

# CAPABILITY MATURITY OF QUANTITY SURVEYING FIRMS ADOPTING BUILDING INFORMATION MODELLING IN NIGERIA

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The capability maturity (CM) of firms bolsters their capacity to adopt innovations like Building Information Modelling (BIM). This study aims to assess the CM of quantity surveying firms (QSFs) that have adopted BIM in Nigeria. Using a Likert-type survey instrument, the study utilised a two-round Delphi technique to obtain the opinions of experts from 18 QSFs that have adopted BIM on the 19 capability attributes derived from literature that are thought to potentially influence QSFs' adoption of BIM. The experts' responses were analysed using descriptive and inferential statistical tools. The result showed that the CM level required by QSFs to adopt BIM in Nigeria was level 3 (defined level) on a scale of 1-5. This level indicates that firms have established processes and methodologies and a developed workforce. Further findings revealed that QSFs that have adopted BIM focus more on human capability, including teamwork and mentoring. The study would assist QSFs that intend to adopt BIM in identifying the capability attributes needed to adopt BIM and be abreast of or surpass the CM Level 3 achieved in this study.

Keywords: Building Information Modelling; capability areas; capability maturity; Nigeria; quantity surveying firm

## INTRODUCTION

Quantity surveying firms (QSFs) are focused on meticulously handling resources during project execution to deliver value for money (Osunsanwo and Dada, 2019). Their traditional functions include the provision of cost plans, cost estimation, and bill of quantities (BOQ). These activities are tedious, time-consuming, and prone to human errors and inaccuracies (Babatunde *et al.*, 2020). Building Information Modelling (BIM) is one of the innovations that has transformed the Architectural, Engineering, and Construction (AEC) industry globally by redefining traditional professional boundaries and improving project delivery and organisational performance (Babatunde *et al.*, 2020). QSFs' traditional functions have been transformed by BIM, offering them capabilities that improve their performance and practice (Makenya and Ally, 2018).

BIM enables QSFs to generate reliable cost estimates, provide rapid and accurate automated quantity take-off, enhance project planning and control, and facilitate cost

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planning and BOQ production (Marsh, 2017). QSFs have a lot to lose if they don't adopt BIM, as they experience challenges like low productivity, a lack of innovation, and inefficient service delivery (Osunsanwo and Dada, 2019). Despite the benefits of BIM, its adoption is still low in Nigeria (Aka *et al.*, 2020). BIM adoption among QSFs in Nigeria is still low, as most of them have not fully embraced it in their practice (Babatunde *et al.*, 2020). The low patronage of BIM could be attributed to QSFs' low capability maturity (CM), as firms with high CM tend to adopt BIM more than those with low CM (Marsh, 2017).

Studies like Mahamadu *et al.*, (2020) reported that the adoption of any innovation or technology by organisations is hinged on their CM. Capability maturity, which depicts how mature an organisation is, has been utilised in several industries but has not been widely explored in the AEC industry (Vivares *et al.*, 2018; Arowosegbe and Mohamed, 2015). There is also a paucity of studies on the CM of QSFs required for the adoption of BIM in Nigeria. There is therefore the need to explore the CM of QSFs in terms of their maturity level to adopt relevant BIM tools. Consequently, this study assessed the capability maturity of QSFs in Nigeria that have adopted BIM by focusing on two research objectives: (1) determining the capability maturity of QSFs that have adopted BIM, and (2) identifying prominent capability attributes of QSFs that have adopted BIM.

## LITERATURE REVIEW

Quantity surveying firms (QSFs) render quantity surveying (QS) services such as expert advice, procurement, contract, and cost management services, and consultancy, to satisfy their clients and maximise profit. They employ QSs with the necessary training, experience, and industry understanding to meet the demands of their clients (Osunsanwo and Dada, 2019; Aluthwela and Perera, 2016). QSFs are reputed to be project-specific and knowledge-intensive, making the use of information and communication technologies (ICT) and software an important part of their practice for performance improvement (Aluthwela and Perera, 2016).

