Case Study

Comparative Study of BIM Acceptance between Korea and the United States

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Abstract: Substantial research has been performed on data standards and exchanges in the AEC/FM (Architecture, Engineering, Construction and Facilities Management) industry over the past several years. The growing popularity of Building Information Modeling (BIM) technology is based heavily on the perception that it can facilitate the sharing and reuse of information during a project's lifecycle. Although many researchers and practitioners are in agreement about the potential applicability and benefit of BIM in construction, it is still unclear why BIM is adopted, and what factors enhance the implementation of BIM. Thus, BIM acceptance and use remains a central concern of BIM research and practice. BIM was accepted in the United States earlier than in Korea, and BIM users are expected to have a higher maturity and positive perception about utilizing BIM depending on a lengthier utilization period. This means that the mechanism for achieving acceptance of BIM in Korea differs from the mechanism in the United States. Therefore, Korea's BIM acceptance model was compared to that in the United States using structural equation modeling. The key components, including the BIM acceptance model, were identified through a literature review of the Technology Acceptance Model (TAM) and related theories and was consolidated by interviews and pilot studies with professionals in the construction industry. Based on these components, a questionnaire was designed and sent out to workers in construction organizations (such as contractors, architects, construction managers, engineers, and facility managers) in Korea and the United States. A total 164 completed questionnaires were retrieved. Structural equation modeling for hypothesis testing was conducted using commercially-available software. The results from this study can serve as a foundation for research looking into the organizational context to further BIM acceptance in the construction industry. The comparison of the mechanism and subsequent results will serve as a guideline for developing an acceptance strategy that is suitable for Korea. **DOI: 10.1061/(ASCE)CO.1943-7862.0001076.** *© 2015 American Society of Civil Engineers.*

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Introduction

According to a 2004 NIST (National Institute of Standards and Technology) report NIST (2004), the capital facilities construction industry wastes $15.8 billion annually due to interoperability inefficiencies. These inefficiencies include the re-entry and recreation of information and data, and a duplication of business functions (Newton 2004). Using Building Information Modeling (BIM), these inefficiencies can be resolved (Mendez 2006). BIM is "a new approach to design, construction, and facilities management, in which a digital representation of the building process [is used] to facilitate the exchange and interoperability of information in digital format" (Eastman et al. 2008). In the construction industry, there is growing interest in the use of BIM for coordinated, consistent, and computable building information/knowledge management from design to construction to maintenance and for the operation stages of a building's lifecycle. Accordingly, many researchers and practitioners are in agreement about BIM's potential applicability and benefits in construction.

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In Korea, the Public Procurement Service has published basic *BIM application guideline* for facility projects PPS (2010), which provide standards for BIM-related work regarding the use of BIM data in the construction and maintenance stages. In 2012, BIM application was imposed on over 50 billion won which is cost of public construction projects, and the same is planned for all public construction projects by 2016. Following this trend, the implementation of BIM in Korea is currently at 58%, which means approximately 6 out of 10 workers in the Korean construction industry are using BIM. Despite higher level of BIM acceptance in Korea, the competency of BIM users in the country, excluding engineers, is lower than in Europe and the United States. Furthermore, the number of non-BIM users (10%) who had used BIM but stopped was higher than in Europe (4%) and the United States (2%) (SmartMarket Report 2012). The SmartMarket Report (2013) also ranked BIM satisfaction by country as the following; Japan, German, France (97%), Canada (87%), Brazil (85%), Australia and New Zealand (78%), the United States (74%), and England (59%). In comparison, BIM satisfaction in Korea is 48%. As such, regardless of the advantages of using BIM and the government's BIM usage expansion policy, the expansion of BIM acceptance is very slow. Continuous BIM use and diffusion still remains a central concern of BIM research and practice.

Currently, Korea's construction organizations have benchmarked the United States as best practice, and since 2007 the United States has mandated the use of BIM for public construction projects. However, because there is a clear difference between Korea's construction industry and the United States' construction industry, an acceptance strategy that reflects Korea's characteristics would be more effective than that which was applied in the United States.

To develop an acceptance strategy that is suitable for the Korean construction industry, the acceptance mechanisms in both the United States and Korea must be understood.

Therefore, the main purpose of this research is to verify whether or not the adoption level and BIM performance of Korea and the United States differ and compare Korea's BIM acceptance model with that of the United States. BIM acceptance model.

This research is structured as follows. First, each measured item of the BIM acceptance model is proposed along with a comprehensive set of hypotheses (Lee et al. 2015). Second, based on the constructs, a questionnaire was designed and sent out to professionals in construction organizations (such as contractors, architects, construction managers, engineers, and facility managers) in Korea and the United States. A total of 164 completed questionnaires were retrieved. Third, differences in adoption level, performance, and user satisfaction between Korea and the United States were verified using an independent sample *t*-test. The hypotheses of the BIM acceptance models for both Korea and the United States were then tested using structural equation modeling. Finally, implications and directions for future research were discussed by comparing the mechanism of BIM acceptance between Korea and the United States.

