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Effects of Intrinsic and Extrinsic Motivation Factors on BIM Acceptance

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Abstract

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 adoption and implementation of BIM. As such, the mechanism of BIM acceptance and use remains in question. Therefore, this paper aims to identify the key factors affecting the acceptance of BIM in construction organizations, and to analyze the effect of intrinsic and extrinsic motivation factors on BIM acceptance. The key factors in BIM acceptance are identified through a literature review in TAM (Davis 1989) and related theories, and consolidated by interviews and pilot studies with professionals in the construction industry. Based on the factors, a questionnaire was designed and sent out to a total of 114 construction organizations in Korea, such as contractors, architects, and engineers. Using SPSS 12.0, the data was analyzed to determine the relationship between intrinsic and extrinsic motivation factors and BIM acceptance through multiple regression analysis. These findings will clarify what the highly prioritized factors are, and can also be used in an assessment tool for the performance of BIM utilization

Keywords : building information modeling (BIM), technology acceptance model (TAM), multi regression analysis

1. Introduction

1.1 Research background and objective

Building Information Modeling (BIM) is defined as “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 a digital format”[1]. As such, as BIM not only provides information on the quantity, cost, and construction schedule and materials list but also enables data analysis considering the structure and environment, there has been a keen interest in its utilization. In addition, the Public Procurement Service (PPS) promulgated the BIM Order Placement Guide, and the application of BIM became mandatory for the turnkey and design bidding construction, contributing to a rise in BIM-based design and construction management. Despite the advantages of BIM and the expansion of its use, problems include a lack of confidence in performance improvement, vagueness regarding the burden to actual users for the utilization of a new information technology, a lack of training in BIM utilization and the burden of the purchasing cost of the software and hardware for BIM utilization. Although these factors are not technical but psychological for actual users or environmental for BIM utilization, the studies that have recently been conducted on practical BIM-based technology utilization plans and on the factors impeding its utilization have mostly focused on improving BIM

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from a technical perspective. However, to ensure that users introduce BIM to their work and continue to use it, the factors influencing user acceptance of BIM need to be promoted to arouse user motivation, so that users can be expected to keep using it. In addition, according to the study conducted by Cho[3] in which the factors impeding BIM utilization were deduced and the relative importance of the factors was analyzed, of a total of 22 factors impeding BIM utilization, 'lack of motivation to use BIM' was ranked 3rd, making it a factor that has a relatively significant influence.

Therefore, this paper aims to understand the motivational factors that affect the action to introduce and utilize BIM through a literature review on the motivation theories and technology acceptance model (TAM) most widely used as an analysis frame for the factors influencing the acceptance and utilization of new IS and IT-based services.

1.2 Research method and scope

As part of the attempt to activate BIM utilization, this study aims to understand the motivational factors that have an impact on BIM acceptance by participants of construction projects.

The research proceeds as follows:

1) By reviewing the advantages of BIM utilization for a construction project and the factors impeding BIM utilization, the importance of determining the factors that can induce BIM acceptance among the participants in the construction projects was presented, and BIM acceptance in construction projects is defined.
2) Through a review on previous studies of the technology acceptance model and factors influencing acceptance and a literature review on motivation theories, the measurement items of BIM acceptance level and the measurement items of intrinsic and extrinsic motivation level were extracted and selected.
3) Based on the review results, a preliminary survey of the participants in the construction projects in which BIM would be utilized (CMer, designer, contractor, and engineer) researchers, and BIM service providers was conducted, and the items were corrected and supplemented to make them more appropriate for BIM in a construction project.
4) Finally, a survey was conducted of the participants in the construction projects in which BIM would be actually utilized (CMer, designer, contractor, and engineer) using the completed measurement items.

And using multi regression analysis, we analyzed relationship between motivation factors and BIM acceptance.

2. Literature Review

2.1 Technology acceptance behavior related theories

The technology acceptance theory (TAM) suggested by Davis[4] has been the most widely used framework in the IT field for analyses of the factors that affect the acceptance and use of new SI and IT-based services. TAM is a refined model suitable to explaining human behavior in computer usage based on the theory of reasoned action (TRA) and theory of planned behavior (TPB). TAM has been utilized to explain the early adoption and continuous usage of various SI or IT-based services, either by including external factors suitable for diverse situations or by adding diverse parameters or variables that can adjust the relationship between extrinsic factors and user intention.

As shown in Figure 1, TAM is a theoretical model that explains how the perception of the utility and usability of a new technology is formed

by diverse extrinsic factors, and the perceived utility and usability affect acceptance and usage in the medium of attitude toward the technology and user's intention.

