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The Validity and Reliability of the Theory Behind BIM Adoption in The Facility Management Using PLS-SEM

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Abstract: The usage of Building Information Modelling (BIM) in the Facility Management (FM) sector will significantly speed up the design and construction phases. However, most facility managers continue to use the traditional paper-based approach to manage facility maintenance and operations, which includes designs and spreadsheets. The goal of this research is to pinpoint the factors that affect BIM's acceptability in the FM sector. Six factors, including organisational culture, individual competency, perceived usability, perceived ease of use, individual intention, and organisational aim in the context of facilities management services, were found. Prior to that, it is necessary to determine whether the theory supporting the adoption of BIM in facility management is valid and reliable. This study used an abductive methodology that blends qualitative and quantitative techniques. 30 respondents completed a set of questionnaires as part of the study's pilot test. Based on the findings of the pilot study, it can be demonstrated that the high degree of Cronbach's Alpha values is accepted, demonstrating the validity and reliability of the theory supporting the adoption of BIM in facility management and its high degree of internal consistency. This study demonstrates that there are important factors that affect how well BIM is received in the facilities management sector. All the six factors have a significant impact indicating that the theory underlying the adoption of BIM in facility management is valid and reliable and has a high degree of internal consistency.

Keywords: Validity, reliability, theory acceptance, Building Information Modelling, facility management

1. Introduction

The cost of a building's life cycle is mostly driven by its operational phase. According to estimates, the lifecycle cost is three times the construction cost and five to seven times greater than the initial investment expenditures (Lee et al., 2012). The requirement to manage both new and existing facilities effectively on an economic and environmental level has increased significantly. Building Information Modelling (BIM) has been acknowledged as an essential technology in this area. According to Lee et al. (2012), BIM data collected throughout the project lifecycle may increase the effectiveness of facility management (FM) operations. FM is comprehensive in nature, spanning everything from maintenance and cleaning to real estate and financial management (Atkin and Brooks, 2009).

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Governments from all over the world have acknowledged the inefficiencies affecting the building sector as a whole and have encouraged and enforced the adoption of BIM as a solution to deal with deteriorating productivity. Building information modelling (BIM) is the process of creating and managing data about a building over its full lifecycle. A digital depiction of the building process is utilised in BIM, a new approach to design, construction, and facilities management, to make it easier for people to share and collaborate on digital information (Eastman et al., 2011). BIM for FM is becoming more and more common within the construction sector. According to Azhar et al. (2012), Smith & Tardrif (2009), and Takim et al. (2013), BIM has the capacity to develop, capture, project, and monitor design performance from planning and construction to operation and maintenance. BIM aims to enhance the supply of goods and services, which includes process quality, consistency, dependability, and timelessness (Che-Ani, et. al., 2015). Different life cycle viewpoints and perspectives are used to define BIM. Azhar et al. (2012) assert that the main objective of BIM is to seamlessly integrate important technical data into FM operations. As a result, BIM offers a repository model that is coupled with a database to store all the data. BIM includes all life cycle applications and information sharing across many software platforms. Despite all the possibilities, BIM acceptability in FM is a problem. Even though facility managers are aware that adopting BIM during operational building can decrease chance of errors and increase efficiency, stakeholders are not fully implementing BIM in the FM industry and in current FM operations that applied BIM, most function are still done manually (Becerik-Gerber; Motamed, Hammad, & Asen, 2014). To meet the task of gathering, classifying, visualising, and updating information for operation and maintenance, as well as integrating with the design data, facility managers are looking for new technology and procedure. Building information modelling (BIM) is one piece of technology that can make the jobs easier. According to Sucar and Sher (2014), BIM is becoming a framework for creating, distributing, and maintaining data on built facilities over the course of their lives. BIM may enhance the standards and efficacy of facility management operations by visualising the lifecycle data (Motamedi et al., 2014). According to Kelly et al. (2013), a BIM visualised database can improve the effectiveness of work order execution in terms of speed, access to data, and location of interventions. Additionally, according to Carbonari et al. (2016), the knowledge contained in the BIM model can lead to a cycle of learning, greater comprehension, and continuous development throughout the building facility life cycle. BIM can therefore serve as a data bank for all building phases, including the operation and maintenance phase. Regarding prospective BIM uses in facility management, there is consensus. These applications can be summed up as building component location modelling, asset management (creating and updating digital assets), building maintenance (planning and determining maintainability), space management (allocating and managing spaces), energy management, and emergency management (Becerik-Gerber et al., 2012, Eastman et al., 2011, Arayici, 2015, Love et al., 2015).

2. Building Information Modeling (BIM) in the context of Facility Management (FM)

2.1 Facility Management (FM) Definition

According to Khemlani (2011), managing facility resources, support services, and the work environment is a crucial task that supports both the organization's long- and short-term core business. The definitions of "facility management" by several international associations vary, albeit only slightly. can result from various ownership and interest relationships. The International Facility Management Association (IFMA) describes facility management as a profession that integrates people, procedures, and space to guarantee the built environment's functionality. The working environment has long been the main emphasis of facilities management. FM is defined by Atkin and Brooks (2009) as an integrated method for operating, maintaining, and enhancing and modifying a company's facilities and infrastructure to foster a setting that strongly supports the organization's main goals.

