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BUILDING INFORMATION MODELLING IN QUANTITY SURVEYING PRACTICES: CURRENT STATE AND FUTURE CHALLENGES IN HONG KONG

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Calvin C.W. Keung, Instructor,
Department of Architecture and Civil Engineering, City University of Hong Kong, Hong Kong;
cwkeung@cityu.edu.hk

Tak Wing Yiu, Professor,
School of Built Environment, The University of New South Wales, Sydney, Australia;
kenneth.yiu@unsw.edu.au

Zhenan Feng, Lecturer, corresponding author
School of Built Environment, Massey University, Auckland, New Zealand;
z.feng1@massey.ac.nz

SUMMARY: *The use of building information modelling (BIM) in recent years has accelerated the performance and productivity of the architecture, engineering, and construction (AEC) industry. BIM can promote lean management, with enhanced control over budget and cost. However, the application of BIM for quantity surveying (QS) practices has not been extensively explored. Thus, this study examined the current situation and future challenges of BIM adoption in QS practices in Hong Kong. Questionnaire surveys and semi-structured interviews were administered to obtain insights from AEC industry practitioners in Hong Kong. Sixty survey respondents and nine interviewees participated in this study. The participants were quantity surveyors from developers, consultancy firms, and contractor companies. Results suggest that quantity surveyors are increasingly adopting BIM in Hong Kong. However, the low quality of BIM models and improper implementation of BIM often limit BIM adoption in QS practices. Another critical challenge is the absence of well-recognised BIM standards. Moreover, the shortage of skilled BIM professionals jeopardises the development and adoption of BIM in QS practices. The findings highlight the current achievements and barriers associated with BIM adoption in QS practices in Hong Kong. Prerequisites for successfully applying BIM in QS practices are suggested herein.*

KEYWORDS: *BIM adoption, Quantity surveying, QS practices, AEC industry*

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1. INTRODUCTION

In recent years, building information modelling (BIM) has fundamentally transformed the traditional practices of the architecture, engineering, and construction (AEC) industry, yielding effective and efficient methods to communicate and exchange information among project stakeholders (Azhar, 2011). BIM has influenced various professional services in the AEC industry, including quantity surveying (QS) (Vineeth & Jenifer, 2014). QS practices focus on the cost and contract management from the feasibility study stage to the handover stage. The key personnel performing QS practices are recognised as quantity surveyors (or cost engineers in Northern America). QS practices include mensuration, accountancy, economics, contracts, legislation, and information management. BIM can help quantity surveyors decrease errors, increase job efficiency, and enhance the quality of deliverables. However, the adoption of BIM in QS practices in the AEC industry is subject to several challenges (Babatunde et al., 2018; Kim & Park, 2016; Shayan et al., 2019). The accuracy and quality of BIM-based QS deliverables depend considerably on the information and data stored in BIM models (Smith, 2016). For instance, inappropriate information and inadequate design details may lead to inaccurate project estimates (Wu et al., 2014). Moreover, the lack of standardised coding systems and consistent modelling standards limit the accuracy and reliability of data extracted from BIM models (Kim & Park, 2016; Smith, 2016). Despite the rapid development of BIM technologies, only a few studies have examined the extent of BIM adoption in the QS profession and the manner in which the limitations of BIM workflows influence QS practices. This study aims to fill this knowledge gap by investigating the current state of adoption of BIM in QS practices in Hong Kong, thereby understanding the achievements and barriers associated with incorporating BIM in QS, and highlighting the prerequisites for successfully applying BIM in QS practices.

2. BACKGROUND

Quantity surveyors implement QS practices for developers, contractors, or consultants in the AEC industry (Wao & Flood, 2016). Across organisations with different characteristics, QS practices include all types of cost management, contractual management, and procurement within a project (Chamikara et al., 2020). Conventionally, quantity surveyors have used paper-based approaches to execute QS practices. The traditional approaches rely heavily on human effort and interpretation, which are time-consuming and susceptible to errors (Monteiro & Poças Martins, 2013). Through BIM, innovative approaches can be applied in QS practices. BIM can enhance the effectiveness and efficiency of QS practices in the form of cost management solutions (Sacks et al., 2018). BIM refers to the process of generating and managing data across a project lifecycle. In a BIM environment, the changes that occur in design can be automatically reflected on all relevant details, schedules, and documentation used by quantity surveyors (Lu et al., 2018). By using BIM workflows instead of paper-based approaches, quantity surveyors can efficiently perform quantity take-off (QTO), planning processes, and cost estimation with fewer errors and enhanced quality of deliverables (Lu et al., 2018; Smith, 2014). For instance, BIM can bring automation to QTO, which is a notable benefit for quantity surveyors (Fung et al., 2014; Monteiro & Poças Martins, 2013; Nagalingam et al., 2013; Stanley & Thurnell, 2014). In addition, BIM enables the automation of workflows, which can facilitate post-contract cost management tasks (Vigneault et al., 2020). The fifth dimension of BIM (5D BIM) is known as the cost element and it has been demonstrated to have the potential to lead to more reliable construction cost management (Mayouf et al., 2019; Moses et al., 2020). 5D BIM can be linked with cost databases, enabling the provision of automated cost advice and valuations for post-contract cost management tasks (Fung et al., 2014; Nagalingam et al., 2013; Stanley & Thurnell, 2014). Moreover, 5D BIM can integrate scheduling and planning data (the fourth dimension, 4D) to streamline time-related cost management tasks, such as interim valuations and cash flow forecasts (Lu et al., 2018; Yeung et al., 2012).