These results can serve as a foundation for research into understanding the organizational context for further BIM acceptance in the construction industry. The comparison results of the mechanism will serve as a guideline for developing an acceptance strategy that is suitable for Korea.

Acceptance Behavior Related Theories

Introduced by Davis (1989), the Technology Acceptance Model (TAM) is an adaptation of the theory of reasoned action (Ajzen and Fishbein 1980) and the theory of planned behavior (Ajzen 1991) specifically tailored for modeling user acceptance of information systems. The goal of TAM is to provide an explanation of the determinants of computer acceptance that is capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified. In this model, perceived usefulness and perceived ease of use are of primary relevance for information system (IS) acceptance behavior. TAM proposes that external variables indirectly affect attitudes toward use, which ultimately leads to actual system use by influencing perceived usefulness and perceived ease of use.

TAM assumes that an individual's behavioral intention to use a system is determined by two beliefs: perceived usefulness, defined as the extent to which a person believes that using the system will enhance job performance, and perceived ease of use, defined as the extent to which a person believes that using the system will be free of effort. TAM assumes that the effects of external variables (e.g., system characteristics, development process, and training) on intention to use are mediated by perceived usefulness and perceived ease of use.

Barki and Hartwick (2001) found that subjective norms have a significant impact on intention in mandatory system use, but not in voluntary settings. Thus, the updated TAM, also called TAM2, extended the original TAM by including subjective norms as an additional predictor of intention in the case of mandatory system use (Venkatesh and Davis 2000). Further research on TAM led to the development of TAM3 (Venkatesh and Bela 2008).

The existing TAM, which was examined as a representative theory related to the selection and use of services based on new information systems and information technologies, is being studied by applying technologies mainly used in individual work, such as e-mail, databases, software, websites, wireless Internet technologies, and e-commerce. Therefore, the selection of technologies by users is possible, and the increased selection of technologies depends on the usefulness of, or on the convenience of using, the applied technologies. Thus, there is a high probability that the properties of technologies are important factors in their degree of use.

In the current BIM situation, the context of organizational properties is likely an important influencing factor that goes along with the technological properties. The literal meaning of the acceptance of a passive situation is identical to the meaning of the word acceptance with respect to TAM, but in truth, it has different meanings. In terms of BIM characteristics, BIM users do not only use BIM tools for their own work, but also share information thru BIM with members of the organization. Therefore, this study proposes a BIM Acceptance Model based on these theories in previous research (Fig. 1).

Unlike the existing TAM, which focuses on individual technology acceptance, this research identifies the importance of organizational BIM acceptance and factors affecting BIM acceptance from an individual and organizational perspective, and analyzes relationships between the factors. However, to develop a BIM acceptance strategy that is suitable for each individual or organization, it is necessary to validate differences in the mechanism of BIM acceptance among organizations.

BIM Acceptance Model in Construction

This study's objective is to understand the differences in the mechanism of BIM acceptance between Korea and the United States as an early adopter, based on empirically tested and proven research models. Thus, a BIM acceptance model defined by previous research (Lee et al. 2015) is used. This model provides a rationale for variables based on the theoretical background of TAM, and the motivation model incorporates additional variables based on the literature regarding BIM use. Definitions of the constructs for a BIM acceptance model are shown in Table 1.

External variables of the BIM acceptance model were composed of four factor groups (organizational competency, personal competency, technology quality, and behavior control). The validation results for the external variables were as follows. First, a total of 28 key factors of BIM acceptance were initially selected from the previously-mentioned TAM and other various researches. Then a questionnaire was developed to collect opinions from experienced users regarding BIM acceptance. The content validity of the 25 items on the questionnaire was tested through face-to-face interviews with three experts who have more than 5 years of experience each and know how BIM can be used for their tasks. The experts were also asked to review the questionnaire for redundancy and accuracy. The next step involved testing of construct validity using

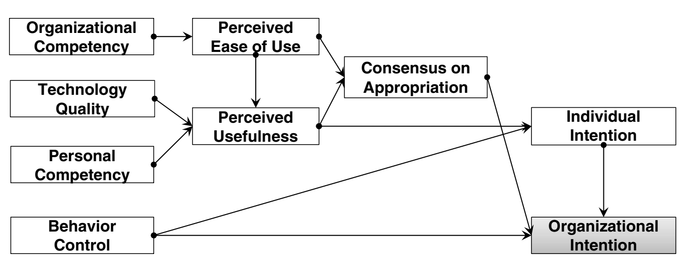

Fig. 1. BIM acceptance model (reprinted from Lee et al. 2015, © ASCE)