2.2 Building Information Modelling (BIM) in Facility Management (FM)

Building information modelling (BIM) is a concept that combines data and information about a building into a software-generated interactive model. Building information models are 3D digital representations of a facility's physical and functional attributes, in accordance with National BIM Standards (NBIMS). It acts as a common knowledge resource for knowledge regarding a facility, providing a trustworthy foundation for decisions throughout the facility's lifecycle from inception onward (NBIMS, 2015). BIM is useful for a variety of professions and practise areas. Building design, construction, maintenance, and operation may all be done with BIM. Building information modelling is a software tool that Teicholz (2013) notes is quickly becoming popular across the architectural, engineering, and construction (AEC) sector. BIM offers a three-dimensional digital representation of a building that is visually and dimensionally accurate. It also functions as a database, providing the ability to track data properties for the construction model's component parts. Building information models provide a description of a physical facility's three-dimensional geometry, objects, and properties. Building geometry is the main component of BIM, but it also includes a structured information base of non-graphic data that gives specific details about the building's parts. The main goal of numerous national BIM initiatives and standards is to enhance the understanding and application of information technology in the Architect, Engineering, Construction (AEC)/Facility Management industry to transform industry supply chains through interoperable information exchange. According to Gu and London (2010), there are many benefits to BIM, including BIM 3D for parametric data in a collaborative model, BIM 4D for scheduling, BIM 5D for cost estimation, BIM 6D for sustainability, and BIM 7D for facilities management. The 3D-Model, which has the lowest dimension, is used to identify conflicts during the design stage before moving forward on the job site (Crotty, 2016). The construction execution process is visualised and simulated using the 4D-Scheduling dimension, particularly the logistics plan (trucks and cranes). This dimension is used to visualise the construction execution process rather than to control it (Crotty, 2016). The 5D-Cost dimension integrates costing data, enabling automatic performance of crucial estimating data including material quantities, costs, size, and area estimations. Energy consumption analysis is made easier with the aid of the 6D-Sustainability dimension, leading to earlier in the design phase energy estimations that are more thorough and precise. Because it can include all the specifications, operations and maintenance manuals, and warranty information necessary for future maintenance, the 7D-Facility Management dimension can be utilised as a "as built" model (Crotty, 2016) as shown in Figure 1.

