The Adoption of Building Information Modeling in the Design Organization: An Empirical Study of Architects in Korean Design Firms

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Abstract -

Recently, Building Information Modeling (BIM) technology has attracted much attention in the Architecture, Engineering, and Construction (AEC) industry. Despite the growing interest in BIM technology, the benefits of BIM have not yet been fully realized during the course of implementation of BIM because of its low adoption rate among architects. Therefore, it is significant important in successful adoption of BIM in design organizations, understanding of the factors influencing the adoption of BIM. The aim of this study is to empirically examine the individual, organizational, social, and technical factors affecting architects' adoption of BIM. The 162 architects with experience using BIM tools at three major design firms in South Korea were selected to participate in the face-to-face survey. This study extends the Technology Acceptance Model (TAM) by incorporating constructs such as computer self-efficacy from the individual domain, top management support and technical support from the organizational domain, subjective norm from the social domain and compatibility from the technical domain. The results strongly support the extended TAM in predicting the intention of users to adopt BIM. It also demonstrates the significant effect of computer self-efficacy, top management support, subjective norm, and compatibility on behavioral intention through perceived ease of use and perceived usefulness. This study provides academics and practitioners with the understanding of factors leading to the successful implementation of BIM in design organizations. It also provides insight into the role management plays in the adoption of BIM among architects in the AEC industry.

Keywords -

Behavioral intention; Building and architecture; Building information modeling; Technology acceptance model; Design organizations

1 Introduction

Recently, BIM technology has been attracted much attention in the AEC industry. BIM technology can be defined as the technology of generating and managing a parametric model of a building [1]. The successful implementation of BIM technology is beneficial for project stakeholders throughout the project life cycle. The following benefits for the architects who utilize BIM in the design process seem especially apparent. Those include reduced document errors and omissions, reduced rework, and reduced cycle time of design process [2]. Moreover, the successful implementation of BIM can help to improve the productivity of subsequent processes, such as construction, operation, and maintenance.

However, the benefits of BIM have yet to be fully realized even during the course of its implementation. According to the SmartMarket Report from McGraw-Hill Construction, only 3% of survey respondents stated that they experience its full benefits [3]. Such a discrepancy between expected benefits and realized benefits of BIM may be explained by its low adoption rates by architects [4]. This raises the following question: Why with significant benefit of BIM do architects hesitate to adopt it? Several previous studies identify various factors that make architects are afraid to accept the BIM. To summarize these previous studies, the main issues to BIM include management support, technical support, compatibility of BIM technology, software/computer skills and organizational culture [5].

Despite the significant importance of BIM's successful adoption by design firms, understanding the factors that influencing this adoption by architects has yet to be seriously explored. Consequently, it is important to examine the question of how those factors affect an architect's decision to adopt BIM. Thus, the aim of this study is to empirically examine the factors affecting architects' adoption of BIM. This study extends the TAM by incorporating constructs such as computer self-efficacy from the individual domain, top management support, technical support, and training from the organizational domain, subjective norm from the social domain and compatibility from the technical domain. The results of this study will provide the understanding of factors leading to the successful implementation of BIM in the organization.

2 Technology Acceptance Model

The TAM is derived from the Theory of Reasoned Action (TRA) and was developed by Davis [6]. It was widely accepted as a framework to explain users' adoption of Information Technology (IT) by examining variables that influence users' behavioral intention and also explaining behavioral intention by using variables [7]. TAM provides general information on users with the advantages of parsimony, robustness, and broad empirical support [8]. However, it has theoretical limitations that cannot reflect various factors [9]. Therefore, to overcome the limitations, an extended TAM has been suggested that enables the investigation of specific factors that are expected to influence the users' behavior by using specific technology that adds additional factors as external variables into the TAM [7].