Table 1. Constructs of BIM Acceptance Model (Adapted from Lee et al. 2015, © ASCE)

Construct	Description
Organizational competency	Organizational competency are belief that BIM is used for cooperative work, an organization's willingness to try out any new information technology, and organized supports such as resource, education, and incentives for BIM utilization
Personal competency	Personal competency are belief that BIM is used for individual's task, and an individual's willingness to try out any new information technology
Technology quality	Technology quality are the degree to which the technology fits the potential adopter's previous experience, work practice, system use and needs, has been identified as an essential factor for innovation adoption, and the useful degree of output required by using BIM
Behavior control	Behavior control are the impact of superiors and colleagues within the organization and involves the influences arising from several sources within the competitive environment surrounding the organization
Perceived ease of use	The organization's or individual's recognition that BIM utilization is not difficult
Perceived usefulness	The organization's or individual's recognition that BIM utilization improves working ability and productivity
Consensus on appropriation	The extent to which individuals agree on how to jointly use BIM utilization
Individual intention of BIM acceptance	Individual intention to accept BIM are willingness to utilize BIM tools and information to fulfill his tasks, willingness to spend time to utilize BIM, and willingness to recommend BIM to co-workers or other entities in a cooperative relationship
Organizational intention of BIM acceptance	Organizational intention to accept BIM are willingness to encourage the use of BIM among group constituents, willingness to recommend the use of BIM to other organizations in cooperative relationships, and willingness to develop BIM application technology

Table 2. Measurement Items of Key Factors for BIM Acceptance

Variable	Assessment items
Organizational competency	
Collective efficacy	My organization doesn't have any resistance to using BIM
	My organization is familiar to BIM tools
	My organization understands the benefits of using BIM
Organizational innovativeness	My organization doesn't have psychological resistance to using new IT
	My organization has technical capability of using new information technology
	My organization is aggressive pushing to use new information technology
Top management support	My organization supports enough resources (hardware and software) for BIM utilization
	My organization provides proper education/training for BIM utilization
Personal competency	
Self-efficacy	I don't have any resistance to using BIM
	I am familiar with BIM tools
	I understand the benefits of using BIM
Personal innovativeness	I don't have psychological resistance to using a new information technology
	I have technical capability of using a new information technology.
	I am aggressive about using a new information technology.
Technology quality	
Compatibility	BIM tools that I use are easy for data input and output
	Screen interface of BIM tools that I use are easily built so that everyone can use easily
	BIM tools that I use are stable when using
Output quality	BIM utilization improves information accessibility
	Information acquired by using BIM is accurate and detailed
	Enough information can be gathered using BIM
	Information acquired by using BIM can be used throughout the course of the project
Behavior control	
Internal pressure	My organization forces us to use BIM by setting up policies and regulations
	I am required to use BIM by superiors and colleagues
External pressure	We are required to adopt BIM by project delivery or contract method
	We are required to adopt BIM by cooperative companies and cooperative relations

exploratory factor analysis (EFA). The criteria used in the EFA were "eigenvalues greater than 1" and "factor loadings greater than 0.5" (Aksorn and Hadikusumo 2008; Li et al. 2005; Norusis 1992). This research used principal component analysis with varimax rotation as the method for data analysis. The factor analysis identified four factor groups: organizational competency (eight items), personal competency (six items), technology quality (seven items), and behavior control (four items). Finally, the reliability of the factors was tested using Cronbach's coefficient alpha value. Cronbach's α value was considered acceptable at 0.6 (Nunnalyy 1978). The test results showed that Cronbach's α ranged from 0.798 to 0.948, thus confirming that the measures used in the assessment were statistically reliable. The assessment items for external variables are shown in Table 2.