BIM allows quantity surveyors to more carefully examine cost management processes than is possible when following traditional approaches (Vigneault et al., 2020). For instance, BIM can provide lifecycle data in the early stages of a project, which can facilitate various types of analyses and influence the decision-making pertaining to materials, designs, schedules, and deliveries and thus decrease project costs (Kim & Park, 2016; Pittard & Sell, 2017). Moreover, BIM aids in the visualisation of construction projects, rendering the preparation of claims faster and more accurate than using conventional approaches (Koc and Skaik, 2014). In addition, with traditional project delivery methods, organisations often fail to keep adequate records and documentation, which can hinder dispute resolution (Dougherty, 2015; Koc and Skaik, 2014). BIM can overcome this limitation by facilitating data exchange and communication for dispute resolution and forensic engineering (Koc and Skaik, 2014; Lu *et al.*, 2018). The use of BIM information can also improve risk management. Moshtaghian and Moorzai (2022) developed a system integrating 3D, 4D, and 5D modelling to identify and manage risks in construction projects. The wide range of BIM information facilities the creation of a knowledge database for providing the optimal risk response.

However, quantity surveyors face some challenges when using BIM. The lack of information in BIM models is one of the biggest concerns for quantity surveyors (Smith, 2016). A BIM model should provide quantity surveyors with as much information as possible since a lack of information makes quantity take-off impractical with the model. In addition, BIM models are extracted using parameters defined by software vendors without following recognised measurement methods (Mayouf et al., 2019). As a result of the absence of consistent modelling standards, quantity surveyors are required to adhere to combined manual and automatic approaches, resulting in inconsistencies and inaccuracies (Mayouf et al., 2019). BIM implementation is further restricted by the lack of standardised coding methods, 5D BIM protocols, and upskilling the quantity surveying workforce with BIM knowledge (Moses et al., 2020).

3. RESEARCH METHODS

Two research methods were applied: questionnaire surveys and semi-structured interviews. Questionnaire surveys were administered to examine the current state and challenges of BIM adoption in QS practices in Hong Kong. Following this, semi-structured interviews were conducted to clarify industry practitioners' perspectives on the current state, challenges, and prerequisites for implementing BIM in QS practices. To validate the overall study results, questionnaire surveys collected quantitative data and interviews collected qualitative information about BIM implementation in the industry. FIG. 1 presents a framework illustrating how these two research methods contribute to the study's quality and robustness.

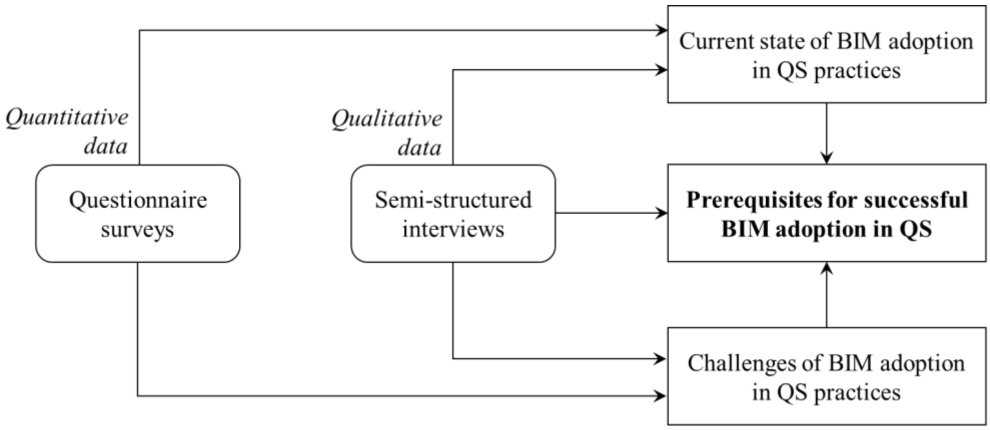

FIG. 1: Research framework

3.1 Questionnaire surveys

An initial questionnaire survey was established based on a comprehensive literature review (Shan et al., 2017). A panel of experts, which included 15 BIM practitioners and quantity surveyors, reviewed an initial draft of the questionnaire before the survey was administered (Liu & Gambatese, 2018; Shan et al., 2017). The panellists included five BIM managers with more than ten years' experience in Hong Kong. The remaining ten experts were quantity surveyors who worked in the local consultant and contractor sectors, with experience ranging from 11 to 20 years. They were assigned middle to senior positions in their companies. The questionnaire was amended and improved according to the suggestions of the expert panel. The final version of the questionnaire survey comprised five parts (see the questionnaire sample in Appendix A). The first part pertained to the demographics and background of the survey respondents' organisations. In addition, information regarding the quantity surveyors' involvement in BIM projects, in-house BIM teams, and external BIM consultants was collected. The second part required survey respondents to provide an overview of their BIM projects, including the number of projects and types. The third part requested survey respondents to specify the role of BIM in their projects. The fourth part was aimed at evaluating the state of BIM adoption in QS practices. The final part solicited the respondents' perspectives regarding the barriers to adopting BIM and their recommendations for promoting BIM adoption in QS practices.

Different data analysis methods were applied according to the data types involved in the questionnaire survey. Specifically, proportions were represented by percentages based on the numbers and frequencies obtained from the questionnaire. Responses to questions related to the level of agreement with a statement were obtained by using a 7-point Likert scale, with '1' and '7' corresponding to strongly disagree and strongly agree, respectively, and processed using the Statistical Package for Social Sciences (SPSS) software package.

Cronbach's alpha reliability coefficient was used to verify the internal consistency of the scales used in the questionnaire survey (Pallant, 2020). Alpha coefficients can range from 0 to 1, with 1 indicating the highest internal consistency among a group of variables. Usually, an alpha coefficient greater than 0.7 indicates 'good' reliability (Sharma, 1996). In addition, we performed an analysis of variance (ANOVA) to examine the consistency of the responses provided by survey participants belonging to different types of organisations. In such analyses, if the p-value (significance level) is less than 0.05, the mean scores of the responses are considered to differ significantly (Hair et al., 2010). Furthermore, Spearman's correlation coefficients were calculated to examine the level of agreement across respondent groups. These coefficients can range from −1 to +1, with negative and positive values representing negative and positive linear correlations, respectively, and a value of zero indicating the lack of any relationship between the two examined groups (Mukaka, 2012).