The extended TAM has enabled the determination of specific validity factors to explain users' behavioral intention and to understand the factors when adopting the technology in each study. Furthermore, it has been helpful for in the successful adoption of technology through considering specific validity factors. Therefore, this study proposes that the extended TAM examine the factors that influence the behavioral intention of architects toward the adoption of the BIM

3 Theoretical Framework and Hypotheses

3.1 Research Model

This study suggests an extended TAM to examine the factors that influence the behavioral intention of architects in the adoption of the BIM. The proposed extended TAM comprises external variables, such as technical support, computer self-efficacy, compatibility, subjective norm, and top management support, as well as components influenced by external variables, such as perceived usefulness, perceived ease of use, and behavioral intention. Figure 1 suggests that perceived usefulness and perceived ease of use are instrumental in explaining the variance in users' intention as based on prior research [10]. Behavioral intention was used to measure the architects' adoption of BIM but not actual use. For some projects, the contractor or client has the right to require the use of BIM [11]. In these cases, usage of BIM is mandatory, thus requiring designers to use BIM regardless of their intention. For this reason, actual use cannot be regarded as a measure of architects' acceptance of BIM adoption. An additional reason that the use of behavioral intention as a measure of the architects' acceptance of BIM adoption is that it is appropriate to measure behavioral intention of technology adoption in a mandatory environment [12].

Perceived usefulness and perceived ease of use are defined by Davis [6] as positively influencing behavioral intention in the original TAM when adopting technology [13]. Perceived usefulness is the degree to which a user believes that using a particular technology will enhance his or her performance [7]. If using BIM for architects enhances their performance, then it would be considered to have a positive effect on behavioral intention. Also, there is some evidence that using BIM can improve productivity [14] in the construction industry. Thus, we hypothesize that:

H1. Perceived usefulness will have a positive effect on the behavioral intention.

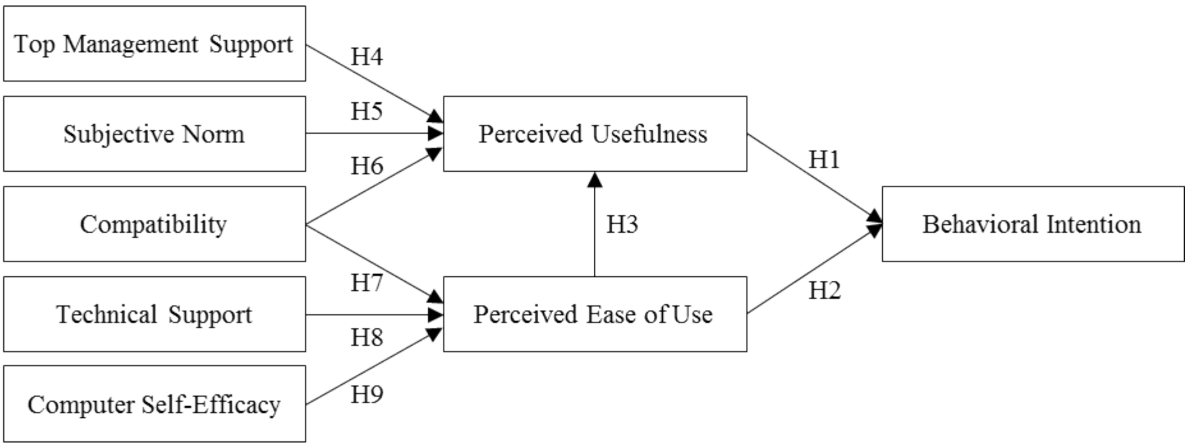

Figure 1. Proposed extended TAM

Specifically, perceived ease of use is the degree to which a user believes that a technology will be easy to understand and will require no effort to use [7]. If architects believe that using BIM is easy, it can affect their behavioral intention positively. So, we hypothesize that:

H2. Perceived ease of use will have a positive effect on the behavioral intention.

H3. Perceived ease of use will have a positive effect on perceived usefulness.

Technical support, computer self-efficacy, compatibility, subjective norm, and top management support were selected as external variables in the adoption of BIM. These external variables are assumed to directly affect perceived usefulness and perceived ease of use, and indirectly affect behavioral intention [15]. Details on each variable will follow.