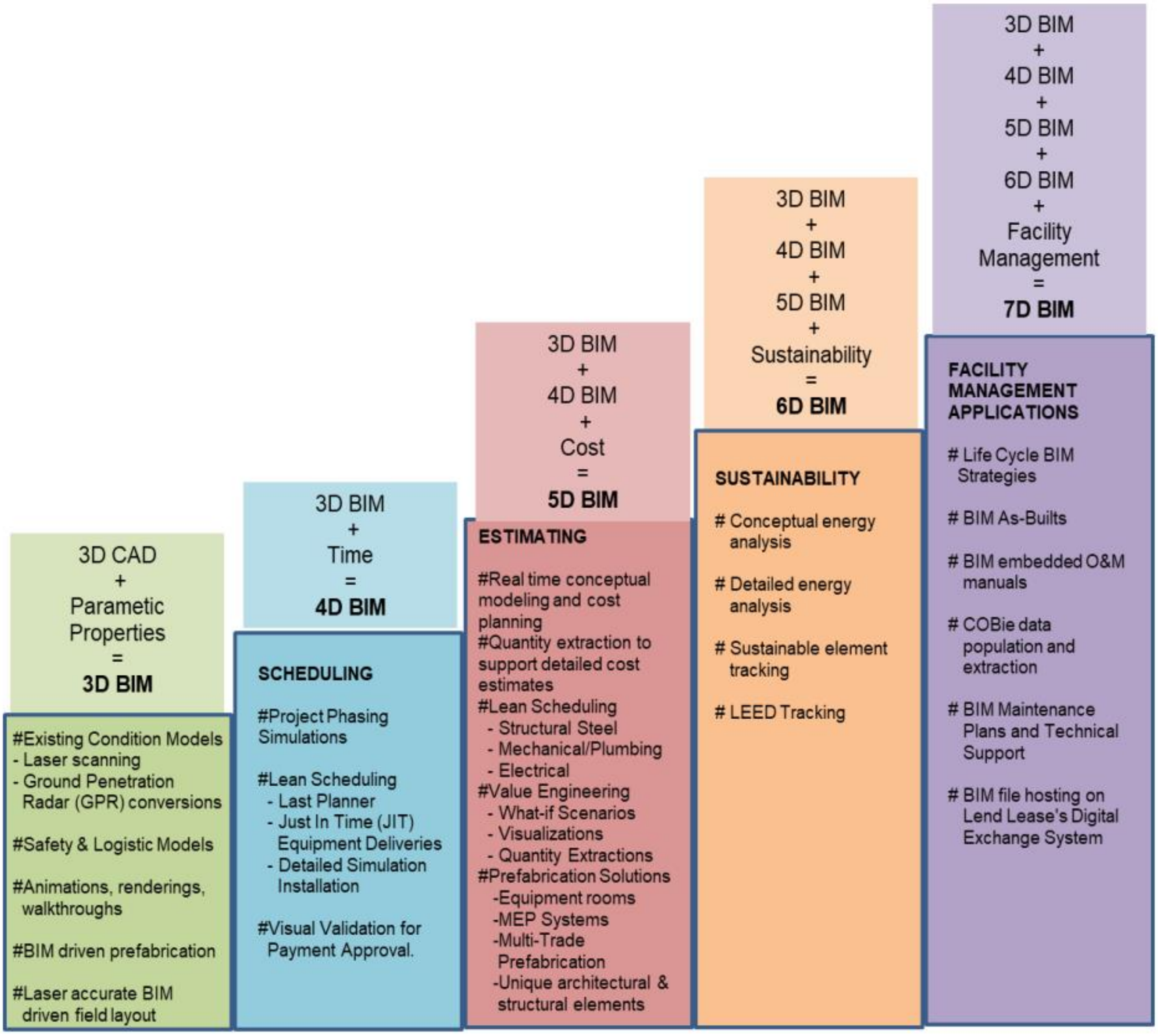

Fig. 1 - BIM dimensions (Crotty, 2016)

Therefore, from the standpoint of FM, BIM may be defined as a repository of live documents used by owners to manage facilities at the FM stage. These documents manage accurate building information throughout the building's life cycle. Several FM practises, including commissioning and closeout, quality control and assurance, energy management, maintenance and repair, and space management, could benefit from the data gathered through a BIM process and kept in a BIM-compliant database. However, the building information must be interoperable or connected with the FM information systems, such as building automation systems (BAS), energy management systems (EMS), and computerised maintenance management systems (CMMS). Even while each of these FM information systems supports FM practises separately, necessary data is scattered across them, and to make matters worse, it must be manually input after a building has been handed over, which is a time-consuming and ineffective process. Building information modelling promises to provide initial data to FM systems and, through its sophisticated visualisation and analysis capabilities, to support and improve other FM activities. The scientific and professional groups have paid a lot of attention to the usage of BIM during the design and construction phases. BIM-enabled design has received a lot of attention from researchers (Eastman et al. 2011 and Khemlani, 2011); automated cost estimation; visualisation of process status and virtual prototyping. One of the most popular research topics has also been the maintenance of information using BIM. In the meantime, maintainability verification has been included in BIM implementations. The use of BIM in energy analysis and sustainability (Arayici et al. 2015) has recently become crucial in research and practise due to the growing interest in and impact of sustainable practises. According to Lee (2012), the use of BIM to assist design and construction practise is rising quickly, and with it, there is an increasing focus on team communication early in the development process and the integration of BIM with FM during the operations and maintenance phase. BIM for FM is a new field, and there isn't much information out there about it. Additionally, there aren't many actual cases of BIM applications in FM (Bercerik-Gerber, 2012). Through the integration of BIM and FM, the full FM package is possible. Building information modelling (BIM) enables the gradual acquisition of building data and may be essential to expediting the data collection procedure. Due to its user-friendly 3D visualisation, BIM has the potential to be utilised as a platform to research and publish information by including a variety of stakeholders (Hijazi & Aziz, 2013). BIM technologies provide facility managers and building owners with a potent way to access data from a virtual representation of a physical structure that is visually accurate. Integrating a BIM model with a facility's maintenance management system results in the first advantage. To provide an even more effective maintenance programme, BIM can automate preventative maintenance tasks and connect to the already installed software to add to the data and information that is already available. The second advantage is BIM helps enhance space management. BIM can quickly and clearly demonstrate potential inefficiencies in space use. Thirdly, BIM can be useful for building analysis, particularly with reference to sustainability programmes. The BIM model can serve as a constantly updated repository for all the information gathered and the programmes created in connection with green objectives. Fourth, BIM can facilitate the management of change. The BIM model can be used by facility managers to configure space and prepare scenarios better effectively. Conflicts that arise when space requirements or objectives change can also be found using BIM. Fifth, new software programmes that enable a BIM model to communicate with a facility's building automation system are being developed and released on the market.

2.3 Theory of Acceptance Behind Building Information Modelling (BIM) Adoption in Facility Management (FM)

The Technology Adoption Model (TAM), developed by Davis (1989), is an adaptation of the theories of reasoned action (Ajzen and Fishbein, 1980) and planned behaviour (Ajzen, 1991) that is especially designed for simulating user adoption of information technologies. To explain user behaviour across a wide range of end-user computing systems and user groups, TAM aims to provide an explanation of the determinants of computer acceptance that is both frugal and theoretically defensible. Perceived utility and perceived usability are of particular importance for information system (IS) acceptance behaviour in this paradigm. According to TAM, external factors indirectly influence attitudes towards usage, which in turn affects how beneficial and simple a system is judged to be to use. TAM assumes that two beliefs affect a person's behaviour towards using a system: perceived usefulness, which is defined as the degree to which a person believes that using the system will improve job performance, and perceived ease of use, which is defined as the degree to which a person believes that using the system will require little effort. TAM assumes that perceived utility and perceived ease of use operate as mediators between the effects of external variables (such as system characteristics, the development process, and training) on intention to use. Subjective norms significantly affect intention in mandatory system use, but not in voluntary situations. To extend the original TAM and account for mandated system use, the updated TAM, also known as TAM2, added subjective norms as a second predictor of intention (Venkatesh and Davis, 2000). TAM3 was created because of additional research on TAM (Venkatesh and Bela, 2008). By utilising technologies primarily used in individual work, such as e-mail, databases, software, websites, wireless Internet technologies, and e-commerce, the existing TAM—which was examined as a representative theory relating to the selection and use of services based on new information systems and information technologies—is being studied. As a result, consumers can choose technologies, and a wider variety of technologies is dependent on how helpful or convenient it is to utilise the applied technologies. Thus, there is a strong likelihood that the characteristics of technologies play a significant role in the extent of their adoption. The context of organisational properties is probably a significant influencing factor in the current BIM situation, together with the technology properties. Although the word "acceptance" has distinct connotations, its literal meaning in a passive circumstance is the same as its meaning in relation to TAM. In terms of BIM characteristics, BIM users communicate information via BIM with other members of the business in addition to using BIM tools for their own work. This research recognises the significance of organisational BIM acceptance, factors affecting BIM acceptance from an individual and organisational perspective, and investigates interactions between the elements, in contrast to the existing TAM, which focuses on individual technological acceptance.