Organisations in the AEC industry that engaged in professional QS practices comprised the research sample. From each organisation, only one quantity surveyor was invited to participate in the questionnaire survey, thus avoiding multiple replies from the same organisation. The target organisations included members of the Real Estate Developers Association of Hong Kong, QS companies from the list maintained by the Hong Kong Institute of Surveyors, and public works contractors approved by the Development Bureau of Hong Kong. Government departments involved in public projects were also requested to respond to the questionnaire survey. A total of 150 questionnaires were disseminated personally or via e-mails. Sixty thoroughly answered questionnaires were returned, yielding a response rate of 40%, which meets the functional response rate of questionnaire surveys (25%–35%) suggested by Fellows and Liu (2015).

3.2 Semi-structured interviews

To validate the current state, challenges, and prerequisites associated with BIM adoption in QS practices, semi-structured interviews were conducted to directly obtain the perspectives of industry practitioners. Nine quantity surveyors from private developers, consultancy firms, and contractor companies were invited in Hong Kong. Three quantity surveyors for private developers had over 20 years' experience and were managerial grade. Three quantity surveyors from consultancy firms had experience ranging from 11 to 30 years, and they were middle and senior management surveyors. Among the remaining three quantity surveyors from contractor companies, they were managers and senior surveyors with an average experience of 11 to 20 years. All interviewees had experience of using BIM on the projects they had worked on. The diversity of the interviewees' backgrounds ensured the validity of the interviews. The interviewees were invited based on the following criteria: 1) involvement in BIM adoption, 2) record of practice in QS, and 3) experience as staff members. The interviews were administered in the form of face-to-face or telephonic conversations. The average duration of each interview was approximately one hour. The interview questions were designed based on literature review findings and results of the questionnaire surveys. Four open-ended questions were asked during the interviews, focusing on the adoption of BIM in QS practices:

- Status of BIM adoption in the interviewee's organisation.
- BIM processes and QS tasks involved in the BIM projects undertaken at the interviewee's organisation.
- Challenges of BIM adoption in QS practices.
- Recommendations for promoting BIM in QS practices.

4. RESULTS

4.1 BIM personnel in QS-involved organisations

The first part of the questionnaire survey clarified the background of the respondents' organisations and their involvement in BIM projects. Table 1 summarises the participation of quantity surveyors in BIM projects in different organisations: 75.7%, 50%, and 13.3% of contractor companies, private developers, and consultancy firms did not involve quantity surveyors in BIM projects. In addition, the establishment and appointment of BIM teams were assessed and found to be as follows: 50% of the private developers have in-house BIM teams, and 40% of the developers seek external BIM consultants. All government departments have in-house BIM teams, but they also seek external BIM consultants on a project basis. Moreover, 46.7% of the consultancy firms have in-house BIM teams, and 6.7% appoint external BIM consultants. Among contractor companies, 33.3% have in-house BIM teams and 75.7% appoint external BIM consultants.

Table 1: Involvement of quantity surveyors in building information modelling (BIM) projects

Quantity surveyors in the organisation (%)	**Private developers**		**Government departments**		**Consultancy firms**		**Contractor companies**	
	N	%	N	%	N	%	N	%
0%	5	50%	-	-	2	13.3%	25	75.7%
1–9%	1	10%	1	50%	2	13.3%	3	9.1%
10–19%	-		1	50%	3	20%	2	6.1%
20–29%	1	10%	-	-	-	-	-	-
30–39%	-	-	-	-	3	20%	-	-
40–49%	-	-	-	-	3	20%	-	-
50–59%	-	-	-	-	2	13.3%	2	6.1%
80–89%	2	20%	-	-	-	-	1	3%
≥90%	1	10%	-	-	-	-	-	-
Total	10	100%	2	100%	15	100%	33	100%

4.2 BIM projects in organisations involved in QS practices

The second part of the questionnaire examined the involvement and types of BIM projects in different organisations. Table 2 lists the proportions of BIM projects undertaken in each organisation in the past five years.

Table 2: Involvement of BIM in projects over the past five years

Projects with BIM (%)	**Private developers**		**Government departments**		**Consultancy firms**		**Contractor companies**	
	N	%	N	%	N	%	N	%
0%	5	50%	-	-	2	13.3%	22	66.7%
1–9%	-	-	-	-	6	46.1%	-	-
10–19%	-	-	-	-	3	23.1%	1	9.1%
20–29%	-	-	1	50%	2	15.4%	-	-
50–59%	1	20%	-	-	-	-	5	45.4%
60–69%	1	20%	-	-	-	-	-	-
70–79%	3	60%	-	-	-	-	3	27.3%
80–89%	-	-	-	-	1	7.7%	-	-
≥90%	-	-	1	50%	1	7.7%	2	18.2%
Total	10	100%	2	100%	15	100%	33	100%

The types of projects pertaining to the private and public sectors are summarised in Table 3. Among the organisations having BIM projects, the respondents from consultancy firms and contractor companies also answered whether the adoption of BIM was mandatory (i.e., mandatory BIM requirements from their clients) or voluntary (i.e., no BIM requirements from their clients). Of 15 consultancy firms, six were bound by mandatory BIM requirements, and seven applied BIM voluntarily. Of 33 contractor companies, nine were bound by mandatory BIM requirements from the clients, and two applied BIM voluntarily. The types of mandatory and voluntary BIM projects are presented in Table 4.