3.2 Top Management Support

Top management support is defined by "how individuals within a firm perceive the support of management for functions such as IT as well as the willingness of management to implement specific IT functions" [16]. It has been emphasized that top management support is critical for the successful adoption of technology within an organization [17]. Specifically, the success of any technological adoption and implementation is dependent upon the support of top management because this group not only establishes priorities within the organization, but also provides funding and implements protocols [18].

Top management support will have similar effects on the acceptance of BIM among employees. Because final decisions are made by top management, top management must have an understanding of the intention of technology users within the firm, how the use of technology can benefit the employees and the costs associated with the technology.

The key to successful implementation and adoption of technology within a firm is ensuring that top management supports the implementation and that employees perceive that management supports the technology [19]. When top management supports the technology, it is also able to provide guidance and support to employees who are not comfortable with the technology or who are reluctant to change [20]. Additionally, there is an element of psychological support that goes along with top management support. Therefore, we can hypothesize that:

H4. Top management support will have a positive effect on perceived usefulness.

3.3 Subjective Norm

Subjective norm is the individual perception that others believe that the individual thinks people should or should not perform certain acts. It has been shown to be linked to individual usage of IT [21]. In this study, subjective norm refers to the architects' belief that BIM is useful. The architects use it due to the suggestions of colleagues and important professionals in their field who have encountered BIM previously. For architects, design firms require the usage of BIM that architects are more influenced by subjective norm than the usage of other voluntary technology [22]. Also, subjective norm is more important in the early stages of technology adoption because of the limited direct experience users have in that stage; in the early stages of adoption, users have not yet formed attitudes about the technology [23]. In the construction industry, when the adoption of BIM is in the early stage [24], subjective norm is supposed to influence architects' behavioral intention. Therefore, based on previous studies, subjective norm is expected to have a significant impact on the adoption of BIM. Thus, we hypothesis:

H5. Subjective norm will have a positive effect on the perceived usefulness.

3.4 Compatibility

Compatibility is the degree to which technology users' feel that a technology matches their needs, values, and work practices. It is measured based on the users' experiences [25]. High compatibility has positive effects on technology adoption [24]. Compatibility will affect users' behavioral intention because it contributes to the ease of adoption of the technology [26]. Users will adopt the technology when they view it as being compatible with and effective for their work goals. Based on these previous findings, compatibility is likely to influence user's behavioral intention with respect to adopting new technology. BIM is a tool that architects will most likely find to be compatible, with their work needs and goals. It is a great tool for data management because it utilizes a constant data format. This makes it possible to retrieve information, and that, in turn, allows architects to display this information to other members of a project as well as to clients [13]. BIM is also a more accurate and suitable tool for architects than is 2-D drawing [27]. When using BIM, architects are able to show and mark their designs and materials from various angles, like construction development processing, by using computer projection that enhances the design with real buildings and materials [28]. For these reasons, we hypothesize that compatibility will affect architects' behavioral intention. In view of these conflicted findings, we hypothesize the following:

H6. Compatibility will have a positive effect on perceived usefulness.

H7. Compatibility will have a positive effect on perceived ease of use.

3.5 Technical Support

Ralph [29] defined technical support as the assistance, offered by knowledgeable people, that technology users need when they use computer hardware or software products [30]. It has been demonstrated in previous research that technical support is one of the most influential factors in determining users' behavioral intention in technology adoption [31].

If technology adoption is mandatory, technological support will have positive effects on individual IT usage [32]. Therefore, it can be reasonably expected that technical support can enhance users' behavioral intention [5]. These previous studies note that, when users encounter new technology as well as being proficient with BIM, support that includes training is essential to learning how to use BIM in their work [26]. However some design firms assume that professionals who are proficient in using Computer-Aided Design (CAD) software can learn BIM quickly without any other training and therefore overlook the importance of training. BIM is fundamentally different from CAD and BIM training is essential for every professional who engages in designing or producing documents with it [26]. Additionally, new staff may be needed, such as an interoperability manager or a structural modeler. This will add to the costs of implementing such a program [2]. Based on the importance of technical support for BIM adoption, we can hypothesize that:

H8. Technical support will have a positive effect on perceived ease of use.