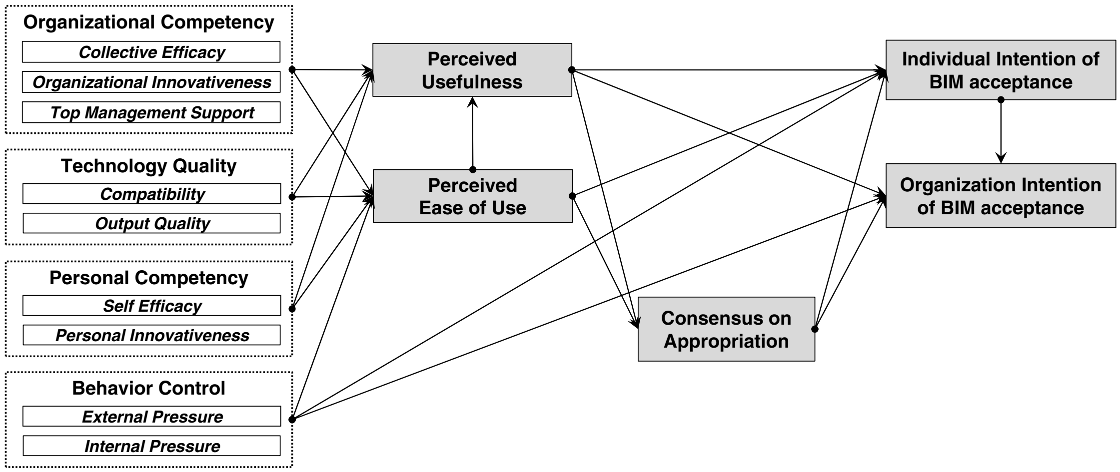

Fig. 2. Research model

The BIM acceptance model included 46 observed indicators describing 9 latent constructs. To validate this measurement model, model-fit indices and convergent and discriminant validity were confirmed. First, the model-fit indices of the proposed model and acceptance level were compared. More than half the model-fit indices met the acceptance level. Root Mean Square Residual (RMR), Turker-Lewis Index (TLI), and Comparative Fit Index (CFI) indices were employed to evaluate fit of the research model, and all were close to the acceptance level. Thus, the measurement model exhibited a fairly good fit with the data collected. Second, convergent validity can also be evaluated by examining the factor loading, the composite reliability of measures, and the average variance extracted (AVE) by measures from the results of confirmatory factor analysis (CFA). Following the recommendation by Hair et al. (1998), factor loading was greater than 0.5 and considered to be very significant. The composite reliability for all factors in the measurement model was above 0.6 (Fornell and Larcker 1981) and the AVEs were all above the recommended 0.5 (Hair et al. 1998). In this research, the factor loading of all factors was higher than 0.5. The composite reliability was also higher than 0.7. The AVE of organizational competency, technology quality, behavior control, and perceived ease of use was lower than 0.5 and was close to the recommended level. Discriminant validity was examined by comparing the shared variances between factors with the average variance extracted from the individual factors (Barclay et al. 1995). The AVEs should be greater than the square of the correlations among the constructs (Barclay et al. 1995). In this research, the discriminant validity test between organizational competency and consensus on appropriation and that between the organizational competency and organizational intention of BIM acceptance was not satisfied. However, the result of the EFA was significant, and organizational competency consists of detailed items verified by professionals. Thus, organizational competency was not deleted. Therefore, research model of this research is shown in Fig. 2.

Comparisons of BIM Acceptance between Korea and the United States

Data Collection

This case study aims to propose a BIM acceptance model that is widely used in the Korea construction industry. The data used to test the research model was obtained from a sample of experienced BIM users. The questionnaire was sent by e-mail to the project directors of each organization. The survey was conducted between April 11, 2012, and June 12, 2012, and a total of 164 responses were received, all of which were valid and used for the analysis. Each item was measured on a 7-point Likert scale ranging from "strongly disagree" to "strongly agree". The descriptive statistics relating to the respondents' characteristics are shown in Table 3.

Analysis

An independent-samples t-test was used to validate that the differences in adoption level, as well as in individual and organizational performance between Korea and the United States were significant. The hypotheses were as follows:

- Adoption level in the United States is higher than in Korea;
- Individual performance in the United States is higher than in Korea; and
- Organizational performance in the United States is higher than in Korea.

Five stages in the decision innovation process (knowledge, persuasion, decision, implementation, and confirmation) (Rogers 1983) were used as measurement items for adoption level. Definitions of the five stages in the decision innovation process are shown in Table 4.

Individual performance and organizational performance were defined as BIM performance, and validated construct validity using the exploratory factor analysis (EFA) and reliability using Cronbach's α. First, construct validity was tested using EFA, which is generally used to identify a relatively small number of factor groups that can be used to represent relationships among sets

Table 3. Characteristics of the Respondents ($N = 164$)

Measure	Frequency	%
Respondent's country		
Korea	114	69.5
United States	50	30.5
Sector of the respondent' organization		
Designer	51	31.1
Contractor	40	24.4
Engineer	33	20.1
CM	36	22.0
Facility manager	4	2.4
Total	164	100

Table 4. Definition for Five Stages of the Adoption Process (Adapted from Rogers 1983)