Table 3: Types of BIM projects in private or public sectors

Types of BIM projects	Private projects	Public projects	
		A	B
Residential	20.6%	100%	7.3%
Office/commercial	17.5%	-	26.8%
Hotel	12.7%	-	-
Infrastructure	11.1%	-	-
Institutional	9.5%	-	7.3%
Industrial	7.9%	-	-
Medical	6.3%	-	9.8%
Recreational	6.3%	-	34.1%
Renovation/fitting out	4.8%	-	4.9%
Others	3.2%	-	9.8%
Total	100%	100%	100%

Note: For public projects, A = Government department 'A', B = Government department 'B'

Table 4: Types of projects with mandatory or voluntary BIM adoption

Types of BIM projects	Mandatory adoption	Voluntary adoption
Residential	28.7%	49.4%
Office/commercial	20.7%	12.7%
Infrastructure	20.1%	11.4%
Recreational	10.3%	5.1%
Medical	5.7%	1.3%
Institutional	5.2%	3.8%
Renovation/fitting out	2.9%	5.1%
Hotel	2.9%	6.3%
Industrial	1.7%	2.5%
Others	1.7%	2.5%
Total	100%	100%

4.3 BIM models produced in QS-involved BIM projects

First, the sources of BIM models were examined in the survey. The primary source of BIM models are independent BIM consultants (46.3%), the secondary source is the design team of a project (43.3%), and the least common source is contractors (10.4%). Independent BIM consultants do not belong to design teams and are usually directly appointed by clients to develop BIM models. As another BIM model source, 2D computer-aided design (CAD) drawings were being transformed into BIM models through proprietary QS software applications. This source was excluded from the results as such BIM models were used only for QTO by quantity surveyors. Second, the common types of BIM models used by quantity surveyors in private and public sectors were examined. The results suggest that 100% of the BIM projects in the private sector involved architectural and structural models, 88.2% involved mechanical, electrical, and plumbing (MEP) models, and 47.1% involved site models. In public sectors, all BIM projects involved architectural, structural, and MEP models.

In addition to the sources and types of BIM models, the status of audit policies for model compliance was investigated. The results indicate that audit policies have a low implementation rate (i.e., 20% and 0% for private developers and government departments, respectively). In other words, developers are yet to recognise and establish quality assurance and quality control measures for BIM models.

4.4 BIM achievements and adoption in QS practices

This section describes the achievements of BIM goals and current status of BIM adoption in QS practices. First, a 7-point Likert scale was adopted to examine the achievements of BIM goals. Respondents rated their levels of agreement on the delivery of expected BIM goals, with '1' and '7' representing strongly disagree and strongly agree, respectively (Table 5). For each BIM goal, ANOVA tests confirmed no significant differences among the mean scores from different types of organisations. Furthermore, according to Spearman's rank correlation tests, the rankings from the three types of organisations were found to be in agreement. Second, the survey highlighted the current status of BIM adoption in QS practices.

Table *6* lists the popular BIM-enabled QS tasks accomplished by consultants and contractors. Moreover, the BIM-enabled QS tasks with mandatory and voluntary BIM adoption are specified.

Table 5: Rankings pertaining to the achievement of expected BIM goals with ANOVA results

Expected BIM goals	All		Clients		Consultants		Contractors		p-value
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	
Enhanced coordination	5.63	1	5.00	3	5.83	1	6.25	2	0.65
Better visualisation	5.56	2	5.50	1	5.13	3	6.50	1	0.90
Decreased errors and omissions	4.94	3	4.80	4	5.00	4	5.00	5	0.64
Constructability review	4.88	4	5.20	2	4.67	6	4.80	7	0.43
Increased productivity	4.76	5	4.40	7	5.29	2	5.50	3	0.77
Decreased abortive works	4.67	6	4.50	5	4.86	5	4.60	10	0.59
Enhanced predictability and cost control	4.50	7	4.20	8	4.40	9	4.95	6	0.47
Decreased overall project duration	4.46	8	4.00	9	4.25	10	5.25	4	0.15
Increased accuracy in quantification works	4.40	9	4.40	6	4.20	11	4.75	9	0.98
Decreased construction cost	4.23	10	3.50	13	4.60	7	4.50	11	0.10
Enhanced documentation	4.14	11	3.75	12	4.00	12	4.75	8	0.87
Increased safety	4.17	12	3.80	11	4.50	8	4.33	12	0.80
Expedition of regulatory approval cycles	3.91	13	3.80	10	4.00	13	4.00	13	0.83

Note: Clients include private developers and government departments

Table 6: BIM adoption in quantity surveying (QS) practices in consultancy firms and contractor companies

Consultant firms' QS practices	Mandatory BIM adoption	Voluntary BIM adoption
Preparation of bills of quantities/schedules of rates measurement	41.7%	75%
Cost planning	25%	66.7%
Preliminary cost advice	25%	50%
Valuation of variations	25%	50%
Cash flow forecast	16.7%	50%
Interim valuation	16.7%	41.7%
Re-measurement of provisional items	16.7%	41.7%
Value engineering	-	41.7%
Contractual advice	-	41.7%
Dispute resolution	-	41.7%
Financial reporting	-	33.3%
Lifecycle costing	-	33.3%
Assessment of financial claims	-	33.3%
Procurement advice	-	25%

Contractor companies' QS practices		
Variations and claim preparation	40%	40%
Tender preparation	-	33%
Payment application	33%	-
Progress reporting	20%	33%
Cost monitoring and control	-	20%
Value engineering	-	20%
Quantification of works for sub-letting/purchasing	-	20%
Arbitration and dispute resolution	-	13%
Risk management	-	13%
Lifecycle costing	-	-
Project cash flow	-	-
Sub-contractor payment preparation	-	-
Financial reporting	-	-

Note: Percentages represent the proportions of organisations engaged in BIM

4.5 BIM facilitators and barriers

The last part of the questionnaire was aimed at highlighting the facilitators and barriers to BIM adoption in QS practices. First, the status of facilitating measures for BIM in QS practices associated with consultancy firms and contractor companies was examined. According to the results, consultancy firms are more encouraging than contractor companies in adopting BIM in QS practices, with 69% and 27% of consultancy firms and contractor companies, respectively, having facilitating measures in place. The types of facilitating measures are listed in Table 7. All consultancy firms engaged in internal BIM project experience-sharing and BIM practice manuals. All contractor companies provide simple guidelines for internal use and offer software training by software vendors or BIM consultants. Second, the barriers to BIM adoption in QS practices were surveyed using a 7-point Likert scale (Table 8). Cronbach's alpha reliability coefficient (0.83) indicated consistency across survey responses. Table 8 presents the ranking of barriers in descending order based on the participant responses. The table also presents individual rankings for three types of organisations (i.e., clients, consultants, and contractors), and diverse views can be observed among the three groups. ANOVA tests were conducted, and the results indicated that significant differences existed within groups in terms of the perspectives regarding the following barriers: benefits of BIM adoption cannot be realised ($p = 0.04$), an organisation must be restructured to accommodate BIM ($p = 0.02$), and high initial cost ($p = 0.01$). The diversity associated with the three organisations in terms of the perspectives of barriers was confirmed by Spearman's rank correlation tests.