3.6 Computer Self-Efficacy

Computer self-efficacy is the individual belief that one is capable of using a computer competently [33]. Computer self-efficacy is based on the concept of self-efficacy by Bandura [34]. The concept refers not only to the individual's abilities, but also to the individual's belief about his or her abilities. These beliefs influence how the individual engages in tasks [34]. Computer self-efficacy takes Bandura's concept and specifically applies it to the use of computers and technology. If an individual has high computer self-efficacy, he or she will be able to proficiently deal with new and difficult computer systems or software with minimal support or assistance. In contrast, if an individual has low computer self-efficacy, they maybe more easily frustrated by learning new technology [35].

In this study, computer self-efficacy is represented by the ways in which architects use BIM proficiently and their beliefs about their abilities with to use BIM. Khorrami-Arani [36] showed that computer self-efficacy corresponds with achievement of computer competency. Success in the use of BIM is related to the confidence that the user is able to use BIM in the future [37]. Therefore, computer self-efficacy will be related to architects' behavioral intentions. Based on empirical evidence from the literature, we tested the following hypotheses:

H9. Computer self-efficacy will have a positive effect on perceived ease of use.

4 Methodology

Design firms, which were either working to introduce or were using BIM tools, were selected to participate in the survey. This included the professionals at three major design firms in South Korea. These three design firms have used a BIM, or BIM tool. According to the Building SMART Korea report [38] these three firms were among the top five in terms of the number times their cumulative BIM applied in practice applications from 2009 to 2012. Also, in 2013, these three firms were listed among the top 100 design firms by the United Kingdom magazine, Building Design [39].

The demographic information of the people who answered the survey is as follows. Senior support workers, accounted for more than 80% of total participants. Average tenure was 6.5 years. Commercial BIM tools were introduced in 2003, and the first wave of adoption in AEC occurred during the mid- to late 2000s [23]. This is consistent with participants' tenure and the length of time they used the BIM in practice. Therefore, the participants are fully capable of responding to the effects of any factors the introduction of the BIM will have on the design professional's behavioral intention. The participants in the survey had experience using BIM tools. The most common of these BIM tools were: Autodesk AutoCAD (of those who answered, 93.83% use it), Autodesk Revit (for 72.22% of those who answered use it), and Graphisoft ArchiCAD (17.28% of those who answered use it). As found in the survey, those participants who are capable of using the most common BIM tools are those that can be targeted.

The research model contains eight constructs to ascertain the participants' perception. The measurement items included 22 questionnaires developed based on previous research. Each questionnaire was measured on a seven point Likert scale (1 being "strongly disagree" and 7 being "strongly agree").

5 Results and Analysis

Before the test of hypotheses process which is used Structural Equation Modeling (SEM) for the data analysis, the measurement model was assessed by a Confirmatory Factor Analysis that took into account reliability, convergent validity, and discriminant validity. The statistical analysis software used was AMOS 18.0.

5.1 Reliability of Results

The reliability indicates good internal consistency and reliability of items which compose constructs. Considering the reliability, it is important for measured whether set of items are useful or not [40]. Cronbach's alpha coefficient is widely used to assess the reliability. According to Nunnally and Bernstein [41], the coefficient above 0.7 is considered acceptable. When the Cronbach's alpha coefficient of the construct are close to 1, then the construct is internally consistent and reliable [42]. The Cronbach's alpha coefficients ranged from 0.768 to 0.946 and exceeded 0.7 (the recommended minimum value), so constructs are acceptable.

5.2 Convergent Validity

Through the convergent validity, it can be known whether or not the construct utilities are properly configured. Three measures were assessed to test convergent validity. Factor loading refers to how the items affect each construct that is represented. Hair et al. [43] recommended a factor loading value of more than 0.5. Composite reliability determines each constructs' reliability [44] and should be at least 0.6 [45]. Average variance extracted measures the variance between constructs [46]. Fornell and Larcker [45] recommended 0.5 as the minimum acceptable value. The values of each measurement of convergent validity was derived: factor loading ranged from 0.640 to 0.968, composite reliability ranged from 0.773 to 0.948, and average variance extracted ranged from 0.532 to 0.858—all of these values satisfied the standards. Therefore, all showed good convergent validity.