Building Information Modelling (BIM) is one of the technological advancements which enhances the management of facilities and projects throughout their lifecycles (Olugboyege and Aina, 2018). BIM promotes collaboration through shared ownership of design and construction processes, enabling the design team to work together on a project (NBS, 2016). BIM enables QSFs to optimise their workflows and deliver high-quality service, leading to project cost accuracy and predictability (Marsh, 2017). The 5D BIM is associated with QS practice as it automatically generates accurate quantities for cost estimation and enables a corresponding change in costs to occur once project designs change (Raphael and Priyanka, 2015). Some of the BIM software used in QS practice include CostX, QS CAD, Masterbill, and Navisworks (Babatunde *et al.*, 2020).

Capability maturity (CM) is the extent of maturity an organisation has attained in achieving certain outcomes or a specific set of operations; be it the adoption of new technology, process, or system (Arowosegbe and Mohamed, 2015). The capability maturity model (CMM) is used to measure the CM of organisations and contains three essential components: generic processes, key practices, and key process areas (Englbrecht, 2021). CMM comprises five levels (1-5) known as maturity levels (MLs), with the highest-level being level five and the lowest being level one (Babatunde *et al.*, 2016). At ML 1 (ad hoc), processes tend to be chaotic as organisations have no stable environment, they go over budget and time for their

projects, and results are often unpredictable (Babatunde *et al.*, 2016; Software Engineering Institute [SEI], 2002).

At maturity level 2 (managed), organisations manage and execute projects based on documented plans with established commitments and resources and training carried out in line with organisation policy (Babatunde *et al.*, 2016; SEI, 2002). At maturity level 3 (defined), techniques, methods, tools, and standards are established and documented within the organisation and used to establish consistency across the organisation (Babatunde *et al.*, 2016; SEI, 2002). Additionally, organisations at this level develop the capability to capture and share best practices, develop their workforce, and gain competitive advantage through the development of different competencies to achieve organisational and business strategies (Babatunde *et al.*, 2016). At maturity level 4 (quantitatively managed), tools and databases are in use, and predictions are made based on statistical analysis, enabling an organisation to manage its capability and performance quantitatively (Babatunde *et al.*, 2016; SEI, 2002).

At ML 5 (optimising), an organisation has accomplished all the specific goals for the process areas of the other maturity levels, making it the most mature level. An organisation at this level continuously enhances their processes through innovative and incremental technical advancements and captures lessons learned with a feedback loop in place (Babatunde *et al.*, 2016; SEI, 2002). QSFs that want to adopt innovations like BIM require a minimum level of certain capabilities, as successful BIM adoption underpins the process capability of organisations (de Carolis *et al.*, 2017). The CM level of QSFs influences their success in the AEC industry and is the basis for competitive advantage (Inan and Bititci, 2015; Oosthuisen and Berry, 2013). Mahamadu *et al.*, (2020) submitted that the capability attributes of QSFs should be in the areas of effective information and data management. Nineteen (19) capabilities were identified from the literature and classified based on the five classifications of capability by Giménez *et al.*, (2019), as shown in Table 1.

## METHOD

The study's population comprised QSFs located in Lagos and Abuja, Nigeria, that are registered with the Quantity Surveyors Registration Board of Nigeria (QSRBN). A total of 205 QSFs (118 in Abuja and 87 in Lagos) were registered with QSRBN as of 2023. The sampling frame comprised QSFs in Lagos and Abuja that have adopted BIM in their practices. The non-probability purposive sampling technique using a pilot survey first and the snowball sampling method were used due to the paucity of information on QSFs that have adopted BIM in the study locations. Eighteen QSFs (12 in Lagos and 6 in Abuja) were found to have adopted BIM and constituted the sample size for the research.

Primary data were used for this study using the The Delphi technique. It is a technique used to collect information from respondents who are competent in their field of expertise or an area using a series of questionnaires to achieve consensus among the expert panel (Babatunde *et al.*, 2016). BIM experts from 18 QSFs that have adopted BIM were used for the Delphi survey. The number was sufficient, as most construction management studies utilised between 5 and 20 experts in their Delphi studies (Evans and Farrell, 2021). The Delphi process comprised of developing the questionnaire, choosing the panel of experts, gathering initial data, and analysing the data gathered from the expert panel. The capability attributes were identified from the literature and formed the items of the Delphi questionnaire survey.