Stage	Definition
Knowledge	The individual is first exposed to an innovation, but lacks information about the innovation. During this stage the individual has not yet been inspired to find out more information about the innovation
Persuasion	The individual is interested in the innovation and actively seeks related information/details
Decision	The individual takes the concept of the change and weighs the advantages/disadvantages of using the innovation and decides whether to adopt or reject the innovation. Due to the individualistic nature of this stage, Rogers notes that it is the most difficult stage on which to acquire empirical evidence
Implementation	The individual employs the innovation to a varying degree depending on the situation. During this stage, the individual also determines the usefulness of the innovation and may search for further information about it
Confirmation	The individual finalizes his/her decision to continue using the innovation. This stage is both intrapersonal (may cause cognitive dissonance) and interpersonal, conformation the group has made the right decision

of many inter-related variables. The criteria used in the EFA were "eigenvalues greater than 1" and "factor loadings greater than 0.5" (Aksorn and Hadikusumo 2008; Li et al. 2005; Norusis 1992). This research used principal component analysis with varimax rotation as the method for data analysis. The factor analysis identified single-factor groups. Second, the reliability of the factors was tested using a Cronbach's coefficient alpha value. A Cronbach's α value that was considered acceptable was 0.6 (Nunnalyy 1978). The test results showed that Cronbach's α ranged from 0.958, thus confirming that the measures used in the assessment were statistically reliable. The validated assessment items of individual performance and organizational performance are as described in Table 5.

The independent-samples t-test statistical analysis tests the assumption of homogeneity of variance, where the null hypothesis assumes no difference between the two groups' variances. Levene's F Test for equality of variances is the most commonly-used statistic to test the assumption of homogeneity of variance. The F value for Levene's test was 3.020 with a Sig. (p) value of 0.084. Because the Sig. value was more than 0.05, the null hypothesis for the assumption of homogeneity of variance is accepted. That is, the assumption of homogeneity of variance is met. Therefore, the data results associated with the assumption of equal variances should be used and the data interpreted accordingly. That is, the top line of information for the t-test should be used.

Table 5. Measurement Items for Individual Performance and Organizational Performance

BIM performance	Measurement items
Individual performance	Processing speed is improved by using BIM (reduction of repetitive activity) Processing accuracy is improved by using BIM (reduction of error) Communication among stakeholders is improved by using BIM Information is systemically managed by using BIM
Organizational performance	Time management is effectively conducted by using BIM Cost management is effectively conducted by using BIM Quality management is effectively conducted by using BIM Safety management is effectively conducted by using BIM Environmental management is effectively conducted by using BIM

In testing the difference between Korea and the United States on adoption level, individual performance and organizational performance, since the t value resulted in a Sig. (p) value that was less than this study's alpha of 0.05 ($p < 0.05$, which puts the obtained t in the tail); therefore the null hypothesis is rejected in support of the alternative hypothesis, and it can be concluded that Korea and the United States differed significantly on adoption level, individual performance, and organizational performance (Table 6).

A meaningful difference was shown in all hypotheses; BIM users showed a higher adoption level, individual and organizational performance, and user satisfaction in the United States than in Korea. These findings confirmed that the perception of BIM utilization by users in the United States differs from the perception of BIM utilization by users in Korea based on the results of the t-test. Consequently, the mechanism for achieving BIM acceptance in Korea will differ from the mechanism in the United States.

Before comparing the mechanism between Korea and the United States, mechanisms for achieving acceptance of BIM in both countries were proposed by defining factors affecting BIM acceptance and the measurement items of the factors and analyzing the relationship among the factors. *AMOS version 20* software was used to employ SEM for hypothesis testing. Figs. 3 and 4 show the standardized path coefficients, their significance for the structural model, and the squared multiple correlations (R_2) for an endogenous construct in Korea and the United States.

Discussion

Table 7 shows the standardized path coefficients, their significance for the structural model, and the squared multiple correlations (R^2) for an endogenous construct.

The commonalities between Korea and the United States were as follows. First, the mechanisms of organizational competency, technology quality, personal competency, and technology quality—which were proposed as BIM acceptance influence factors—that continue to BIM acceptance were different, but the validation and reliability of the BIM acceptance influence factors were both found in Korea and the United States, and the effect of the influence variables of the BIM acceptance model on BIM acceptance was found to be significant. Accordingly, as the effect of the BIM acceptance influence factors was found in organizations in both Korean and United States, it was deemed that a certain degree of standardization of the specific effects that influence acceptance would be possible. Second, it was found that the factors of behavior control in both Korea and the United States did not affect BIM acceptance through perceived usefulness and perceived ease of use but through a direct effect on the

Table 6. T-Test Results

Variable	Levene's test for equality of variances		t-test for equality of means					95% confidence interval of the difference	
	F	p	t	df	p	Mean difference	Standard error difference	Lower	Upper
Adoption level									
Equal variances assumed	14.894	0.000	2.426	162	0.016[a]	0.467	0.192	0.087	0.847
Equal variances not assumed	—	—	2.114	70.610	0.038[a]	0.467	0.221	0.026	0.907
Individual performance									
Equal variances assumed	12.352	0.001	6.372	162	0.000[b]	1.408	0.221	0.972	1.844
Equal variances not assumed	—	—	5.576	71.136	0.000[b]	1.40798	0.253	0.905	1.911
Organizational performance									
Equal variances assumed	19.713	0.000	5.616	162	0.000[b]	1.200	0.214	0.778	1.622
Equal variances not assumed	—	—	4.764	67.425	0.000[b]	1.200	0.252	0.698	1.703

[a] $p < 0.05$.
[b] $p < 0.001$.