5.3 Discriminant Validity

In order to find out whether the model consists of different constructs, the process of independent verification is applied. The independence of the construct can be proven when the self-correlation of the construct is higher than the correlation of other constructs. To achieve discriminant validity, it is necessary to compare the root square of the average variance extracted (AVE) value [47]. In Table 1, the square root of the average variance extracted and diagonal value is larger than the other values in the same row and column. Therefore, each construct's discriminant validity is significant.

Table 1. Correlation matrix and discriminant assessment

	BI	PU	PEU	TMS	SN	CP	TS	CSE
BI	0.91							
PU	0.56	0.87						
PEU	0.53	0.51	0.73					
TMS	0.14	0.29	0.15	0.78				
SN	0.58	0.51	0.40	0.37	0.92			
CP	0.69	0.67	0.64	0.06	0.46	0.93		
TS	0.03	-0.04	0.06	0.35	0.05	-0.08	0.77	
CSE	0.47	0.31	0.69	0.02	0.26	0.53	0.06	0.82

5.4 Model Fit

The degree of consensus between the model and data is assessed by fit indices [48]. As seen in Table 2, we used five different indices: the ratio of χ^2 to degrees of freedom (χ^2/d.f.), Goodness-of-Fit Index (GFI), Tucker Lewis Index (TLI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). All the model fit indices satisfied the recommended values except the GFI which is slightly less than 0.9 but very close to it.

Table 2. Evaluation of overall fitness of model

Fitness Index	Recommended Value	Value
χ^2 /d.f.	$\leq$ 3.00	2.000
GFI	$\geq$ 0.90	0.825
TLI	$\geq$ 0.90	0.904
CFI	$\geq$ 0.90	0.921
RMSEA	$\leq$ 0.08	0.079

5.5 Tests of Hypotheses

In order to verify the statistical significance and the validity of path, this research conducted testing of the 9 hypotheses. As seen in Table 3, the relationship, the standardized path coefficient, the critical ratio (*t*-value) and the test result of each hypothesis are demonstrated. At this point, the standardized path coefficients (β) point to the statistical significance and the degree of the relationship between each construct. Also, depending on the value of p, the hypothesis is either supported or not supported in this test result. Most of the hypotheses were strongly supported, excluding hypotheses H3 and H8, as shown in Table 3.

Table 3. Hypothesis testing

Hypothesized Paths	β-value	t-value	Result
H1	0.33	3.33***	Supported
H2	0.49	3.87***	Supported
H3	-0.05	-0.36	Not Supported
H4	0.18	2.41*	Supported
H5	0.20	2.40*	Supported
H6	0.61	5.09***	Supported
H7	0.53	5.73**	Supported
H8	0.08	1.20	Not Supported
H9	0.44	3.92***	Supported

Note: *Significant at $p<0.05$, **Significant at $p<0.01$, ***Significant at $p<0.001$

6 Conclusions

The extended TAM presented provides insights and better understanding regarding the factors leading to the successful adoption of BIM in the design organization in South Korea. It entailed the incorporation of several constructs, such as computer self-efficacy from the individual domain, top management support and technical support from the organizational domain, subjective norm from the social domain, and compatibility from the technical domain. Thus, an important contribution of the paper is the identification of the critical factors pertaining to the full realization of the benefits of BIM adoption in the design organization.

Organization leaders should consider architects' behavioral intention which, in turn, would support the beneficial BIM adoption. If a design organization wants to improve business performance and to increase behavioral intention, it must improve its top management support, subjective norm, compatibility, and computer self-efficacy to make it conducive for BIM adoption. The following limitations of this study will guide future work. First, the validation of results requires a larger sample of individuals. Second, the study is cross country; a longitudinal study would be advisable in order that the different countries' adoption of BIM be compared.

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References

[1] Lee G., Sacks, R., and Eastman, C.M. Specifying parametric building object behavior (BOB) for a building information modeling system. *Automation in Construction*, 15(6):758–776, 2006.