The attributes were ranked by the respondents on a 5-point Likert scale of maturity levels 1 to 5 (1 = ad-hoc, 2 = repeatable, 3 = defined, 4 = managed, and 5 = optimised) based on the traits listed under each maturity level.

Table 1: Organisational Capability Attributes

S/N	Capability Areas or Attributes of QSFs	Literature Sources
<b>Innovative capability</b>		
1	Technology use	Giménez et al. (2019), Aluthwela & Perera (2016)
2	Smart work methods and problem-solving techniques	Aluthwela & Perera (2016)
3	Innovation adoption	Aluthwela & Perera (2016)
4	Research and development	Oosthuizen & Berry (2013)
<b>Marketing capability</b>		
5	Marketing of practice	Aluthwela and Perera (2016)
6	Securing/satisfying clients	Aluthwela & Perera (2016)
7	Feedback from clients	Aluthwela & Perera (2016)
<b>Financial capability</b>		
8	Firm's financial management	Oosthuizen & Berry (2013)
<b>Managerial capability</b>		
9	Employee reward and welfare	Aluthwela & Perera (2016)
10	Performance evaluation and orientation of employees	Aluthwela & Perera (2016)
11	Clear profession-specific functions for employees	Aluthwela & Perera (2016), Oosthuizen & Berry (2013)
12	The existence of cost database for cost management services	Oosthuizen & Berry (2013)
13	Adherence to laws and legislation governing country and quantity surveying profession	Oosthuizen & Berry (2013)
14	Functional organisational structure	Aluthwela & Perera (2016)
15	Clear leadership in an organisation	Oosthuizen & Berry (2013)
16	Management of time and budget for each project	Aluthwela & Perera (2016)
<b>Human capability</b>		
17	Mentoring of young employees	Aluthwela & Perera (2016), Oke et al. (2016)
18	Teamwork among employees	Aluthwela & Perera (2016)
19	Staff training and development	Aluthwela & Perera (2016), Oke et al. (2016)

Source: Synthesis from literature reviewed

Since the selection of respondents to form the expert panel is key to the successful outcome of the Delphi survey (Evans and Farrell, 2021; Ameyaw *et al.*, 2016), some of the criteria the respondents for this study must fulfil include: (a) work in a QSF that has adopted and possesses a thorough grasp of BIM concepts; (b) possess a bachelor's degree, at the very least in construction, management, and engineering, or a closely connected profession; (c) be an affiliate of a professional body, in this case, quantity surveying.

In the first round of the Delphi survey, questions and instructions on how to answer regarding the capability attributes obtained from related literature were sent to the experts electronically to provide their opinion. Responses from the panel of 18 experts were retrieved and analysed (the first round). The analysed data retrieved from the first round of data collection was sent back to the experts to compare their responses to the group mean and decide whether to review or confirm them in the second round. This process was repeated until a consensus was reached among the experts (Saunders *et al.*, 2019). Most studies in construction management establish that consensus can be reached in 2-3 rounds of the Delphi survey (Evans and Farrell, 2021; Ameyaw *et al.*, 2016). The data garnered from each round was analysed using the mean score analysis. Also, as the most used consensus tools in Delphi studies, Chi-Square and Kendall's coefficient of concordance were used to analyse the degree of consensus among the expert panel (Ameyaw *et al.*, 2016).

The Cronbach's alpha test, Shapiro-Wilk's test, and Kruskal-Wallis' H test were employed to test the reliability and normality of the data collected. Cronbach's alpha and Shapiro-Wilk's tests were the most used tools for testing the reliability and normality of data retrieved in Delphi studies (Evans and Farrell, 2021). The Kruskal-Wallis H test is used to determine if a significant difference exists in the responses of three or more groups of respondents (Paul *et al.*, 2021). Statistical Package for Social Sciences (SPSS) version 23 was used to analyse the collected data.