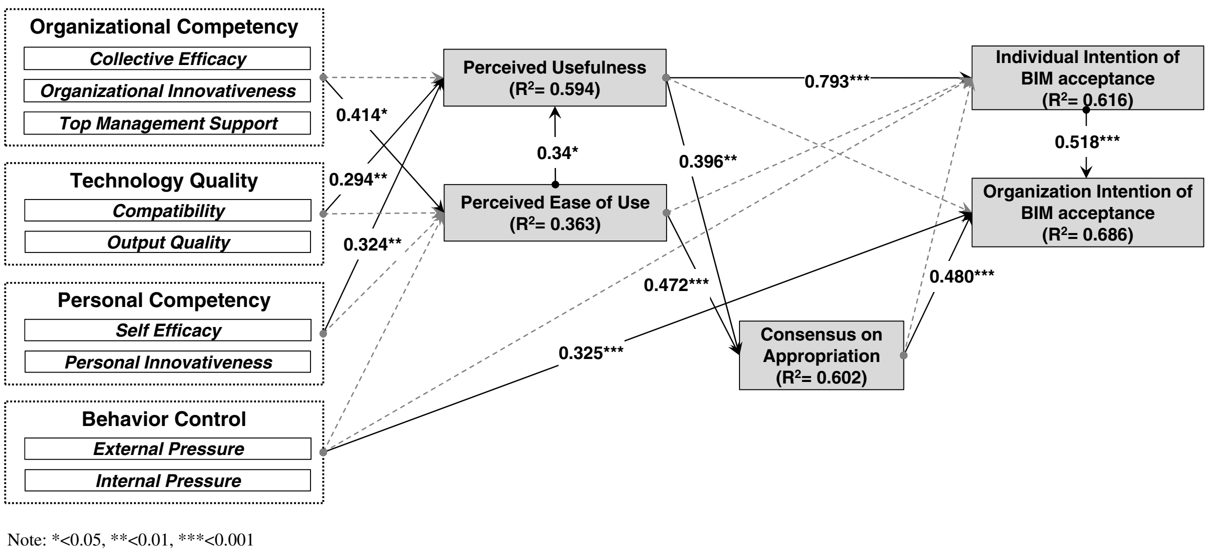

Fig. 3. Korea's BIM acceptance model

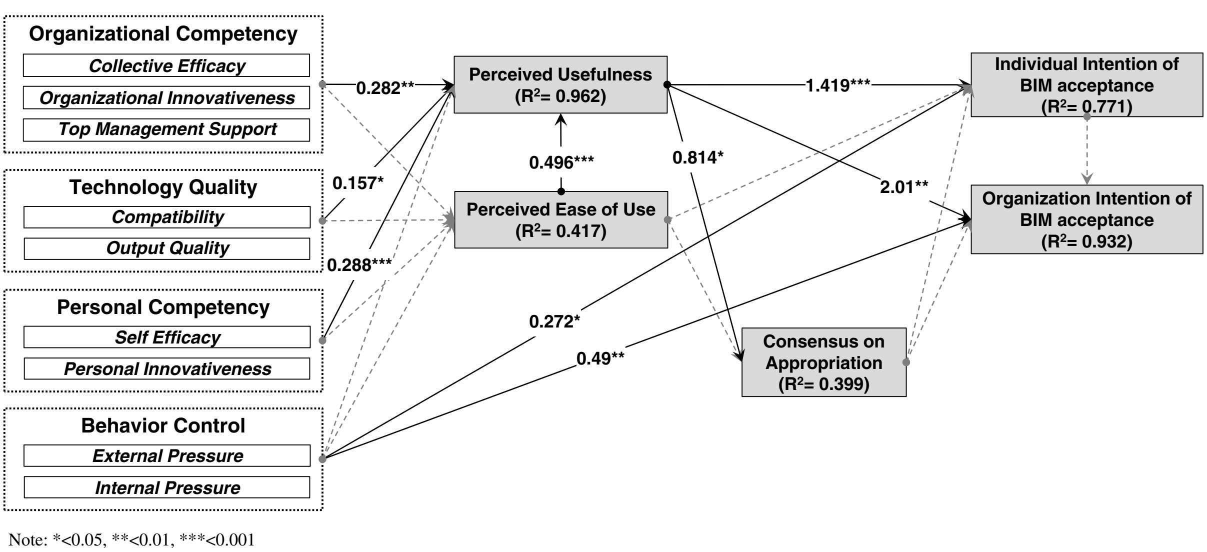

Fig. 4. United States' BIM acceptance model

Table 7. Comparison of BIM Acceptance Model between Korea and the United States

Hypothesis		Korea		United States	
Independent variable	Dependent variable	Path coefficients	R^2 (%)	Path coefficients	R^2 (%)
Organizational competency	Perceived ease of use	0.414[a]	36.3	0.288	41.7
Technology quality		0.145		0.167	
Personal competency		0.096		0.237	
Behavior control		0.115		0.146	
Organizational competency	Perceived usefulness	0.095	59.4	0.282[b]	96.2
Technology quality		0.294[b]		0.157[a]	
Personal competency		0.324[b]		0.288[c]	
Behavior control		−0.034		−0.152	
Perceived ease of use		0.342[a]		0.496[c]	
Perceived ease of use	Consensus on appropriation	0.472[c]	60.2	−0.230	39.9
Perceived usefulness		0.396[b]		0.814[a]	
Perceived ease of use	Individual intention to BIM acceptance	0.112	61.6	−0.682	77.1
Perceived usefulness		0.793[c]		1.419[c]	
Behavior control		0.059		0.272[a]	
Consensus on appropriation		−0.152		−0.142	
Perceived ease of use	Organizational intention to BIM acceptance	−0.050	68.6	−1.09	93.2
Perceived usefulness		−0.213		2.01[b]	
Behavior control		0.325[c]		0.49[b]	
Consensus on appropriation		0.480[c]		0.039	
Individual intention		0.518[c]		−0.460	

[a]<0.05.
[b]<0.01.
[c]<0.001.

organizational intention of BIM acceptance. This indicates that behavior control, such as coercion by a superior or a colleague or by the external environment, affects the acceptance of a new technology with no reference to its usefulness and ease of use in both Korea and the United States.

The significant differences between Korea and the United States were as follows. First, the "individual intention of BIM acceptance" affects the "organizational intention of BIM acceptance" in Korea, but there is no influential relationship between these two factors in the United States, since the variables of "perceived usefulness" and "behavior control" appear to simultaneously influence "individual intention of BIM acceptance" and "organizational intention of BIM acceptance." There is no difference between "individual intention of BIM acceptance" and "organizational intention of BIM acceptance." This appears to be the result of the indifference between individuals and organizations based on an individualistic culture in the United States' construction industry.