Table 7: Types of measures for facilitating BIM adoption in QS practices

Measures	Consultancy firms %	Contractor companies %
Internal BIM project experience-sharing	100%	67%
BIM practice manual	100%	33%
Simple guidelines for internal use	78%	100%
Software training by external agencies such as software vendors or BIM consultants	67%	100%
Recruitment of BIM specialists	44%	67%
Software customisation for QS tasks such as quantity take-off (QTO)	44%	67%
Development of a standard approach of modelling to suit QS requirements	-	33%
Project-based BIM execution plan	-	67%

Table 8: Ranking of barriers based on ANOVA results

Barriers	All		Clients		Consultants		Contractors		p-value
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	
Rush culture in the construction industry	5.76	1	5.80	2	5.38	4	6.20	1	0.87
Lack of well-recognised industry BIM standard	5.52	2	5.90	1	5.88	2	5.80	3	0.91
Shortage of in-house BIM specialists	5.48	3	5.60	3	5.50	3	5.40	5	0.96
Lack of BIM expertise in the market	5.04	4	4.90	7	5.25	5	5.80	2	0.83
Lack of successful showcasing of BIM projects	4.74	5	5.10	4	4.50	10	4.80	8	0.80
Problem of interoperability among BIM software	4.70	6	4.80	8	5.25	6	4.00	13	0.77
Additional cost for appointing BIM consultants	4.70	7	4.10	15	4.75	8	4.20	12	0.64
Benefits of BIM adoption cannot be realised	4.61	8	5.00	5	4.13	12	4.60	9	0.04*
Staff refusal/reluctance to learn new technology	4.61	9	4.90	6	3.63	15	5.20	6	0.52
Restructuring of organisation to accommodate BIM	4.57	10	4.30	13	4.13	13	5.60	4	0.02*
High initial cost	4.57	11	3.50	16	6.13	1	3.20	16	0.01*
Unforeseen positive return on investment on BIM	4.57	12	4.40	11	5.00	7	3.80	14	0.58
Lack of government support and incentive	4.45	13	4.20	14	4.75	9	4.40	10	0.23
Unsuitability of several projects for BIM adoption	4.39	14	4.60	9	4.38	11	5.00	7	0.35
Concerns regarding security of confidential data	4.26	15	4.30	12	3.25	16	3.20	15	0.72
Non-availability of standard BIM contract	4.22	16	4.60	10	4.00	14	4.40	11	0.60

Note: Clients include private developers and government departments

5. DISCUSSION

After analysing the survey results, interviews were conducted to provide insights into the survey findings and prerequisites for successful BIM adoption in QS practices.

5.1 Current state of BIM adoption in QS practices

The results indicate that BIM is being increasingly used in the AEC industry; however, the rate of BIM incorporation by contractor companies is lower than that of other organisations (Table 1). According to interviewees, a likely reason is that the Hong Kong government has launched several initiatives to promote BIM. For instance, BIM is required for most public projects. In the private sector, private developers considerably influence the BIM adoption and extent of BIM use. In this context, BIM adoption can be promoted if the use of BIM is mandated in such projects.

Despite the increasing rate of BIM adoption across the industry, the involvement of quantity surveyors in BIM projects is limited. Results suggest that 75.7% of contractor companies and 50% of private developers do not involve quantity surveyors in BIM projects (Table 1). The engagement in QS practices is higher for consultancy firms and government departments. Over 53% of consultancy firms involve 30% or more of their quantity surveyors in BIM projects, and all government departments involve their quantity surveyors in BIM projects

(Table 1). Interviewees advised that consultancy firms have begun recognising the benefits of BIM and are willing to apply BIM in QS practices. This finding is further supported by the status of mandatory and voluntary BIM adoption: Consultancy firms reported the highest proportion of voluntary adoption (53.8%). In comparison, 81.8% of contractor companies adopted BIM because BIM was contractually mandated.

Quantity surveyors were found to participate in a wide range of construction projects involving BIM. In the private sector, the most popular BIM projects that involved quantity surveyors were related to residences (20.6%), offices or commercial spaces (17.5%), and hotels (12.7%) (Table 3). This distribution of the project types reflects the primary construction volume in Hong Kong. Interestingly, Table 4 indicates that residential projects, office space or commercial projects, and infrastructure projects most commonly involve mandatory or voluntary BIM adoption. This finding suggests that the project types do not determine the mandatory or voluntary adoption of BIM for quantity surveyors.

The results of BIM model sources indicate that in Hong Kong, independent BIM consultants are the primary sources of BIM models (46.3%). Design teams and contractors only produced 43.3% and 10.4% of BIM models, respectively. Independent BIM consultants do not belong to design teams and are directly appointed by clients to provide BIM services. According to interviewees, independent BIM consultants commonly obtain 2D CAD drawings from design teams and develop BIM models based on these drawings. The BIM models are aimed at realising visualisation and design coordination. However, such BIM models represent a set of standalone information and data with no live links to original project designs. The primary design documents are 2D CAD drawings. This type of indirect BIM models deviates from the original rationale and intent of BIM. With reproduced BIM models developed by independent BIM consultants, quantity surveyors and other construction disciplines are discouraged from using BIM as this BIM workflow does not provide the live and accurate information and data of a project. Mayouf et al. (2019) stressed the importance of involving all stakeholders in the BIM project's supply chain to ensure a consistent flow of information.