## FINDINGS AND DISCUSSION

The 18 experts responded to the Delphi survey, indicating a 100% response rate. The data retrieved from the first round was analysed using mean score analysis, and the results were sent back to the experts; for the second round. The second round was conducted to allow the experts to review and comment on the capability attributes from the first round by providing them with the group mean from the first round, and they were allowed to either agree with the group mean or stick to their old ratings. The experts decided to stick to their old ratings, indicating that the Delphi survey went through two rounds.

### Profiles of Expert

The profiles of experts in a Delphi survey are significant as their backgrounds should show they have adequate knowledge in the area being explored, in this case, BIM adoption among QSFs. The result of the data collected shows that most of the expert panel (44.4%) had a bachelor's degree, and the average years of work experience in the construction industry were 12 years. Most of the experts (55.6%) were members of the Nigerian Institute of Quantity Surveyors (NIQS), were senior quantity surveyors (senior level) in their organisations and had been involved in BIM for an average of 3 years, indicating they were well experienced and professionally qualified and their responses could be relied upon.

### Capability Maturity Level of QSFs

The result of the CM level (calculated as the weighted mean score of the capability attributes) of all QSFs that have adopted BIM is shown in Table 2. Previous studies like Oke *et al.*, (2016) have shown that the CM of firms to adopt new technologies was influenced by financial capacity, age of firm, size of firm, and firm's annual turnover. In this study, the convenient distinguishing factor was the age of the QSFs. Hence, the results were classified as firms that have existed for 1-10 years (young firms), 11-20 years (old firms), and above 20 years (older firms).

### *Consensus among experts*

The consensus among the experts was measured using the Chi-Square ( $\chi^2$ ) and Kendall's coefficient of concordance ( $W_a$ ) and is presented in Table 2. The computed Chi-Square ( $\chi^2$ ) value was 47.480, while its critical Chi-Square ( $\chi^2_{\alpha}$ ) value was 28.869 ( $p = 0.05$ ) at a degree of freedom of 18 (obtained from the statistical table). The  $\chi^2$  value being higher than its  $\chi^2_{\alpha}$  value indicates that consensus was reached among the experts (Evans and Farrell, 2021). Kendall's coefficient of concordance ( $W_a$ ) was also used to measure the level of consensus among the experts. The result in Table 2 showed that the  $W_a$  was 0.147, indicating weak agreement among the experts, as Moslem *et al.*, (2019) reported that a coefficient of concordance value of 0.10 indicates weak agreement, 0.30 indicates moderate agreement, and 0.60 and above indicates strong agreement.

### *Reliability and normality of data*

The reliability of the data collection instrument was measured using Cronbach's alpha test. The Cronbach's alpha was 0.919, as shown in Table 2. This value is considerably higher than the 0.700 minimum value threshold set for confirming the reliability of the research instrument for data collection, indicating that the data collected were reliable (Paul *et al.*, 2021). The normality of the data collected was also tested using Shapiro-Wilk's test of normality. The data were not normally distributed, as the significance level (p-value) was 0.000 and less than the 0.05 value threshold ( $p < 0.05$ ), as shown in Table 2. The result indicated that non-parametric statistical approaches should be used for subsequent analyses.

### *Capability maturity level*

The result in Table 2 showed that the overall CM level of QSFs was 3.61. From the result, it can be inferred that QSFs that have adopted BIM are generally at CM level 3 (defined level), tilting towards CM level 4 (quantitatively managed). Thus, QSFs that intend to adopt BIM should focus on attaining CM level 3 by improving their capabilities to attain CM level 3 requirements. At the defined level, firms have established standard operating procedures and practices, shared best practices, implemented organisational and business plans through the combination of a variety of competencies available, and created the framework for their workforce development (Babatunde *et al.*, 2016).