2.4 Framework for Building Information Modelling (BIM) Acceptance in Facility Management (FM)

The principles that serve as the foundation for the entire research are mostly covered by the conceptual framework. A conceptual framework is a construct in which each notion plays a crucial part rather than merely being a collection of ideas. A conceptual framework, according to (Miles and Huberman, 1994), identifies the important concepts, variables, or elements and presupposes relationships between them. The goal of the study is to identify, investigate, and assess the level of Building Information Modelling (BIM) adoption in the Facility Management (FM) sector using empirical data and tried-and-true research techniques. As a result, the research-based BIM acceptance model (Lee et al. 2012) is employed. This model incorporates further literary elements on the use of BIM and provides the justification for variables based on TAM's theory of background. However, the design for the BIM Acceptance Model into FM context as illustrated in figure 2 has been adjusted for this conceptual framework study. To quantify the level of individual acceptance of utilising BIM and, as a result, the reflected organisational intention to accept BIM, the framework depends on technology acceptance and use theories outlined in the literature review. Measuring the acceptance level will show whether the behavioural intention was motivation (positive level) or resistance (negative level). Controlling BIM adoption habits in the FM business will be made easier with an understanding of the factors that influence the amount of acceptance.

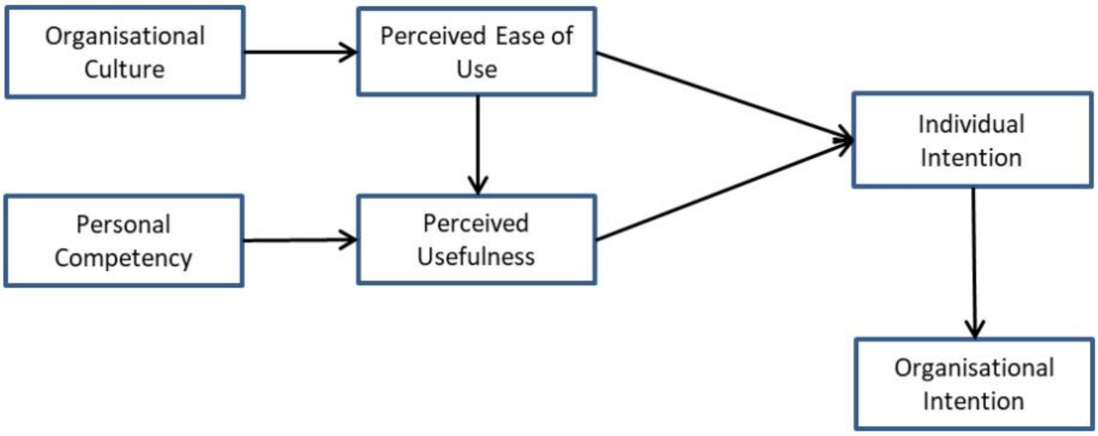

Fig. 2 - Conceptual framework of BIM adoption in FM

2.4.1 Organisational Culture

Organisational culture includes the conviction that BIM is utilised for collaborative work, a company's openness to experimenting with new information technology, and structured supports including resources, training, and incentives for BIM adoption. Inquiries concerning organisational efficacy beliefs are made using the concept of collective efficacy, which is related to the organisational dimension. Research on collective efficacy views highlights the fact that teachers hold beliefs about users' combined abilities as well as beliefs about their own self-referential effectiveness judgements. Such group referent views reflect perceived collective efficacy, an emerging organisational feature (Goddard and Hoy, 2000). Organisational innovativeness was characterised as a company's readiness to experiment with new information technologies. Effective collaboration and transparent role sharing for modelling among organisations are required for BIM adoption success. All organisations are required to follow uniform modelling policies and practises. Therefore, both individual and organisational innovation should be considered. According to Gilligan and Kunz (2007), top management support has long been acknowledged as a crucial factor in studies on the adoption of new technologies. Absent a solid commitment from top management, an organization's decision to embrace BIM could be problematic. Top management support was identified by Gilligan and Kunz (2007) as one of the key success elements for implementing BIM technologies. It is expected that businesses are more likely to employ BIM if there is considerable top management backing for it.

