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# Determinants of BIM Adoption in Facilities Management in South Africa: An Application of the UTAUT Model

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## ABSTRACT

Based on the diversity of the informational needs of an organisation, various information technology systems are introduced and used to support a wide range of Facilities Management (FM) information. The adoption of BIM in FM offers an opportunity for facilities managers to add value to the facilities planning, maintenance, occupation and operations management. Effective adoption of BIM in FM would require better knowledge of relevant and influential factors, which hitherto have not been explored adequately in emerging economy contexts such as South Africa. Therefore, this study aimed to identify and evaluate the determinants for adopting BIM for FM practice, using South Africa as context and the UTAUT model as a theoretical framework for examining determinants of BIM adoption in FM. Relevant literature review was complimented with a survey strategy for data collection. The results demonstrate a strong relationship between Performance Expectancy and Behavioural Intention, the influence of organisations and senior management on BIM adoption in FM and that Attitude has a significant effect on Use Behaviour. The findings align with the UTAUT model and add to the body of practical reference on BIM adoption in FM.

**Keywords:** BIM, Facilities management, Determinants, UTAUT model, Information management

## INTRODUCTION

FM has grown into a discipline and profession within the property and construction industry, exemplified by the establishment of professional FM institutions globally. They include bodies such as IFMA in the USA, JFMA in Japan, BIFM in the UK, FMA in Australia, and SAFMA in South Africa (Tay and Ooi, 2001). FM is a component of the building life-cycle that contributes the most to the total cost of a project, compared to the cost of design and construction (Gallaher et al., 2004). According to Jordani (2010), the cost of FM activities accounts for 85% of the life cycle cost of a building. Hence, information management tools used during FM should reduce costs and improve efficiency.

The introduction of computers in the 20th century advanced facility information management systems (Graddy, 2010). Computers have since evolved from large mainframe types, to more miniature personal computers. An increase in demand for information management due to computerisation within the Architecture, Engineering and Construction (AEC) sector has impacted FM (Pärn, Edwards and Sing, 2017). The drivers include problems such as collecting, retrieving and sharing of data that is not integrated (Cardellino and Finch, 2006). The diversity of informational needs for FM demands a well-structured computer-aided maintenance programme, for adequate facilities maintenance without compromising safety (Shohet, Lavy-Leibovich and Bar-on, 2004). The need for a 'golden thread' of information between all stages of a facility's life cycle, requires information technology systems to collect and make information available in an integrated way, across a facility's life cycle stages (Motamedi, 2013). The shared digital representation of built environment data, known as Building Information Modeling (BIM), holds information for different stakeholders at different phases of a facility life cycle (Liu, 2012). BIM in FM can be used for interpretation and analysis, enabling more efficient building management while adding value to stakeholders (Carbonari et al., 2018). BIM is described as a tool for improving cost efficiency, and generating and managing FM-related information (Parn et al., 2016). It also facilitates the integration of information throughout the life cycle of a building (Mohanta and Das, 2016).

However, there is still a very low adoption of BIM by FM practitioners, occasioning limited experience, inadequate knowledge, and difficulties with using BIM software (Teicholz, 2013). Even so, the adoption of any new technology is influenced by determinants, and BIM is no exception Succar et al., (2012). Though BIM has gained momentum in AEC, its utilisation is complicated with several challenges (Sabol, 2013), as substantiated by Eastman et al. (2011), Kekana et al. (2014) and Azhar (2011). Even so, the specific determinants of BIM in FM and the relative strengths have not been thoroughly investigated.

The challenges of BIM adoption can be broadly classified into two categories: business process challenges, and technological challenges. Various models of innovation and adoption are used to understand adoption of new technology. Many models examine individual choices of acceptance or rejection of innovations. According to Straud (2009), some models focus on the adoption environment, and others focus on type of innovation. In FM studies, the specific determinants of BIM adoption and their relative strengths have not been thoroughly examined. Over other models, the UTAUT model presents relevant features for such examination and it has been successfully used in technology adoption studies. See Howard et al. (2015). It also explains over 70% of all the technology acceptance behaviour, beyond other models (Waehama et al., 2014). Therefore, the research design for the current study was set with the UTAUT model as a lens.

## THE UTAUT MODEL FOR BIM ADOPTION

The UTAUT model employed in the study consists of four core determinants of usage intention – Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC). Behavioural Intention (BI) is a mediating variable for PE, EE and SI, and a predictor of technology

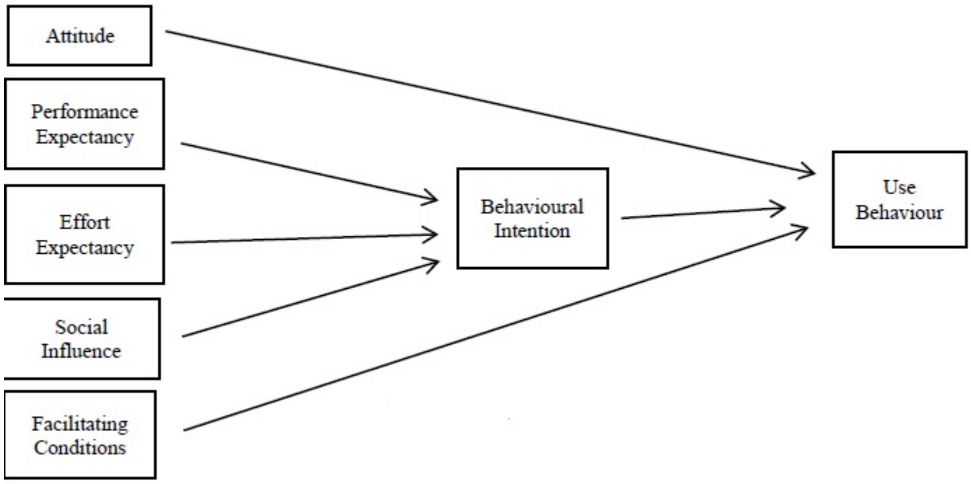


**Figure 1:** UTAUT model *(Adopted from Howard et al., 2015).*

Use Behaviour (UB) (Waehama et al., 2014). The Attitude (ATT) variable was included by Howard et al. (2015). Depending on the gravity of the determinants, the value of BI mediates in regard to the outcomes in UB. The UTAUT model applied in the study is presented in Figure 1.

## RESEARCH DESIGN FOR THE STUDY

Fieldwork was based on data collection by survey strategy through the use of questionnaires which were self-administered and returned. The South African Facilities Management Association (SAFMA), made up of 360 members was used as sample population, with Gauteng Province of South Africa as geographical scope. A sample size of 30 was used, following Saunders et al. (2012). The UTAUT model was applied by measuring each variable in the questionnaire through questions, addressing aspects of BIM adoption and utilisation in FM. The model explained user intention to use BIM and usage behaviour, measuring dependent, independent and mediator variables. The question design used the 7-point Likert scale as follows: 1 – Strongly agree; 2 – Agree; 3 – Somewhat agree; 4 – Neither agree nor disagree; 5 – Somewhat disagree; 6 – Disagree; 7 – Strongly disagree.

### Validity-and-Reliability

A Cronbach alpha analysis was used to validate the questionnaire. Reliability was analysed with the use of factors loading and Cronbach's Alpha. In Table 1, all factor loadings exceed 0.5, while Cronbach's Alpha values for PE, EE, SI, FC and ATT are higher than 0.7, indicating a high level of reliability. The values of BI and UB are below 0.7 but above 0.5. The low alpha is most probably due to a lower number of questions (Tavokol and Dennick, 2011). Considering the results in light of George and Mallery (2003), the questionnaire was deemed a reliable tool.

**Table 1.** Standard item loading and reliability.

| | Indicators | Factors loading | Cronbach alpha |
|---|---|---|---|
| Performance Expectancy PE | PE1 | 0.949 | |
| | PE2 | 0.943 | 0.911 |
| | PE3 | 0.924 | |
| | PE4 | 0.605 | |
| Effort Expectancy EE. | EE1 | 0.921 | |
| | EE2 | 0.952 | 0.882 |
| | EE3 | 0.594 | |
| | EE4 | 0.838 | |
| | SI1 | 0.887 | |
| Social Influence SI | SI2 | 0.94 | 0.911 |
| | SI3 | 0.856 | |
| | SI4 | 0.775 | |
| Facilitating Conditions FC. | FC1 | 0.979 | |
| | FC2 | 0.954 | 0.843 |
| | FC3 | 0.884 | |
| | FC4 | 0.872 | |
| | FC5 | 0.721 | |
| Attitude ATT | ATT1 | 0.848 | |
| | ATT2 | 0.853 | 0.879 |
| | ATT3 | 0.94 | |
| Behavioral Intentions BI. | BI1 | 0.954 | |
| | BI2 | 0.896 | 0.680 |
| | BI3 | 0.796 | |
| Use Behavior UB | UB1 | 0.826 | 0.527 |
| | UB2 | 0.733 | |

## DATA ANALYSIS AND RESULTS

The questionnaire was administered online through the Qualtrics© platform, for data collection and management. Data analysis was performed with IBM SPSS Statistical Package for the Social Sciences Version 23. The method of data analysis included Descriptive and Correlation analysis.

### Descriptive Statistics

Descriptive statistics was performed by generating the mean and standard deviation (SD), from responses. Variables were expanded into relevant indicators for FM Practitioners perceptions of performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions. The mean shows average perception through the the Likert scale responses, while the SD shows the concentration or spread of response values, to the mean, in other to validate the average. See Table 2.

### Correlation Analysis

Correlation analysis was subsequently used to analyse the UTAUT data further. Correlation analysis was used to work out the extent and nature of the relationship between the different variables as follows: Relationship between

**Table 2.** Descriptive statistic of UTAUT indicators.

| Variables | | Indicators | N | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Performance Expectancy | PE1 | I find BIM useful | 36 | 3.61 | 2.06 |
| | PE2 | Working with BIM increases productivity | 36 | 3.61 | 2.088 |
| | PE3 | Using BIM increases my performance | 36 | 4.94 | 1.788 |
| | PE4 | BIM enables me to accomplish tasks more quickly | 34 | 4.81 | 2.095 |
| Effort Expectancy | EE1 | Learning to operate BIM is easy for me | 36 | 4.5 | 2.091 |
| | EE2 | My interaction with BIM is clear and understandable | 36 | 4.47 | 1.859 |
| | EE3 | It is easy for me to become skilful at using BIM | 36 | 3.64 | 2.031 |
| | EE4 | I find it easy to use BIM | 36 | 2.72 | 1.446 |
| Social Influence | SI1 | People who influence my behaviour think I should use BIM | 36 | 3.64 | 2.031 |
| | SI2 | People who are important think I should use BIM | 36 | 3.64 | 2.058 |
| | SI3 | Senior management has been helpful in the use of BIM | 36 | 4.94 | 1.788 |
| | SI4 | The organisation has supported the use of BIM | 34 | 5.36 | 1.659 |
| Facilitating Conditions | FC1 | I have the resources necessary to use BIM | 36 | 4.44 | 2.157 |
| | FC2 | I have the knowledge necessary to use BIM | 36 | 4.44 | 1.889 |
| | FC3 | BIM is not compatible with other computer systems I use | 36 | 4.03 | 1.158 |
| | FC4 | There is assistance available with BIM difficulties | 36 | 3.78 | 1.245 |
| | FC5 | Using BIM fits into my work style | 36 | 3.58 | 1.251 |
| Attitude | ATT1 | Using BIM is a good idea | 36 | 2.69 | 1.47 |
| | ATT2 | I like working with BIM | 36 | 3.39 | 1.293 |
| | ATT3 | Working with BIM makes work interesting | 36 | 3.25 | 1.18 |
| Behavioural Intention | BI1 | I intend to use BIM whenever possible | 36 | 2.92 | 1.228 |
| | BI2 | I have plans to use BIM in the near future | 36 | 2.92 | 1.317 |
| | BI3 | I predict I will use BIM | 35 | 2.67 | 1.454 |
| Use Behaviour | UB1 | I use BIM for different facilities management tasks | 36 | 4.36 | 1.641 |
| | UB2 | I perceive using BIM as voluntary | 36 | 3.47 | 1.647 |

attitude and use behaviour, relationship between performance expectancy and behavioural intention, relationship between effort expectancy and behavioural intention, relationship between social influences and behavioural intention, and relationship between facilitating conditions and use behaviour. The Correlation matrix shows the P-values and correlations coefficients. The P-value was set at $p \leq 0.05$., the p-value is significant at 0.01. As shown in Table 3

**Table 3.** Correlation matrixes.

**Correlations**

| | | PE | EE | SI | FC | ATT | BI | UB |
|---|---|---|---|---|---|---|---|---|
| PE | Pearson Correlation | 1 | .917** | .929** | .846** | .862** | **.763**** | .494** |
| | Sig. 2-tailed | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 |
| EE | Pearson Correlation | .917** | 1 | .947** | .921** | .955** | **.852**** | .496** |
| | Sig. 2-tailed | 0.000 | | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 |
| SI | Pearson Correlation | .929** | .947** | 1 | .856** | .888** | **.807**** | .506** |
| | Sig. 2-tailed | 0.000 | 0.000 | | 0.000 | 0.000 | 0.000 | 0.002 |
| FC | Pearson Correlation | .846** | .921** | .856** | 1 | .946** | .932** | **.729**** |
| | Sig. 2-tailed | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 | 0.000 |
| ATT | Pearson Correlation | .862** | .955** | .888** | .946** | 1 | .876** | **.650**** |
| | Sig. 2-tailed | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | 0.000 |
| BI | Pearson Correlation | .763** | .852** | .807** | .932** | .876** | 1 | **.721**** |
| | Sig. 2-tailed | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 |

**Correlation is significant at the 0.01 level 2-tailed.

## FINDINGS AND DISCUSSION

From Table 2, the mean values of PE 1-4 are between 3 and 4, indicating that the respondents are neutral in their perception that BIM enables them to accomplish tasks faster and that working with BIM increases productivity. Although the respondents agree that BIM is easy to use (EE4), the descriptive analysis of EE 1-3 shows that the respondents are neutral in their interaction with BIM. The mean values of FC 1-5 are also between 3 and 4, which means that most of the respondents' answers fall within the range of somewhat agree and neither agree non-disagree. In addition, SI 1-4 is between 3 and 5, and it shows that people disagree or may not be influenced by people important to them to use BIM. ATT 1-3 is between the values of 2 and 3, meaning that the most common answers were agreed and somewhat agreed. These results indicate that the respondents have a positive attitude towards using BIM. The results for BI. 1-3 indicate that the respondents intend or have plans to use BIM. UB 1-2 values are between 3 and 4, respondents neither agree nor disagree.

Furthermore, a correlation analysis was conducted to examine the data from the UTAUT survey in Table 3. The results show a significant correlation between PE — BI of 0.763, EE – BI of 0.852, SF-BI of 0.807, BI. — UB of 0.721, FC - UB of 0.729 and ATT — UB of 0.650. Moreover, the results show that the correlation coefficient is above 0.50, meaning that the relationship between all variables is positive. The UTAUT model demonstrates that the independent variables PE, EE, SI, FC and ATT directly influence UB and BI;

and, further, that BI impacts UB. The model was used to determine if PE, EE and SI can strengthen the intent to use BIM in FM. Based on the validity and reliability analysis PE, EE and SI are determinants of BI to use BIM in FM. A p-value of less than 0.05 was set to achieve significance. Table 3 shows that the p-value of PE, EE and SI to BI is 0.00, indicating that PE, EE and SI are significant to BI. The Correlation Coefficient for PE, EE and SI to BI are above 0.7. According to Pallant (2011), a value between 0.5 and 1 is considered significant, indicating a high and positive correlation between the variables. Therefore, there is a positive relationship between PE, EE, SI and BI. The results further suggest that BI has a significant effect on UB. These results correspond to the finding of Venkatesh et al. (2003). Thus, it can be deduced that PE, EE and SI influence the prediction of future use of BIM in FM in South Africa. The original model by Venkatesh et al. (2003) predicts that BI affects the UB of individuals, as is the case with the current study. BI has a correlation coefficient of 0.721. The results also show that ATT and FC significantly affect UB, with a p-value of less than 0.05. The correlation coefficient is also high. Hence, ATT and FC positively influence UB. These results align with Attuquayefio and Addo (2014) and Howard et al. (2015), who agree that ATT significantly affects UB.

## CONCLUSION

In the current study, a conceptual framework for technology acceptance, UTAUT, has been used to build a holistic understanding of how individuals adopt technology in an emerging economy context. Using the UTAUT model, findings here demonstrate that Performance Expectancy (PE), Effort Expectancy (EE) and Social Factors (SI) have substantial effects on Behavioural Intention (BI). There is a strong relationship between Performance Expectancy (PE) and Behavioural Intention (BI). This suggests that practitioners regard BIM as a tool that can increase productivity, increase work performance, and enable individuals to complete tasks faster. This perception is viewed as a positive factor towards BIM adoption in FM in South Africa. Secondly, the p-value of Social Influence (SI) towards Behavioural Intention (BI) was significant, meaning that organisations and senior management can influence the adoption of BIM in FM. With the support of senior management, the use of BIM in FM practice will gain more traction, thereby encouraging more adoption at the design and construction stages. Thirdly, the results confirm that Attitude (ATT) has a significant effect on Use Behaviour (UB). Similarly, in determining intent to adopt BIM, a positive attitude towards working with BIM was stronger than the notion that using BIM is good. The findings discussed here reveal that the five independent variables of the UTAUT model affect BI and UB positively. Essentially, within the limits of this study, the findings indicate a strong agreement with the UTAUT model. To further this research, it would be interesting to see the results of a national survey, an exploration of the BIM maturity level of the local FM industry. It is important to explore the FC factor elements in terms of studies such as Ozumba and Shakantu (2018).

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