In connection to this, in order to develop suitable management strategies based on the national cultures within IBM, a multinational corporation, Hofstede (1995) first categorized cultures into five cultural properties and categorized the bases into four dimensions, then conducted a survey with 116,000 employees of IBM's branches in approximately 50 countries, assigned scores ranging from 0 to 100 to the personalities and culture of each country, and deduced the cultural types of each country. Among the five cultural properties, the properties with the biggest differences between Korea and the United States were found to be the gap in power and individualism versus collectivism. First, the gap in power (power and inequality) is a standard that indicates the degree to which the members of the organization tolerate the unequal distribution of power in their system or organization and can be referred to as the degree to which the class with weak power accepts the unequal distribution of authority. Having a low gap in power points to an inability to accept differences in authority, and thus, the organizations in countries with a low gap in power are decentralized and have a horizontal composition, whereas cultures with higher gaps in power are centralized and have organizational structures that are more hierarchal. Societies with a big power distance accept the inequality in the population as natural and have authoritative social relationships. Another divergent property between Korea and the United States was the difference in individualism versus collectivism. Individualistic societies do not sacrifice individual benefits to the advantage of the society, while collectivistic societies believe that individual benefits can always be sacrificed for the benefit of society.

Second, in Korea, "perceived usefulness" influences "organizational intention of BIM acceptance" through "consensus on appropriation" and "individual intention of BIM acceptance," whereas, in the United States, "perceived usefulness" directly influences "organizational intention of BIM acceptance" and also plays a significant role in the high explanation power of perceived usefulness influencing BIM acceptance. Due to the collectivistic culture underlying the Korea construction industry, it appears that coinciding opinions on BIM use and individual acceptance are essential for perceived usefulness to convert to the organizational intention of BIM acceptance.

Third, in the United States, "consensus on appropriation" does not affect BIM acceptance. This appears to be due to the individualistic culture underlying the United States' construction industry, as stated previously.