2.4.2 Personal Competency

A person's readiness to test out any new information technology and their opinion that BIM is appropriate for their purpose are examples of personal competency. Self-efficacy is a notion that has its roots in social cognitive theory (Bandura, 1977). It speaks to the confidence that one can carry out the behaviour necessary to bring about the desired result. Self-efficacy is described as perceived behavioural control, which refers to how easy or difficult a given behaviour is seen to be. It is associated with control beliefs, which are notions about the existence of elements that could facilitate or obstruct the performance of the behaviour. Furthermore, the willingness of an individual to test out any new information technology is referred to as personal innovativeness. Personal innovation helps identify people who are likely to adopt IT advancements earlier than others, according to Agarwal and Prasad (1997). It is better comprehend how perceptions are created and the subsequent role they play in the construction of individual behaviour if we were to learn about each person's unique innovativeness.

2.4.3 Perceived Easy of Use

The organisation or person acknowledges that using BIM is not difficult. In more detail, a user's perception of a technology's usability refers to how easily they anticipate using it and how little work it will involve. Architects' behavioural intentions may be positively impacted if they believe adopting BIM is simple. Easy usage is one of the major factors, according to prior study, that determine whether IT is successfully adopted. The degree to which someone perceives a system to be simple to use is referred to as perceived ease of use. This is implied by the definition of ease, which is the absence of difficulty or significant effort. According to Davis (1989), a technology that was found to be simpler to use than another was more likely to be adopted. These results support the premise that ease of use and acceptance intention are positively correlated. Therefore, it is believed that the perception of BIM's utility, the level of agreement over its appropriation, and the intention to adopt it will all be closely tied to the notion that BIM is simple to use. Three questions in all were used to gauge the degree of perceived usability: the simplicity of using the collaboration guidelines, the simplicity of learning how to work with BIM, and the simplicity of sharing information across stakeholders.

2.4.4 Perceived Usefulness

The firm or individual acknowledges that using BIM enhances productivity and working capacity. The extent to which a user thinks employing a certain technology would improve his or her performance is known as perceived usefulness. Using BIM for architects would be regarded as having a positive impact on behavioural intention if it improved their performance. The usefulness of technology is thought to be a key determinant of user acceptability. According to Davis (1989), user perception of usefulness is the extent to which a person thinks utilising a certain technology will improve his or her ability to accomplish their work. From the definition of useful, which states that something can be employed in a beneficial way, this is implied. It has a positive correlation with accepting intention, according to earlier studies. When a person is ready to use BIM's resources for their activities and when their affiliated organisation is ready to set up a BIM-based system of collaboration, BIM can be accepted. Because of this, the measuring criteria for perceived utility can be roughly separated into individual and organisational acknowledgment that the usage of BIM increases working capacity and productivity.

2.4.5 Individual Intention of Accepting Building Information Modelling (BIM)

According to Ajzen and Fishbein (1980), behavioural intention is a gauge of how strongly one intends to carry out a given behaviour. Many academics predict that behavioural intentions will significantly increase the likelihood that people will adopt new technology. The majority of studies on the application of information technology (IT) have included user approval as a dependent variable (Saga and Zmud, 1994). User acceptability might be a requirement for system use, according to Davis et al. (1989). Regardless of the perspective chosen, it is obvious that user acceptance is essential for a successful implementation. Acceptance of BIM is viewed as a dependent variable in this study. Therefore, readiness to use BIM tools and information to complete his job, willingness to invest time in using BIM, and willingness to suggest BIM to coworkers or other entities in a cooperative connection are the measurement items for individual intention to adopt BIM.

2.4.6 Organisational Intention of Accepting Building Information Modelling (BIM)

The following criteria are used to gauge an organization's readiness to adopt BIM: willingness to promote BIM usage among group members, willingness to advocate BIM adoption to other organisations in cooperative connections, and willingness to create BIM application technology.

3. Research Methodology

Research philosophy examines the origins, nature, and progression of knowledge. A research philosophy is simply a set of beliefs about how information about a topic should be gathered, examined, and applied. Saunders (2012) claims that the four categories of research philosophy are positivism, realism, interpretivism, and pragmatism. Positive knowledge is based on natural phenomena and their properties and relationships, according to the positivism theory. The positivists contend that reality is steady and amenable to observation and objective description. While realism makes the case that things exist regardless of our understanding of them. Direct realism and Critical realism are the two categories of realism. A critical realist holds that rather than experiencing things, one experiences sensations (the images of the objects). A Direct Realist, on the other hand, thinks that what one perceives with their senses truly represents reality. In addition, Interpretivism acknowledges that scientists cannot help but have an impact on the phenomena they investigate while studying phenomena in their natural surroundings. Pragmatists, on the other hand, emphasises on practical methods to address practical issues. This research uses positivism as its philosophy of choice. The decision was made because positivism is the view that the only authentic knowledge is scientific knowledge, and that such knowledge can only come from positive affirmation of theories through strict scientific method (techniques for investigating phenomena based on gathering observable, empirical and measurable evidence, subject to specific principles of reasoning) (Saunders, 2012).