The result in Table 2 revealed that the CM level of QSFs in the 1–10-year age band was 3.40, 11-20 years was 3.59, and above 20 years was 3.67. The result inferred that the CM of QSFs in the 11-20 year and above age bands was slightly higher than that of QSFs in the 1–10-year age band. While QSFs that have existed for 1-10 years were closer to CM level 3, the two other categories of QSFs were tilting towards CM level 4. The result further revealed that QSFs in the above-20-year-old age band had the highest CM level, inferring that older firms tend to be more mature in their capabilities than younger firms. Since there is a paucity of studies to compare with this finding, more studies are required in this area. The finding on the CM level of this study is a bit higher than the 3.29 reported by Ajayi and Mohamed (2015); both findings indicate that firms in Nigeria that have adopted innovations are on CM level 3. Although their study was on contracting firms, the firms are situated in the AEC industry, like QSFs. Thus, similar studies on QSFs or other organisations that have adopted BIM in the AEC industry should be conducted to compare findings.

The Kruskal-Wallis' test was first conducted on the collected data to compare the responses of the experts across the three age categories of firms. The result in Table 2 revealed no significant difference in the experts' scoring of the 19 capability attributes of QSFs that have existed for 1-10 years, 11-20 years, and above 20 years, as they all had p-values greater than 0.05. A p-value greater than 0.05 means there was no significant difference in the scoring of the three categories of QSFs (Paul *et al.*, 2021).

The result in Table 2 revealed that all attributes under the five capability clusters had mean scores above 3.00. The top attribute in the innovative capability cluster was smart work methods and problem-solving techniques (MS = 3.72), and that of the marketing capability cluster was securing/satisfying clients (MS = 3.94). The top attribute in the financial capability cluster was the firm's financial management (MS = 3.56), and that of the managerial capability cluster was adherence to laws and legislation governing the country and the quantity surveying profession (MS = 4.00). The top attribute in the human capability cluster was teamwork (MS = 4.17). The

human capability cluster ranked the highest among the five capability clusters, while managerial and marketing capability clusters ranked next.

Table 2: Capability Maturity Level of QSFs

N	Capability Attributes	All			Firms (1-10 Yrs)			Firms (11-20 Yrs)			Firms (>20 Yrs)			K-W	
		MS	SD	R	MS	SD	R	MS	SD	R	MS	SD	R	$\chi^2$	Sig.
<b>Innovative capability</b>															
1	Smart work methods and problem-solving techniques	3.72	0.958	1	3.67	1.155	1	4.00	0.816	1	3.64	1.027	2	0.386	0.825
2	Innovation adoption	3.67	1.237	2	3.67	1.155	1	3.50	1.291	2	3.73	1.348	1	0.197	0.906
3	Technology use	3.39	1.243	3	3.00	1.000	4	3.50	1.291	2	3.45	1.368	3	0.314	0.855
4	Research and development	3.11	1.278	4	3.67	1.155	1	3.00	1.826	4	3.00	1.183	4	0.623	0.733
<b>Marketing capability</b>															
1	Securing/satisfying clients	3.94	1.056	1	4.00	1.000	1	3.75	0.957	1	4.00	1.183	1	0.591	0.744
2	Feedback from clients	3.56	1.097	2	4.00	1.000	1	2.75	0.500	3	3.73	1.191	2	4.085	0.130
3	Marketing of practice	3.06	1.162	3	2.67	0.577	3	3.25	1.708	2	3.09	1.136	3	0.739	0.691
<b>Financial capability</b>															
1	Firm's financial management	3.56	0.984	1	3.33	0.577	1	3.75	0.957	1	3.55	1.128	1	0.279	0.870
<b>Managerial capability</b>															
1	Adherence to laws and legislation governing country and quantity surveying profession	4.00	0.907	1	3.33	0.577	2	4.50	0.577	1	4.00	1.000	1	3.233	0.199
2	Clear leadership in organisation	3.78	1.003	2	4.00	1.000	1	4.00	0.816	2	3.64	1.120	4	0.436	0.804
3	Management of time and budget for each project	3.61	1.037	3	3.00	1.000	5	3.75	1.258	4	3.73	1.009	2	1.240	0.538
4	Functional organisational structure	3.56	0.984	4	3.33	0.577	2	4.00	0.816	2	3.45	1.128	6	1.108	0.575
5	Employee reward and welfare	3.50	1.150	5	3.00	1.000	5	3.25	0.957	5	3.73	1.272	3	1.875	0.392
6	Performance evaluation and orientation of employees	3.39	1.092	6	3.33	0.577	2	3.25	1.258	5	3.45	1.214	7	0.296	0.862
7	Existence of cost database for cost management services	3.33	0.970	7	3.00	1.000	5	3.25	1.258	7	3.45	0.934	5	0.628	0.731
8	Clear profession-specific functions for employees	3.17	1.098	8	2.67	0.577	8	3.00	1.414	8	3.36	1.120	8	1.794	0.408
<b>Human capability</b>															
1	Teamwork among employees	4.17	0.786	1	4.00	1.000	1	3.75	0.500	2	4.36	0.809	1	2.215	0.330
2	Mentoring young employees	4.17	0.924	2	3.67	1.528	2	4.25	0.500	1	4.27	0.905	2	0.570	0.752
3	Staff training and development	3.83	1.043	3	3.33	1.528	3	3.75	0.500	2	4.00	1.095	3	1.156	0.561
Capability Maturity of QSFs		3.61			3.40			3.59			3.67				
Cronbach's $\alpha$ reliability coefficient		0.919													
Number of respondents (N)		18													
Kendall's coefficient of concordance ( $W^2$ )		0.147													
Computed $\chi^2$		47.480													
$\chi^2$ critical value – Statistical Table (p = 0.05)		28.869													
Degree of freedom (df)		18													
Significance level (p)		0.000													