Conclusion

According to Korea's governmental policy to expand BIM usage, the BIM adoption rate in Korea is increasing. However the rate of discontinuance of BIM users is also high. Continuous BIM use and diffusion still remains a central concern of BIM research and practice. Meanwhile, since 2007, the United States has mandated the use of BIM for public construction projects, and the adoption level and BIM satisfaction in the United States is higher than that in Korea (SmartMarket Report 2012; SmartMarket Report 2013).

Korea's construction organizations have benchmarked the United States use of BIM as best practice; however, there is a clear difference of the construction industry between the two countries. As such, the difference between Korea's acceptance mechanism and that of the United States needs to be understood.

Therefore, this research first verified whether or not the adoption level and BIM performance of Korea and the United States differed and compared the BIM acceptance mechanism between Korea and the United States based on the BIM acceptance model, which was developed through previous research (Lee et al. 2015). The important implications for BIM acceptance are as follows.

Comparison between Korean and the United States

BIM users in the United States showed higher adoption level, BIM performance, and user satisfaction than those in Korea. Also, this study confirmed that the key factors affecting the acceptance of BIM are significant influence factors in both Korea and the United States. This means that the key factors affecting the acceptance of BIM may be generalized. It ws also confirmed that the mechanism for achieving BIM acceptance in Korea differs from the mechanism in the United States. The significant differences between Korea and the United States were found to exist in the following aspects:

- The relationship between "individual intention of BIM acceptance" and "organizational intention of BIM acceptance";
- The relationship between "perceived usefulness" and "organizational intention"; and
- The relationship between "consensus on appropriation" and "BIM acceptance."

Korea's Acceptance Mechanism

First, the results of the relationship hypothesis test on perceived usefulness, perceived ease of use, and organizational intent to accept BIM show that neither perceived usefulness nor perceived ease of use have a direct relationship with organizational intent to accept BIM; however, they do have an indirect relationship through consensus on appropriation. The level of consent among organizational members has the largest impact on BIM acceptance from an organizational perspective. This means that organizational intent to accept BIM can be increased not only by individuals recognizing the usefulness of BIM in their tasks and cooperative work, but also by recognizing a certain level of consent among organizational members. To increase consensus on appropriation, an organization should meet regularly to dialogue and exchanges opinions about the proper work method for BIM. Second, unlike the United States, Korea must establish organizational support, user competency, technology quality, and behavior pressure as external variables for balanced overall BIM acceptance. The results of the hypothesis test on the relationship of external variables, perceived usefulness, and perceived ease of use that impact BIM acceptance show that organizational competency has the most significant and largest impact on perceived ease of use. In comparison, personal competency (especially technology quality) has a significant impact on perceived usefulness. This indicates that perceived ease of use of BIM when performing individual tasks or cooperative work is higher when the organization is more flexible and active in accepting new technology. This also indicates that to increase the perceived usefulness of BIM, the agent using BIM must be active and have no difficulty in accepting new technology; moreover, the quality of the outcome after using BIM must be high.

To improve BIM acceptance for Korea, an organization should make efforts not only to provide positive recognition for BIM application such as by providing best-practice techniques in using BIM but also by fundamentally changing a top-down organization's attitude to new technologies and increase belief in successful accomplishment of BIM use. Further, the BIM department must formulate policies to provide resources, education, and incentives for proper BIM use, and organize a group of employees who are open to applying new information technologies. However, behavior control, which indicates external and internal pressure on BIM utilization, has no impact internal factors, but does impact on external factors (such as individual and organizational intent to accept BIM). It has a significant relationship with the intent to accept BIM, especially with organizational intent. This indicates that in conditions where BIM use is unavoidable, such as in a demand from the ordering body, the organizational intent to accept BIM increases without regard to the usefulness of BIM, consensus among members, or individual intent to accept BIM.

Particularly, these differences were found to come from cultural differences between the construction industry in Korea and that in the United States (Hofstede 1995). These results provided a better understanding of the organizational context necessary to accept BIM in the construction industry and the possibility of further research regarding how social, cultural, or organizational differences caused differences in BIM acceptance. Existing literature has been lacking in looking at this issue. It is quite likely that merely adopting the prerequisites of accepting information technologies in a state that does not consider the aspect of organizational context may result in a lack of full BIM acceptance in a construction organization. This research was conducted in recognition of the need for an approach that emphasizes the interaction between the user and BIM in connection with the organizational context to further BIM acceptance in the construction industry of Korea. A comparison of results of varying mechanisms will serve as a guideline to develop an acceptance strategy that is suitable for Korea.

Thus, further research should concretely analyze the effect of organizational culture on BIM acceptance. This study's findings also provide some insight into related research since the investigation of BIM acceptance models is relatively new. One limitation, however, is that this investigation is based on a particular country. Thus, the interpretation of the results should be confined to Korea or to countries with similar settings.

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