were adopted to analyze the available data.
- Responses to the survey were analyzed by using descriptive statistics, sampling method and relative important index (RII).

Following basic formulas were used for analysis-

- Relative Importance Index (RII) was used for analysis of data. It helps to rank the factors from collecting data.

RII is defined by the following formulae:

- **Relative Importance Index (RII) = ΣW (AxN), (0 ≤ index ≤ 1) ……………………(1)**

Where, W is the weight given to each factor by the respondents and ranges from 1 to 4.

W ranges

1 = strongly agree

2 = agree

3 = disagree

4 = strongly disagree

A is the highest weight = 4.

N is the total number of respondents.

4.3 Demographic Information

A breakdown of the demographic information for questionnaire respondents is presented in table given above. This shows that 91% of the respondents hold tertiary education, and 89% of them are professionally qualified. The mean work experience of the participants is 13.67 years.

This demographic information indicates that the participants are reasonably experienced in project developments and therefore have some knowledge of issues relating to factors affecting the adoption of BIM.

Table 1 Demographic information of respondent

Registered members	Civil engineer (40)	Quantity surveyor (25)	Total (65)
Number of willing Respondents	32	20	52
Fraction (%)	62	38	100
Number of responses	23	18	41
Fraction (%)	34	44	78

Table 2 Questionnaire Administration and responses: Questionnaire Distribution Based on Sampling Method

Characteristics	Frequency	%	Cum. %
Civil engineer	23	56.09	56.09
Quantity surveyor	18	43.9	100.00
Total	41	100.0	-
Academic qualification			
MSc/MBA	2	4.87	4.87
BE/BArch	22	53.65	58.52
diploma	17	41.46	100.00
Total	41	100.0	-
Professional experience			
1-10	19	46.34	46.34
11-20	17	41.46	87.8
21-30	5	12.19	100.00
31-40	0	0	-
Total	41	100.0	-
Type of client engaged			
Private	22	53.65	53.65
Government institutions	15	36.58	90.3
Federal and state government	4	9.75	100.00
Total	41	100.0	-
Mean	**13.67**	-	-

5. Result and Discussion

This section determined the respondents' perceptions of the most significant factors influencing the implementation of BIM in quantity surveying. The main survey question required the participants to identified factors for the implementation of BIM in quantity surveying. Rating the extent and impact of factors occurrence was used as criteria for ranking.

For the purposes of this study, the results are presented in the following subheadings, aligned with the results of previous studies on factors influencing in implementation of BIM in quantity surveying.

5.1 Key Factors for BIM adoption

"Initial Investment Cost" (RII, 0.587) and "Clients' interest in the use of BIM in their projects" (RII, 0.577). BIM Software availability and affordability" (RII, 0.452) are less important as a key factor for BIM adoption. The RII value given to "Prequalification of Team Member" (0.529) indicates that: Prequalification is less needed for BIM adoption on the project.

5.2 Use of BIM during the construction project stage

The results in Table 4 which describes the ranking given to use of BIM during construction stage indicates that BIM is most used in the design stage (RII 0.596), rank 1. The second-place ranking of application across the project lifecycle of BIM is construction stage (RII 0.519).

BIM is least used in the operation and maintenance stage as (RII 0.519), rank 3. The preconstruction stage is ranked 4 (RII 0.519). Feasibility stage is a potential area for future research to adapt BIM software (RII 0.500), rank 5 which is the least one among all the rank the ranks.

5.3 Ranking of Stakeholder's contribution in BIM

For this study Table 6.3 indicates that the top two stakeholder's contributions in BIM on projects are "Project Managers" (RII, 0.712) and "Sub-Contractors" (RII, 0.712). Project managers contribute most to adopt BIM on projects.

After project managers, consultants contribute for the BIM adoption (RII, 0.596). Client's contributions to adopt BIM on projects are less important (RII, 0.655). The RII value given to "Suppliers" (0.452) indicates that suppliers are not important for BIM adoption on projects hence it provides an ease in understanding. This research also recommends that further studies be centered towards ensuring providing ways of incorporating BIM training in the curriculum of tertiary institutions offering any building construction related programs.

Table 3 Result for the Key Factors for BIM adoption

Sr. no.	Factors	Strongly disagree		Disagree		Agree		Strongly agree		Total (N)	ΣW	RII=ΣW / (A*N)	Rank
		R	W	R	W	R	W	R	W				
		4	4	3	3	2	2	1	1				
1	Availability of trained professionals to handle the tools	2	8	2	6	17	34	5	5	26	53	0.510	12
2	BIM Software availability and affordability	0	0	3	9	15	30	8	8	26	47	0.452	20
3	Clients' interest in the use of BIM in their projects	4	16	5	15	12	24	5	5	26	60	0.577	3
4	Awareness of the technology among industry stakeholders	0	0	4	12	14	28	8	8	26	48	0.462	17
5	Collaborative Procurement methods	0	0	3	9	16	32	7	7	26	48	0.462	18
6	Social and Habitual Resistance to Change	1	4	5	15	13	26	7	7	26	52	0.500	13
7	Legal and Contractual Constraints	0	0	4	12	14	28	8	8	26	48	0.462	16
8	High Cost of Training	0	0	8	24	13	26	5	5	26	55	0.529	8
9	Lack of Enabling Environment	0	0	9	27	12	24	5	5	26	56	0.538	7
10	Lack of Trained Professionals to handle the tools	0	0	2	6	18	36	6	6	26	48	0.462	19
11	Clients not requesting the use of BIM on projects	1	4	9	27	10	20	6	6	26	57	0.548	5
12	No proof of financial benefits	2	8	4	12	15	30	5	5	26	55	0.529	9