The term "research approaches" refers to a set of presumptions and attitudes regarding the growth of knowledge. According to Saunders (2012), there are three different sorts of research approaches: deductive research method, inductive research approach, and abductive research approach. A research method that employs a quantitative approach is the deductive approach. According to Saunders et al. (2012), a deductive approach focuses on "developing a hypothesis (or hypotheses) based on existing theory, and then designing a research strategy to test the hypothesis." Deductive methods are most suited for quantitative research designs, to put it simply. Otherwise, research that employs a qualitative technique is known as an inductive approach. However, the inductive approach does not preclude the researcher from using an existing theory to frame the research question to be explored. This method seeks to generate meanings from the data set collected to identify patterns and relationships to build a theory (Saunders et al., 2012). As a result, results are gathered and only depend on qualitative information. The abductive method is created by observation of actual world events, such as actual human behaviour or actual human interpretation of a certain circumstance. Consequently, both qualitative and quantitative methodologies are needed to ascertain the current situation. The conclusions are based on both qualitative and quantitative observations. In other words, the abductive method enables researchers to assess data from multiple points of view (Creswell, 2011). From the points of view, the deductive approach is employed in this study to examine the data on BIM acceptability in the FM business to meet the study's goals and objectives. The degree of BIM acceptability in the FM industry is evaluated using a quantitative approach.

3.1 Research Method

The outcomes of this study were based on quantitative data because the researchers utilised a deductive approach. In doing so, the researcher decides to carry out questionnaire surveys. Following the collection of the data via the questionnaire, the Partial Least Square of Structured Equation Modelling (PLS-SEM) method was used to analyse the data. This statistical model was selected as the analysis methodology since it has been shown to be an effective method for creating a new model from freshly developed constructs (Hair et al., 2014). The accuracy of this model's statistical predictions is enhanced by its rigour in predicting the relationships found in the literature review. The bootstrapping approach was then used to test the developed hypotheses. Whether to accept or reject the hypotheses depends on the importance of the route coefficient. To create a thorough picture, the questionnaire was gathered and examined to gather information about the FM industry's embrace of BIM.

3.2 Research Instrument

3.2.1 Questionnaire

The researcher has created a set of questionnaires for this study that examine the acceptance of building information modelling in the facilities management sector. Compared to interviews, a questionnaire has the advantage of reaching a larger audience. As a result, the researchers submitted the whole questionnaire that was utilised in the study. The questionnaire is a tool for gathering information that demonstrates one or more characteristics of a specific group. To address the study issues and evaluate the results of the key pieces of literature, this questionnaire was created and used as the primary data gathering tool (Davis, 1989). According to the location and demographic of the building's inhabitants, the number of respondents fluctuates. The self-completed questionnaire approach was used to obtain the survey's data. Self-completed questionnaires are a method where the respondents answer the questions on their own, without the help of the researcher or other outside parties (Saunders et al., 2012). The questionnaire was created to gauge many constructs. It also examines how the constructs relate to one another. Since administering questionnaires took less time and effort, they were used. Furthermore, because the individuals' identities were not required on the completed surveys, it provided the opportunity for anonymity for privacy purposes. Additionally, because they were presented in a uniform way, there is less room for bias. The researcher offers an online survey as well, which is sent via Google Form. It was found that an online survey was the most economical way to gather information from responders spread across various geographic locations. The questionnaire for this study is broken down into seven components, including Part A: Respondent Profile, Part B: Organisational Culture, Part C: Personal Competency, Part D: Perceived Ease of Use, Part E: Perceived Usefulness, Part F: Individual Intention and Part G: Organisational Intention. The questionnaire's items are all bilingual in English and Bahasa Malaysia. A few open-ended questions are included in Section A, but most of the questions are structured. Nearly all the questions in Sections B to G are organised, using a seven-point numerical Likert Scale, and the data is all presented as ordinal data. Ordinal scales are frequently used to measure concepts other than numbers, such as satisfaction, happiness, discomfort, etc. Reflective indicators are included on each item in sections B to G. Reflective indicators can be thought of as a representative sampling of all conceivable items that could be found inside the construct's conceptual scope. Reflective indicators are a group of features that, to put it another way, reflect the construct. Scale is the term used to describe the collection of reflecting measures. This indicator is replaceable and not fixed. The table below summarised all the items within the questionnaire.

Table 1 - Items related to organizational culture

Item Label	Purposes
B1	To determine whether the organisation is unaffected by BIM resistance
B2	To determine the organization's level of familiarity with BIM tools.
B3	To determine whether the organisation is aware of the advantages of utilising BIM
B4	To assess the organization's psychological openness to using new information technology.
B5	To assess the organization's technical readiness for utilising cutting-edge information technology.
B6	To determine whether the organisation encourages its staff to use cutting-edge technologies.
B7	To evaluate the organization's ability to offer sufficient hardware and software for BIM use.
B8	To determine whether the organisation offers the required BIM training and instruction.
B9	To determine whether the organisation offers incentives for BIM adoption or use.

Table 2 - Items related to personal competency

Item Label	Purposes
C1	To assess if respondents believe they have no objections to using BIM
C2	To assess the respondent's level of familiarity with BIM tools
C3	To assess whether respondents are aware of the advantages of utilising BIM
C4	To assess the respondent's psychological openness to using new information technology.
C5	To determine if respondents possess the technical skills necessary for using new informational technologies.
C6	To determine whether respondents believe themselves to be aggressive in their use of new information technology.

Table 3 - Items related to perceived usefulness

Item Label	Purposes
DI	To assess respondents' perceptions of whether BIM enhances stakeholder cooperation
D2	To find out if respondents think that BIM enables thorough administration of life-cycle information (design, construction - O&M).
D3	To determine whether respondents believe BIM speeds up decision-making.
D4	To determine whether respondents think BIM broadens the possibilities for working with other organisations.
D5	To determine whether respondents think BIM speeds up task handling.
D6	To determine whether respondents believe BIM shortens response times.
D7	To assess the accuracy of the respondents' belief that BIM improves task accuracy.