According to the survey results, BIM adoption is more common in pre-contract QS practices than in post-contract QS practices (Table 6). BIM is most commonly used by consultant quantity surveyors to prepare bills of quantities and schedules of rates measurement (41.7% and 75% mandatory and voluntary BIM adoption, respectively). The other common QS practices accomplished with BIM pertain to cost planning (25% and 66.7% mandatory and voluntary BIM adoption, respectively) and preliminary cost advice (25% and 50% mandatory and voluntary BIM adoption, respectively). The most popular use of BIM in the post-contract stages pertains to the valuation of variations (25% and 50% mandatory and voluntary BIM adoption, respectively). No significant differences were found between the rankings of mandatory and voluntary BIM adoption for consultant quantity surveyors in terms of BIM use in QS practices. However, voluntary adoption corresponds to a more varied use of BIM than mandatory adoption. For instance, 41.7% of consultant quantity surveyors voluntarily applied BIM for value engineering, contractual advice, and dispute resolution, although project clients did not mandate these use cases for BIM. Contractor quantity surveyors realised fewer types of QS practices with BIM (Table 6). Mandatory BIM adoption was focused on variations and claims (40%), payment applications (33%), and progress reports (20%). In terms of voluntary adoption, contractor quantity surveyors accomplished more QS tasks with BIM, such as tender preparation (33%), cost monitoring and control (20%), value engineering (20%), and quantification of works for subletting (20%). The results presented in Table 6 highlight the perspectives of different types of organisations, in terms of BIM adoption in QS practices. Several interviewees highlighted that consultancy firms are adopting BIM in QS practices more readily than contractor companies. Because BIM use is often not mandated by clients, the push from clients to adopt BIM in QS practices is limited. Nevertheless, both consultancy firms and contractor companies have demonstrated recognition for the potentials of BIM in QS practices, manifesting in more types of voluntary BIM use than mandatory BIM use.

5.2 Challenges of BIM adoption in QS practices

The different organisations in this study expressed similar views regarding the achievement of expected BIM goals in QS practices (Table 5). According to client quantity surveyors, BIM can promote enhanced visualisation (mean = 5.50, rank 1), constructability review (mean = 5.20, rank 2), and coordination (mean = 5.00, rank 3). However, increase in accuracy in quantification of works (mean = 4.40, rank 6) and superior predictability and cost control (mean = 4.20, rank 8) remain to be fully achieved through BIM. For consultant quantity surveyors, the top three achieved BIM goals pertain to enhanced coordination (mean = 5.83, rank 1), productivity (mean = 5.29, rank 2), and superior visualisation (mean = 5.13, rank 3). However, BIM cannot enhance the predictability and cost control (mean = 4.40, rank 9) and accuracy in quantification of works (mean 4.20, rank 11). Contractor quantity surveyors agreed that BIM can enhance the visualisation (mean = 6.50, rank 1), coordination (mean =6.25, rank 2), and productivity (mean = 5.50, rank 3). However, it was challenging for BIM to enhance the predictability and cost control (mean = 4.95, rank 6) and accuracy in quantification of works (mean = 4.75, rank 9).

According to the survey results, the performance of BIM in implementing QS practices is varied. Several interviewees noted that the current BIM models lack comprehensive and accurate information and data. The results of this study are in line with those of Mayouf et al. (2019), which demonstrate that the lack of information in BIM models is a major concern among quantity surveyors. Consequently, quantity surveyors must expend additional effort to comprehensively examine the data and information required for QS tasks. These efforts include retrieving additional 2D drawings, documents, and databases to determine the quantities and align the BIM data with prescribed measurement rules. Quantity surveyors cannot fully exploit BIM to extract accurate and complete data. Therefore, additional verification processes must be implemented to overcome this limitation.

Notably, the BIM model quality is also related to the audit policies. According to the survey results, the industry is yet to recognise the significance and necessity of BIM audit policies. Only 20% of private developers and none of the government departments formulated such policies. According to interviewees, audit policies can be formulated in BIM execution plans (BEPs), in which the data and information required in BIM models are recorded. Quantity surveyors must engage with project teams in the initial stages of a project to articulate the essential information that they need for QS tasks. These information requirements must be a part of BEPs and can be used to develop audit policies. Through the implementation of audit policies, quality assurance and quality control can be realised in terms of the designs, datasets, properties, and BIM data by the design teams before they provide the BIM deliverables to the quantity surveyors. Moses et al. (2020) identified similar challenges in this scenario. To increase project and cost efficiency, quantity surveyors and design teams should collaborate early to develop a 5D BIM cost protocol within the existing BEP structure. This will enable quantity surveyors to generate reliable and accurate cost information during the project lifecycle. Also, according to the case studies conducted in Spain, Aragó et al. (2021) argued that a rich database and comprehensive information associated with BIM models are the key to perform efficient and accurate quantity take-off and cost estimation.