13	Lack of Standards to Guide Implementation	2	8	8	24	11	22	5	5	26	59	0.567	4
14	Poor Internet Connectivity	3	12	3	9	15	30	5	5	26	56	0.538	6
15	Lack of Awareness of the technology among industry stakeholders	4	16	5	15	13	26	4	4	26	61	0.587	1
16	Efficiency of BIM Software	0	0	5	15	15	30	6	6	26	51	0.490	15
17	Initial Investment Cost	2	8	8	24	13	26	3	3	26	61	0.587	2
18	Site Layout Planning and Site Safety	1	4	5	15	12	24	8	8	26	51	0.490	14
19	Software and Hardware Upgrading and Maintenance Cost	2	8	4	12	14	28	6	6	26	54	0.519	11
20	Prequalification of Team Member	1	4	5	15	16	32	4	4	26	55	0.529	10

Table 4 Use of BIM during the construction project stage

Sr. no.	**Use of BIM during the constructio n project stage**	**Strongl y disagre e**		**Disagree**		**Agree**		**Strongly agree**		**Total (N)**	**ΣW**	**RII= ΣW / (A*N)**	**Rank**
		R	**W**	**R**	**W**	**R**	**W**	**R**	**W**				
1	Design	6	24	2	6	14	28	4	4	26	62	0.596	1
2	Constructi-on	1	4	3	9	19	38	3	3	26	54	0.519	2
3	Operation & Maintenance	2	8	4	12	14	28	6	6	26	54	0.519	3
4	Preconstru-ction	4	16	5	15	6	12	11	11	26	54	0.519	4
5	Feasibility	2	8	9	27	2	4	13	13	26	52	0.500	5

Table 5 Ranking of Stakeholder's contribution in BIM

Sr.no.	Stakeholder's	**Total (N)**	**Σ W**	**RII= ΣW / (A*N)**	Rank
1	Project Managers	26	74	0.712	1
2	Consultants	26	62	0.596	3
3	Main Contractors	26	62	0.596	4
4	Clients	26	47	0.452	6
5	Sub-Contractors	26	74	0.712	2
6	Suppliers	26	58	0.558	5

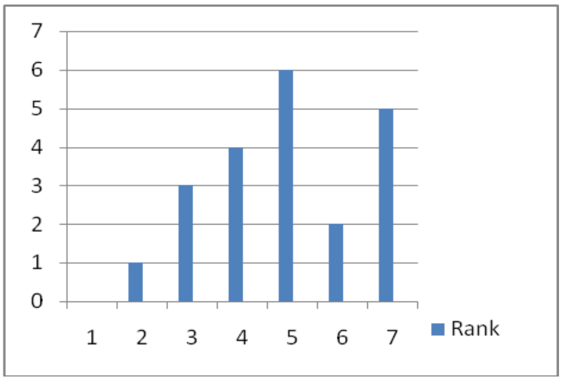

Figure 5 Graphical presentation of the ranks

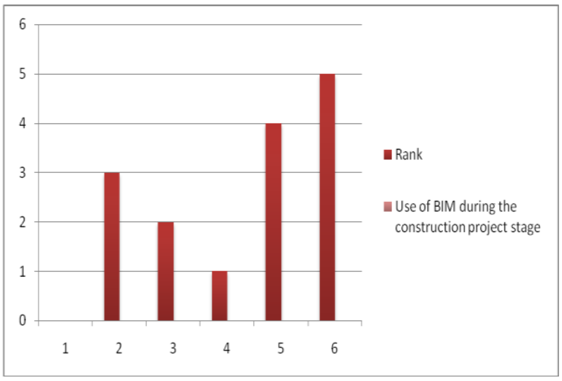

Figure 6 Graphical representations of the ranks obtained for Use of BIM during the construction project stage

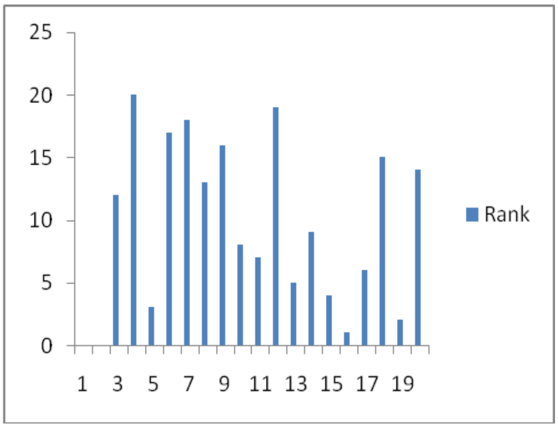

Figure 7 Graphical representation of the Ranking of Stakeholder's contribution in BIM adoption

6. CONCLUSIONS

- BIM in quantity surveying provides huge benefits to quantity surveyor, architectures and contractors. It provides the BOQ which is the most important document required during the tendering process or contracting process.
- BIM also provide fast, effective and efficient quantity take-off and cost estimations.
- It reduces human errors.
- Handover project to another party more quickly and reduces double handling.
- Enhance communication and collaboration among team members.
- Improve cost database management which reduces loss of information.
- From the survey results it also been identified some influencing factors that affecting BIM adoption and execution in AEC industry and the most influencing factors for all phases are identified as follows: Lack of Awareness of the technology among industry stakeholders" (RII, 0,587), "Initial Investment Cost" (RII, 0.587) and "Clients' interest in the use of BIM in their projects" (RII, 0.577).

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