Table 4 - Items related to perceived usefulness

Item Label	Purposes
E1	To assess respondents' perceptions on BIM's ease of learning
E2	To determine whether respondents think BIM makes it simple for stakeholders to communicate information.
E3	To determine whether respondents think the BIM guidelines are clear and simple to follow.
E4	To assess respondents' perceptions of the BIM interfaces' readability
E5	To determine if respondents believe BIM makes it simple to maintain records and information.

Table 5 - Items related to individual intention

Item Label	Purposes
F1	To determine whether respondents plan to use BIM to complete their task.
F2	To determine whether respondents plan to share their experience with BIM with others
F3	To determine whether respondents intend to devote time to learning BIM.

Table 6 - Items related to organisational intention

Item Label	Purposes
G1	To measure whether the organisation have an intention encourages members of organisation to use BIM technology.
G2	To assess whether the organisation is sufficiently ready to participate in a BIM project
G3	to determine whether the company intends to advocate BIM to other companies with whom it has working relationships.
G4	To measure whether the organisation intends to embrace and develop BIM application technology.

3.2.2 Sampling

The process of selecting the sample population to be utilised as respondents is known as sample design (Chua, 2012). Based on the study's objectives, necessary sample size, budget, and time constraints, sample size design is chosen (Sabitha, 2006). As a result, the purpose of this sample is to gather research data from respondents or a variety of demographics. Additionally, to guarantee that the research process runs smoothly, the researchers have created the essential sample designs, which in turn indicate the goal of the investigation, the size of the sample used, and the amount needed by the researcher to do this study. For the quantitative data (questionnaire survey), the researcher focused on facilities management staff respondents at all position levels. The choice was made since these individuals are already familiar with the facility management industry, making it more likely that their response will be foreseeable. This study used a straightforward random sampling technique that concentrated on choosing sample group members at random. This study used Cohen's (1992) general rule of thumb to calculate the sample size. Table 7 provides the general guidelines. As a general guideline, the minimal sample size could be established using the maximum number of arrows pointing at a construct, the lowest R2 value that the analysis can detect, and the significance level for the specific analysis using 80% as the default value for statistical power. In this study, the construct Individual Intention has the most predictors in the model, with two. The significance level is 5%, and the smallest R2 value that can be recognised is 0.1. The minimal number of observations (sample size) needed to do the analysis with 80% statistical power is 110.

Table 7 - Sample size recommendation an in PLS-SEM for a statistical power of 80%

Maximum number of arrows pointing at construct	*Significance level*											
	1%				5%				10%			
	Minimum R^2				Minimum R^2				Minimum R^2			
	0.10	0.25	0.50	0.75	**0.10**	0.25	0.50	0.75	0.10	0.25	0.50	0.75
2	158	75	47	38	**110**	52	33	26	88	41	26	21
3	176	84	53	42	124	59	38	30	100	48	30	25
4	191	91	58	46	137	65	42	33	111	53	34	27
5	205	98	62	50	147	70	45	36	120	58	37	30
6	217	103	66	53	157	75	48	39	128	62	40	32
7	28	109	69	56	166	80	51	41	136	66	42	35
8	238	114	73	59	174	84	54	44	143	69	45	37
9	247	119	76	62	181	88	57	46	150	73	47	39
10	256	123	79	64	189	91	59	48	156	76	49	41

Source: Hair et. al. (2014)

4. Results and Discussion

Rossiter (2002) defined content validity as the degree to which an instrument's items adequately capture all the important facets of the subject under study. According to Saunders et al. (2012), the extent to which the measurement tool—in this example, the measuring questions in the questionnaire—provides appropriate coverage of the research investigation questions is known as content validity. To achieve content validity, various methods might be used.