Three respondent groups expressed diverse perspectives regarding the barriers to BIM adoption in QS practices (Table 8). Client quantity surveyors considered that a lack of well-recognised industry BIM standards (mean =5.90, rank 1) is the most notable barrier to BIM adoption in QS practices. This result echoes the findings of the study conducted by Chan et al. (2019), which indicated that the lack of BIM standards appears to retard the application of BIM in the AEC industry. A similar view was shared by interviewees, who believed that the current first version of BIM standards published by the Hong Kong Construction Industry Council is not sufficient and fully recognised by the industry. The subsequent version must be enhanced with more consultation and involvement with the industry. Client quantity surveyors also believed that the ‘rush culture’ (i.e., progress is the golden key while other aspects are overlooked) in the AEC industry (mean = 5.80, rank 2) is jeopardising the application of BIM. According to interviewees, the rush culture generates insufficient and sightless BIM models in which the latest data and changes are not updated and reflected. Consequently, BIM fails to effectively communicate accurate data within project teams. Another major barrier highlighted by client quantity surveyors is the shortage of in-house BIM specialists (mean = 5.60, rank 3). In contrast, the high initial cost is the most notable issue (mean = 6.13, rank 1) for consultancy firms in adopting BIM. A few interviewees expressed the same concern. The interviewees acknowledged the support provided by the Hong Kong government in the form of the Construction Innovation & Technology Fund to purchase BIM software applications. However, this funding only lasts for three years, whereas most BIM software applications require annual subscriptions. After the funding tenure is completed, consultancy firms must pay for these subscriptions. Similar to client quantity surveyors, consultant quantity surveyors were also concerned about the lack of well-recognised BIM standards (mean = 5.88, rank 2) and shortage of in-house BIM specialists (mean = 5.50, rank 3). For contractor quantity surveyors, the rush culture in the construction domain in Hong Kong (mean = 6.20, rank 1) is the most notable barrier to BIM adoption in QS practices. This finding was further confirmed by interviewees. Owing to tight project schedules, contractors do not have sufficient time, resources, and buffer to try innovative technologies. Because of the reluctance in adopting BIM, the contractors and sub-contractors do not have similar BIM capabilities, rendering it challenging to synchronise BIM deliverables. Contractor quantity surveyors also indicated that they suffered from the lack of BIM expertise in the market (mean = 5.80, rank 2) and well-recognised industry BIM standards (mean = 5.80, rank 3). These barriers have been reported in other studies. For instance, Ma et al. (2020) discovered that lack of technical personnel, lack of knowledge and experience for BIM implementation, and missing regulations and rules are among the most critical barriers to BIM implementation in China. Ma et al. (2022) suggested that knowledge barrier is one of the most critical barriers in New Zealand. The similar barriers have been discovered in Australia as well (Olatunji et al., 2021).

5.3 Prerequisites for successful BIM adoption in QS practices

Two prerequisites to successful BIM adoption in QS practices were specified according to the findings of the questionnaire surveys and recommendations of the interviewees.

First, the fundamental principles of BIM and proper ways to implement BIM must be recognised by the industry. Both survey respondents and interviewees raised concerns regarding the non-standard implementation of BIM in the industry in Hong Kong. Typically, BIM is adopted throughout the project lifecycle, from the beginning of a project. Thus, design teams must initiate and develop BIM models, which can then be maintained and used by other project stakeholders throughout the project lifecycle. For quantity surveyors, well-maintained BIM models can be the source of data for various QS practices, to be processed by QS software applications and tools. The AEC industry is transiting from the CAD era to the BIM era. Thus, conflicts between 2D CAD drawings and BIM models may exist for an extended period. These conflicts may lead to disputes, confusion, delays, variations, and claims. All project stakeholders are expected to suffer if this indirect use of BIM continues. The mindset and project operation mode in the AEC industry must change to adapt to the nature of BIM, which is further validated by another study about BIM maturity levels in Hong Kong (Lu et al., 2021). The change of mindset and appraisal of true values of BIM may occur after years of BIM experience (Ahankoob et al., 2019). A possible solution to this issue is to enhance the awareness of industry professionals by demonstrating case studies and benchmarks (Sepasgozar et al., 2022).

Second, a set of BIM standards for QTO must be established, especially in terms of the modelling principles and information requirements. Quantity surveyors from different organisations shared a similar concern regarding the current modelling approaches and information associated with BIM model elements. Because a well-recognised BIM standard for modelling is not available in the AEC industry in Hong Kong, modellers have been using various modelling principles to develop BIM models. Consequently, BIM deliverables received by quantity surveyors always deviate from the requirements to accomplish QS tasks. Additional efforts such as manual adjustments and further verification must be expended in this scenario. A number of 5D BIM studies have addressed similar concerns (Mayouf et al., 2019; Moses et al., 2020). Furthermore, the quality of BIM models must be enhanced to avoid modelling errors such as overlaps or gaps among model elements and inconsistent element naming. The introduction of audit policies, which remain absent in most organisations at present, can alleviate this issue. Quantity surveyors hold a consensual view regarding standardised BIM data input and output. However, it is challenging to establish BIM standards based on the requirements for QS practices. Universal BIM standards must be established with consensus among all construction disciplines. It is necessary to review and revise the existing measurement rules and QS principles to establish universal BIM standards if discrepancies exist. Government effort cannot be absent to promote universal BIM standards (Liao & Teo, 2019).

6. CONCLUSION

The current state of BIM adoption in QS practices in Hong Kong was examined. Client quantity surveyors expressed diverse perspectives regarding BIM. Several individuals are willing to embrace BIM in QS practices, whereas others are conservative as evidence of BIM success remains to be recognised. In comparison, consultant quantity surveyors are leading the adoption of BIM in QS practices in the AEC industry. These surveyors have been exploring additional types of BIM use in QS practices. For consultant quantity surveyors, the most notable concern pertains to BIM hardware and software expenditure. The rate of BIM adoption in QS practices by contractor quantity surveyors is relatively low because of the inadequate organisational support and operation. The findings also highlight challenges that will limit the uptake of BIM in QS practices in the future. Firstly, the mindset, culture, and skillset in the AEC industry are yet to adapt to the transition from the CAD era to the BIM era. Secondly, the quality of BIM models is inadequate for quantity surveyors to adopt BIM in their practices. The low quality can be attributed to the lack of BIM audit policies in most organisations. Thirdly, the lack of BIM specialists and well-recognised BIM standards in the AEC industry has decelerated the adoption of BIM in QS practices. The general BIM adoption in QS practices in Hong Kong is consistent with previous BIM studies. In a number of BIM research studies, quality models and QS information requirements have also been endorsed as being imperative to support an efficient 5D BIM process (Aragó et al., 2021; L. Ma et al., 2022; Olatunji et al., 2021). In Hong Kong, however, the rush culture transforms legitimate BIM workflows and generates insufficient data for BIM models, posing a unique BIM challenge. Consequently, quantity surveyors are discouraged from using BIM in their QS practices due to possible conflicts of design information.