Note: MS = Mean Score; SD = Standard Deviation; R = Ranking; K-W = Kruskal Wallis

### Mean Score of Capability Attributes

The finding agrees with that of Giménez *et al.*, (2019), who reported that human capability impacts innovation and the performance of an organisation. The finding is also in consonance with Oke *et al.*, (2016) and Alutwela *et al.*, (2016), who reported that human capability is an integral aspect of QSFs for optimum performance and productivity. The study's findings showed that QSFs that have adopted BIM focus more on teamwork, mentoring, and staff training and development. The finding aligns with the finding of Alutwela *et al.*, (2016), who noted that QSFs need to encourage teamwork, carry out consistent and relevant training and development for their staff, and mentor young employees to improve their performance.

## CONCLUSIONS

The study assessed the capability maturity of QSFs in Nigeria that have adopted BIM by determining the capability maturity of QSFs that have adopted BIM and their prominent capability attributes. The study used the Delphi approach to solicit experts' opinions on the capability maturity of QSFs that have adopted BIM and their prominent capability attributes. The study, therefore, concludes that QSFs that have adopted BIM have a standard and consistent process in their quantity surveying practice, as they were positioned at CM level 3. At this level, QSFs have established processes and methodologies, shared best practices, and developed their workforce. Furthermore, older QSFs (firms that have existed for more than 20 years) were more mature in their capabilities than old and young QSFs (firms that have existed for 11-20 years and 1-10 years, respectively). Most QSFs that have adopted BIM focus more on human capability, including attributes like teamwork among employees and mentoring young employees.

This study contributes to the body of existing knowledge as it shows the capability maturity level needed for QSFs to adopt BIM and the capability attributes they need to focus on in a developing country like Nigeria, where the adoption of BIM is still low. It is believed that the findings will assist both professional and regulatory bodies of quantity surveying practice to serve as a basis for BIM adoption by QSFs of various ages that intend to adopt BIM. The knowledge of the capability maturity required to adopt BIM will help to increase BIM adoption among QSFs and other organisations in the AEC industry.

While this study contributes significantly to the body of knowledge, care must be taken in generalising its findings. For example, while the study was conducted in two major states of the country, future studies would benefit more from broader coverage, which would lead to a larger sample size than what is seen in the study. Also, this study adopted the Delphi approach; future studies could adopt other approaches, like the interview, for a more indepth understanding of the subject.

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