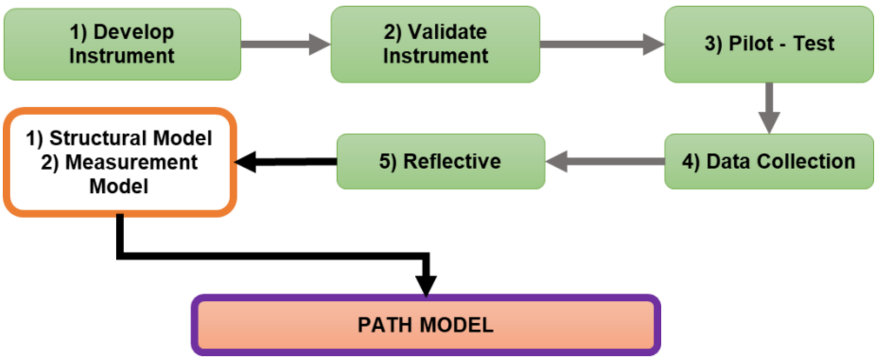

Fig. 3 - Process for validity and reliability tests

To obtain content validity, use Figure 3, First and foremost, the questionnaires must be consistent with the research design based on the methodology, approach, and research philosophy used. The issue statement, primary research question, subsidiary research questions, goals, and objectives of the study must be connected to the data gathering and analysis strategies employed in the research design. Second, the researcher reviewed and revised the questionnaire draught as part of a pilot test with ten individuals. Third, a careful sampling technique has been employed, which includes carefully choosing the sample size and design. Based on Hair's computation of the Cohen table, the sample size of respondents was determined. Finally, the data from the questionnaire will be examined using PLS-SEM, or partial least squares structural equation modelling. This statistical model has a long history of success in handling latent variables obtained from questionnaire data. Construct Validity was confirmed using PLS-SEM in the data analysis. According to Bhattacherjee (2012), reliability is the degree to which a construct's measure is trustworthy or consistent. It forecasts a model's internal consistency. Cronbach's alpha and Composite Reliability (CR) measurements were used to assess the suggested model's internal consistency. Cronbach's alpha should be larger than 0.7 and each construct's composite score should be over 0.7, according to Nunally's (1978) recommendation (Fornell and Larcker, 1981). Measurement items for each construct are trustworthy and stable if all values fall within the required range, which guarantees the internal consistency of the data. To assess the study's dependability, this research conducted test-retests with 30 respondents. According to Krejcie & Morgan's (1970) research, the researcher chose a response sample size for test-retest.

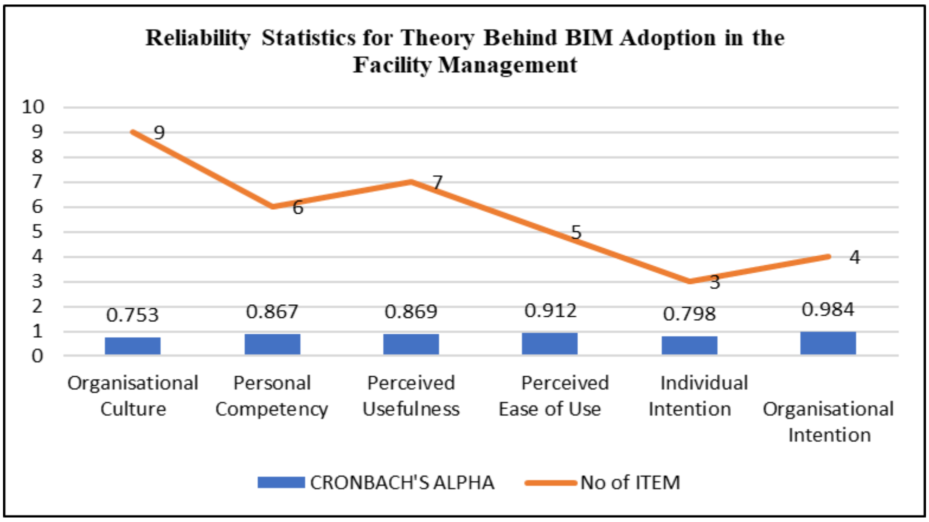

Fig. 4 - Reliability statistics for pilot test

Figure 4 presents the test-retest results that were provided by 30 respondents; the average correlation value of the 30 respondents was 0.7 to 0.9, supporting the validity of the study instrument. Nevertheless, a greater correlation value can be influenced by using experts to conduct the test/retest and confirm the content validity. As a result of their prior knowledge of the facility management industry, their responses may be more predictable than if the exam were administered to a random selection of people.’

5. Conclusions

Finding out whether the theory supporting the adoption of BIM in facility management is valid and reliable is the aim of this study. The sort of category the researchers are attempting to quantify is called a variable. The Technology uptake approach (TAM), first proposed by Davis (1989), a well-established research approach, is used to study the variables that affect BIM uptake in the FM business. According to an analysis of the data, all levels of facility workers employed in the facilities management sector were included as research participants. Each of the six construct variables—organizational culture, individual competency, perceived utility, perceived ease of use, individual intention, and organisational intention—was the subject of a question. The definition of organisational intention is the organization's readiness to promote BIM usage among group members and readiness to create BIM application technology. Individual intention is the willingness of the individual to use BIM and information to complete tasks and the willingness to devote time to using BIM. It was discovered that individual intention is a factor that directly affects organisational intention, therefore higher individual intentions to adopt BIM are necessary to attain higher organisational intentions to adopt BIM. Perceived usefulness is defined as the extent to which an organisation or individual believes that using BIM will improve the performance of his or her tasks, while perceived ease of use is defined as the extent to which an organisation or individual believes using BIM would require little effort. Perceived usefulness and ease of use have a direct impact on a person's intention. Personal competency in the use of information technology, according to the previous study, is the user's assessment of his or her capacity to use BIM for the fulfilment of a particular task. Perceived utility is influenced by personal competency, with the user believing BIM is more effective if applied alongside current practise. A conceptual research model for BIM adoption in FM is proposed based on TAM ideas, and the variables impacting BIM acceptability in the FM industry have been evaluated using the proposed research conceptual framework. To evaluate the scales' dependability, Cronbach's alpha was used. The internal consistency of the indicators within the same construct is typically assessed using Cronbach's Alpha as a metric. Cronbach's Alpha must be 0.60 or higher to be considered satisfactory, but a value of 0.80 or higher implies strong internal consistency (Sekaran, 1992). Based on the results of the pilot test, it can be shown that the Cronbach's Alpha values are in the range of 0.753 to 0.984, indicating that the theory underlying the adoption of BIM in facility management is valid and reliable and has a high degree of internal consistency. As a result, actual data analysis for more research is possible.

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