[2] McGraw Hill Construction. Business value of BIM in North America multi-year trend analysis and user ratings (2007–2012). On-line: http://analyticsstore.construction.com/index.php/2012-business-value-of-bim-in-north-america-smartmarket-report.html, Accessed: 02/15/2014.

[3] McGrawHill Construction. The business value of BIM: getting building information modeling to the bottom. On-line: http://fiatech.org/images/stories/research/2009_BIM_SmartMarket_Report.pdf, Accessed: 02/15/2014.

[4] Deutsch R. *BIM and integrated design: Strategies for architectural practice*, John Wiley & Sons, Hoboken, NJ, 2011.

[5] Gu N. and London K. Understanding and facilitating BIM adoption in the AEC industry. *Automation in Construction*, 19(8):988–999, 2010.

[6] Davis F.D. A technology acceptance model for empirically testing new end-user information systems: Theory and results, Doctoral dissertation, Massachusetts Institute of Technology, Cambridge, MA, 1986.

[7] Moon J.-W. and Kim Y-G. Extending the TAM for a World-Wide-Web context. *Information & Management*, 38(4):217–230, 2001.

[8] Lin H.-F. Predicting consumer intentions to shop online: An empirical test of competing theories. *Electronic Commerce Research and Applications*, 6(4):433–442, 2007.

[9] King J.L., Gurbaxani V., Kraemer K.L., McFarlan F.W., Raman K.S., and Yap C.S. Institutional factors in information technology innovation. *Information Systems Research*, 5(2):139–169, 1994.

[10] Linderoth H.C.J. Understanding adoption and use of BIM as the creation of actor networks. *Automation in Construction*, 19(1):66–72, 2010.

[11] Amoako-Gyampah K. and Salam A.F. An extension of the technology acceptance model in an ERP implementation environment. *Information & Management*, 41(6):731–745, 2004.

[12] Wu J.-H. and Wang S.-C. What drives mobile commerce? An empirical evaluation of the revised technology acceptance model. *Information & Management*, 42(5):719–729, 2005.

[13] Goedert J. and Meadati P. Integrating construction process documentation into building information modeling. *Journal of Construction Engineering and Management*, 134(7):509–516, 2008.

[14] Burton-Jones A. and Hubona G.S. The mediation of external variables in the technology acceptance model. *Information & Management*, 43(6):706–717, 2006.

[15] Ragu-Nathan B.S., Apigian C.H., Ragu-Nathan T.S., and Tu Q. A path analytic study of the effect of top management support for information systems performance. *Omega*, 32(6):459–471, 2004.

[16] Chung B., Skibniewski M., Lucas H., and Kwak Y. Analyzing enterprise resource planning system implementation success factors in the Engineering–Construction Industry. *Journal of Computing in Civil Engineering*, 22(6):373–382, 2008.

[17] Yoon Y., Guimaraes T. O'Neal Q. Exploring the factors associated with expert systems success. *MIS Quarterly*, 19(1): 83–106,1995.

[18] Sultan F. and Chan L. The adoption of new technology: The case of object-oriented computing in software companies. *IEEE Transactions on Engineering Management*, 47(1):106–126, 2000.

[19] Veiga J.F., Floyd S. and Dechant K. Towards modelling the effects of national culture on IT implementation and acceptance. *Journal of Information Technology*, 16(3):145–158, 2001.

[20] Fishbein M. and Ajzen I. *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*, Addison-Wesley, Boston, MA, 1975.

[21] Sherrie Y.X.K. and Izak B. The effects of personalization and familiarity on trust and adoption of recommendation. *MIS Quarterly*, 30(4):941–960, 2006.

[22] Tan M. and Teo T.S.H. Factors influencing the adoption of Internet banking. *Journal of the AIS*, 1(1):1–43, 2000.

[23] Won J.L., Dossick C., and Messner J. Where to focus for successful adoption of building information modeling within organization. *Journal of Construction Engineering and Management*, 139(11), 2013.

[24] Wu J.-H., Wang S.-C., and Lin L.-M. Mobile computing acceptance factors in the healthcare industry: A structural equation model. *International Journal of Medical Informatics*, 76(1):66–77, 2007.