Prerequisites for the successful adoption of BIM in QS practices were highlighted. According to the generalised results, it is necessary to change the mindset of industrial practitioners because many individuals insist on applying traditional and incorrect perceptions to BIM projects. In addition, quantity surveyors must be involved in the early stages of the project and communicate with design teams to ensure that BIM models are developed with proper geometry and information required for QTO. The introduction of an audit policy can help obtain quality BIM models that can facilitate quantity surveyors in efficiently accomplishing their tasks. These prerequisites for optimising BIM from the perspective of quantity surveyors can be generalised to stimulate BIM adoption, particularly in countries or regions lagging in 5D BIM. This study has several limitations. First, the research samples for this study were limited to Hong Kong. Future research can expand the investigation to other countries and regions worldwide. Second, this study only sampled major organisations in the AEC industry in Hong Kong. Other organisations, such as sub-contractors, manufacturers, or fabricators, were not considered. The AEC industry can be comprehensively studied in future studies.

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APPENDIX A: SAMPLE QUESTIONNAIRE

A Study on BIM Adoption in Quantity Surveying in Hong Kong

Part 1 – Background of the respondent

Company name	
Total number of QS staff in your company	
Number of QS staff involved in BIM projects	
Is there any BIM team established in your company?	
Has your company directly appointed BIM consultant on project basis?	

Part 2 – BIM projects

2.1 Involvement of BIM in projects:	
Number of new projects over the past five years	
Number of new projects using BIM over the past five year	
Mandatory BIM adoption (i.e., BIM adoption is required by clients)	
Voluntary BIM adoption (i.e., BIM is adopted voluntarily)	

2.2 Types of BIM projects under mandatory BIM adoption:		
Project types	Private projects	Public projects
A) Residential		
B) Office/commercial		
C) Hotels		
D) Industrial		
E) Institutional		
F) Medical		
G) Recreational		
H) Infrastructure		
I) Renovation / fitting out		
J) Others		

2.3 Types of BIM projects under voluntary BIM adoption:		
Project types	Private projects	Public projects
A) Residential		
B) Office/commercial		
C) Hotel		
D) Industrial		
E) Institutional		
F) Medical		
G) Recreational		
H) Infrastructure		
I) Renovation / fitting out		
J) Others		

Part 3 – BIM models and goals

3.1 BIM model production:		
Project team members	Private projects	Public projects
A) Design team (e.g., Architects, Engineers, and Designers)		
B) Construction team (e.g., Contractors and sub-contractors)		
C) Independent BIM consultant (not responsible for project design)		
D) Others		

3.2 Types of BIM models:		
Model types	Private projects	Public projects
A) Architectural model		
B) Structural model		
C) MEP model		
D) Site model		
E) Others		

3.3 Achievement of expected BIM goals:	
A) Better visualization	
B) Increased productivity	
C) Decreased errors and omissions	
D) Decreased abortive works	
E) Constructability review	
F) Decreased construction cost	
G) Enhanced predictability and cost control	
H) Increased accuracy in quantification works	
I) Enhanced documentation	
J) Enhanced coordination	
K) Decreased overall project duration	
L) Increased safety	
M) Expedition of regulatory approval cycles	
N) Enhanced organization's images	
O) Marketing new business	
P) New services to be offered	
Q) Increased profits	
R) Repeat business to be maintained	
S) Reduced cycle time of workflows	
T) Others	

Part 4 – BIM adoption in QS practices

4.1 BIM-based QS tasks (consultant QS practices):		
Task types	Mandatory	Voluntary
A) Cost planning		
B) Life cycle costing		
C) Value engineering		
D) Preliminary cost advice		
E) Procurement advice		
F) Contractual advice		
G) Preparation of BQ/SOR		
H) Valuation of variations		
I) Interim valuation		
J) Re-measurement of provisional items		
K) Financial reporting		
L) Cash flow forecast		
M) Assessment of financial claims		
N) Dispute resolution		
O) Others		

4.2 BIM-based QS tasks (contractor QS practices):		
Task types	Mandatory	Voluntary
A) Tender preparation		
B) Cost monitoring and control		
C) Project cash flow		
D) Value engineering		
E) Quantification of works for sub-letting/ purchasing		
F) Payment application		
G) Sub-contractor payment preparation		
H) Variations and claim preparation		
I) Lifecycle costing		
J) Risk management		
K) Financial reporting		
L) Progress reporting		
M) Arbitration and dispute resolution		
N) Others		

4.3 Types of measures for facilitating BIM adoption in QS practices:	
A) Software customisation for QS tasks such as QTO	
B) Software training by external agencies such as software vendors or BIM consultants	
C) Recruitment of BIM specialists	
D) BIM practice manual	
E) Simple guidelines for internal use	
F) Internal BIM project experience-sharing	
G) Development of a standard approach of modelling to suit QS requirements	
H) Project-based BIM execution plan	
I) Others	

Part 5 – Barriers to BIM adoption

5.1 Barriers that significantly cause late BIM adoption:	
A) Lack of well-recognised industry BIM standard	
B) Non-availability of standard BIM contract	
C) Lack of government support and incentive	
D) Lack of successful showcasing of BIM projects	
E) Benefits of BIM adoption cannot be realised	
F) Restructuring of organisation to accommodate BIM	
G) Staff refusal/reluctance to learn new technology	
H) Unsuitability of several projects for BIM adoption	
I) High initial cost	
J) Additional cost for appointing BIM consultants	
K) Unforeseen positive return on investment on BIM	
L) Shortage of in-house BIM specialists	
M) Lack of BIM expertise in the market	
N) Concerns regarding security of confidential data	
O) Problem of interoperability among BIM software	
P) Rush culture in the construction industry	
Q) Others	

5.2 Recommendations for promoting BIM adoption in QS practices: