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# What drives the adoption of building information modeling in design organizations? An empirical investigation of the antecedents affecting architects' behavioral intentions

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ABSTRACT

For years, building information modeling (BIM) has attracted much attention in the architecture, engineering, and construction industry. BIM has furthermore been widely employed in design organizations. Although BIM is emerging as a useful tool for facilitating design processes, the expected benefits of BIM have not yet been fully realized during the course of its implementation. The aim of this study is to empirically examine the factors that can potentially facilitate architects' adoption of BIM through an extension of the technology acceptance model. The results revealed that top management support, subjective norm, compatibility, and computer self-efficacy are critical factors affecting architects' behavioral intentions to adopt BIM. The relationships between these antecedent factors and behavioral intentions are mediated by perceived usefulness and/or ease of use. This study provides a framework to broaden understanding of adoption behavior within this context and thereby increasing the chances for successful adoption of BIM.



## 1. Introduction

Recently, building information modeling (BIM) has attracted much attention in the architecture, engineering, and construction industry. BIM can be defined as the technology of generating and managing a parametric model of a building [1]. The successful implementation of BIM is beneficial for project stakeholders throughout the project lifecycle. In particular, the benefits to architects who use BIM in the design process seem apparent. These benefits include reduced document errors and omissions, reduced rework, and reduced cycle time of the design process [2]. The study by Sacks [3] found that three-dimensional (3D) parametric modeling results in a reduction in the cost of drafting of approximately 80–84%. Another study by Sacks and Barak [4] reported that the potential productivity gain from 3D modeling is estimated to be in the range of 15–41% of the hours required for drawing production. Moreover, the successful implementation of BIM can be a source of productivity improvement for subsequent processes such as construction and operation and maintenance.

However, the benefits of BIM have not yet been fully realized during the course of its implementation. According to the SmartMarket Report from McGraw-Hill Construction, only 3% of survey respondents stated that they received the full benefits of BIM [5,6]. Such a discrepancy between expected benefits and the realized benefits of BIM may be explained by the low adoption rates of BIM by architects [7]. In the literature, various issues causing architects to be afraid to adopt BIM have been reported (see, for example, [8,2]). In a summary of previous studies, the main issues related to BIM adoption can be summarized as 1) management support [8,2], 2) technical support [8], 3) compatibility of BIM [8], 4) software/computer skills [8], and 5) organizational culture [8,2]. However, the impacts of such issues on BIM adoption by architects have not been empirically validated.

Thus, the aim of this study is to empirically examine the factors affecting architects' adoption of BIM. Specifically, this study investigates the following research question: how do the organizational, social, technical, and individual factors affect architects' adoption behaviors as related to BIM? This study extends the technology acceptance model (TAM) by incorporating constructs such as top management support and facilitating conditions from the organizational domain, subjective norm from the social domain, compatibility from the technical domain, and computer self-efficacy from the individual domain. The remainder of the paper is organized as follows: Section 2 develops the theoretical background of our study, focusing on the technology acceptance theories and current practices of BIM in Korea. Section 3 presents the research model and hypotheses. Section 4 provides a discussion of the research methods. Section 5 provides the analysis of the survey results. Section 6 discusses the results with the summary, contributions, implications, and limitations of the study.

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## 2. Research background

### 2.1. Current BIM practices in Korea

BIM has been recognized as the emerging technology to improve the practices of design, construction, and maintenance of building in the Korean architecture, engineering, and construction industry. With the recognition, the use of BIM has recently rapidly increased in Korea. According to a survey by McGraw-Hill Construction [9], approximately 74% of architects have experience using BIM in their design works. The Korean government has been a major force for the rapid introduction of BIM. For public projects, budgeted at 50 billion won or more, procured by the Public Procurement Service, BIM-based designs have been mandated since 2012. Such government legislative action has led to the widespread use of BIM in Korea. The thematic pavilion for the 2012 Yeosu Expo and the Dongdaemun design plaza and park are exemplary cases where public projects have employed BIM-based designs.

Despite the rapid diffusion of BIM, the majority of Korean architects seem to lack confidence in BIM as a replacement for traditional 2D-based design practice. The survey by McGraw-Hill Construction [9] revealed that only 13% of respondents have used BIM on more than 60% of their projects. In the same survey, 56% of architects answered that they only partially used the potentiality of BIM [9]. BIM has not been fully adopted by Korean architects and design organizations fail to secure benefits from the investment they made in adopting BIM. Then, the question arises as to why architects hesitate to adopt BIM despite its significant benefits.

### 2.2. Technology acceptance model

Understanding user acceptance of information technology (IT) has progressed significantly in the last two decades [10]. The TAM adopted the theory of reasoned action [10–12] and has been accepted as a parsimonious but highly predictive model for understanding a user's technology adoption behavior [10,13,14]. The TAM has been applied to understand user adoption behavior for a variety of information systems (ISs) [15].

TAM has also been used to investigate user technology adoption in the field of construction. Nevertheless, very little research has been conducted on the architects' behaviors related to BIM adoption. Most published studies on TAM (or its extended models) in construction industry investigated construction professionals' technology-related behaviors. Chung et al. [16] applied an extended TAM model with DeLone and McLean's IS success model to examine the adoption of enterprise resource planning among 281 construction professionals in the United States. Park et al. [17] applied an extended TAM model to investigate the adoption of web-based training systems among 408 Korean construction professionals. It is expected that the use of BIM will increase. A better understanding of the adoption behavior of BIM among architects will facilitate raising BIM adoption rates among architects.

## 3. Theoretical framework and hypotheses

In this study, TAM was used as a basis for investigating the architects' behavioral intentions to adopt BIM. The TAM, suggested by Davis [13], explains the determinants of technology acceptance in general and traces the impact of external factors on internal beliefs-perceived usefulness and perceived ease of use-intention to use, and actual usage [14]. According to the TAM, adoption behavior is determined by the intention to use a particular system, which in turn is determined by the perceived usefulness and perceived ease of use of that system. It is based on the assumption that individual's cognitive beliefs, perceived usefulness, and perceived ease of use, influence system usage. This study extends the TAM developed by Davis [13] by adding variables such as top management support, subjective norm, compatibility, facilitating conditions, and computer self-efficacy (see Fig. 1).

### 3.1. Variables of the TAM

The TAM postulates that a user's behavioral intention to use technology is determined by two beliefs: perceived usefulness (PU) and perceived ease of use (PEOU) [10]. PU is defined as "the extent to which a user believes that using the technology will improve his or her job performance" [10]. Previous studies have proved that PU has a direct effect on user's behavioral intention to use the technology [18–22]. As such, we hypothesize that:

**H1.** PU will have a positive effect on the behavioral intention to use.

PEOU is defined as "the extent to which a user believes that using the technology will be free of effort" [10]. PEOU has direct effect on PU and both beliefs have direct effects on behavioral intention to use the technology [10]. Previous studies have proved that PEOU has a direct effect on users' behavioral intention to use the technology [23,24,21,25] and PU [13,26,23,25]. Thus, we hypothesize that:

**H2.** PEOU will have a positive effect on the behavioral intention.

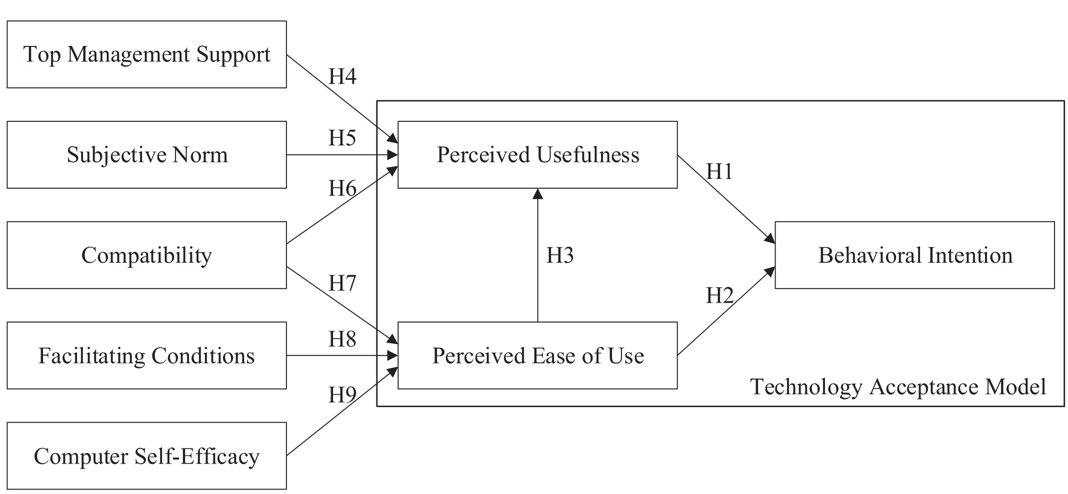


**Fig. 1.** Proposed extended TAM.