[25] Rogers E.M. *The diffusion of innovation*, Simon & Schuster, New York, NY, 1983.

[26] Hu P.J.-H., Clark T.H.K., and Ma W.W. Examining technology acceptance by school teachers: a longitudinal study. *Information & Management*, 41(2):227–241, 2003.

[27] InfoComm International. Building Information Mo-deling. On-line: http://www.infocomm.org/cps/rde/xbcr/infocomm/BIM_Brochure.pdf, Accessed: 02/15/2014.

[28] Howes C.J. Construction management versus construction project management. Graduate dissertation, University of Pretoria, Gauteng, South Africa, 2009.

[29] Ralph W. *Help! The art of computer technical support*, Peachpit Press, San Francisco, CA, 1991.

[30] Ngai E.W.T., Poon J.K.L., and Chan Y.H.C. Empirical examination of the adoption of WebCT using TAM. *Computers & Education*, 48(2):250–267, 2007.

[31] Staples D.S and Seddon P. Testing the technology-to-performance chain model. *Journal of Organizational and End User Computing*, 16(4):17–36, 2004.

[32] Sun Y. and Bhattacherjee A. Multi-level analysis in information systems research: the case of enterprise resource planning system usage in China. *Enterprise Information Systems*, 5(4):469–494, 2011.

[33] Compeau D.R. and Higgins C.A. Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly*, 19(2):189–211, 1995.

[34] Bandura A. Self-efficacy mechanism in human agency. *American Psychologist*, 37(2):112–147, 1986.

[35] Wangpipatwong S., Chutimaskul W., and Papasratorn B. Understanding citizen's continuance intention to use e-government website: A composite view of technology acceptance model and computer self-efficacy. *The Electronic Journal of e-Government*, 6(1):55–64, 2008.

[36] Khorrami-Arani O. Researching computer self-efficacy. *International Education Journal*, 2(4):17–25, 2001.

[37] Pika E., Sacks R., and Hazzan O. Building Information Modeling education for construction engineering and management. II: Procedures and implementation case study. Journal of Construction Engineering and Management, 139(11):85–92, 2014.

[38] Building SMART Korea report. On-line: http://www.buildingsmart.or.kr/.

[39] Winston A. WA100 Top 100 architects 2013, Design Build. On-line: http://www.bdonline.co.uk/.

[40] Anderson J.C. and Girbing D.W. Some methods for respecifying measurement models to obtain unidimensional construct. *Journal of Marketing Research*, 19(4):453–460, 1982.

[41] Nunnally J.C. and Bernstein I.H. *Psychometric theory*. McGraw Hill, New York, NY, 1994.

[42] Nisbet S.L. Modelling consumer intention to use gambling technologies: An innovative approach. *Behaviour & Information Technology*, 25(3):221–231, 2006.

[43] Hair J.F., Anderson R.L., Tatham R.L., and Black W.C. *Multivariate Data Analysis with Reading*, London, United Kingdom, 1992.

[44] Tung F.-C., Chang S.-C., and Chou C.-M. An extension of trust and TAM model with IDT in the adoption of the electronic logistics information system in HIS in the medical industry. *International Journal of Medical Informatics*, 77(5):324–335, 2008.

[45] Fornell C. and Larcker D.F. Evaluating structural equation models with unobervables and measurement error. *J. Mark.Res.* 18:39–50., 1981.

[46] Wu J.-H., Shen W.-S., Lin L.-M., Greenes R.A., and Bates D.W. Testing the technology acceptance model for evaluating healthcare professionals' intention to use an adverse event reporting system, *Journal for Quality in Health Care*, 20(2):123–129, 2008.

[47] Van Raaij E.M. and Schepers J.J.L. The acceptance and use of a virtual learning environment in China. *Computers & Education*, 50(3):838–852, 2008.

[48] Doll W.J., Hendrickson A., and Deng X. Using Davis's perceived usefulness and ease-of-use instruments for decision making: A confirmatory and multigroup invariance analysis. *Decision Science*, 29(4):839–869, 1998.