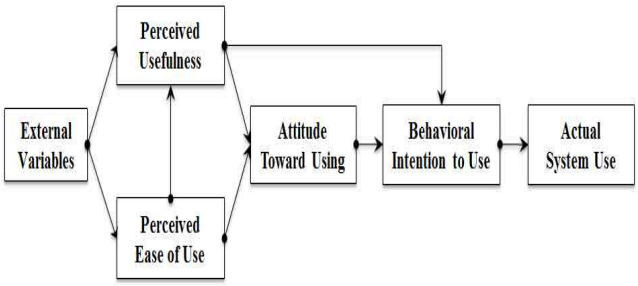

Figure 1. TAM [4]

Here, the perceived utility refers to a "level of individual belief that using a specific system will improve his/her job performance," and the perceived usability refers to a "level of individual belief that he/she can use a specific system without special efforts, or with less physical or mental efforts." The perceived utility has a direct influence on the user's intention to use IT, and is affected by the combination of perceived usability and extrinsic factors. In addition, the utility and usability are revealed to be affected by the extrinsic variables. TAM has been presented in the advanced form of TAM3 after TAM2 by Ventatesh and Davis[5] and Ventatesh and Bela[6], respectively.

2.2 Motivation theory

Motivation is defined as the psychological process to draw and urge a voluntary action for goal attainment. In academic terms, motivation stimulates a person to pursue a goal, and more specifically to induce concrete actions, and keep carrying out the actions to attain the goal[7]. Theory X and Theory Y formulated by McGregor and the motivation-hygiene theory formulated by Herzberg are the representative motivational theories, and a brief explanation of these theories will now be provided.

McGregor formulated Theory X and Theory Y, assuming that the holistic characteristics of an organization vary depending on the underlying theoretical assumption when a manager controls human resources from the human management perspective. In Theory X, human nature is considered negative, while in Theory Y, human nature is considered positive[8]. According to Theory X, human motivation is aroused by control and direction, including management, thorough supervision and material compensation, while according to Theory Y, human motivation is aroused by achievement, emotional compensation, and self-confidence.

Herzberg presented the motivation-hygiene model, a two-factor model[9]. Motivation factors include the pleasure of work itself, acknowledgement, and promotion, all of which are related with satisfaction with the work itself. The hygienic factors include company policy, managerial style of the company, the wage system, working conditions and human relationships, which are closely related with job performance conditions. The intrinsic factors include achievement in the job, acknowledgement of achievement, fruitfulness of work, responsibility and desire for progress, and these are also referred to as motivational factors that affect the work motivation. The extrinsic factors can be classified into the company policy, supervision and relationship with other members, and working conditions, which are referred to as hygienic factors. That is, motivational factors have a direct connection with the job. If the motivational factors are related with human intrinsic factors they are called 'intrinsic factors,' while if the factors are related with the job performance conditions, they are called 'extrinsic'

or hygienic factors.

The motivation factors deduced from the previous studies are indicated in Table 1.

Table 1. Motivation factors in the literature

Factors	Reference
Wage, Supervision, Human Relationship, Work condition, Position, Stability	[10]
Optimism, Innovativeness	[11]
Personal Innovativeness, Self-efficacy	[12]
Self-Determination, Confidence, Joyful, Competition, Evaluation, Recognition, External Reward, Control by other	[13]
Self-efficacy, User Innovativeness, Interactivity	[14]
Self-efficacy, Innovativeness, Knowledge	[15]
Promotion, Compensation, Recognition	[16]
Economic Compensation, Recognition, Promotion	[17]

2.3 BIM in construction projects

BIM enables the construction of better buildings throughout the entire building process (design, construction and post management) in a faster and cheaper manner, because through BIM each property of the building object (wall, slab, window, door, roof and stairs, etc.) can be expressed, and any changes can be reflected in each factor by perceiving the relation of the factors[18].

Similarly, if BIM is used in a construction project, it not only provides support for graphic factors and the data management environment including the provision of quantity, cost, the schedule and materials list, but it also enables a data analysis that takes the structure and environment into account. However, despite these advantages, BIM is being adopted slowly in construction projects. Table 2 indicates the reasons for the factors impeding its adoption discussed in the previous studies.

Table 2. Obstacles to BIM utilization

Obstacle factor	Reference
- Unclear and invalidated benefits of BIM in ongoing practices - Lack of supporting education and training to use BIM - Lack of familiarity with adopting this new technology - Lack of supporting resources (software, hardware) to use BIM tools - Lack of effective collaboration between project stakeholders for modeling and model utilization - Unclear roles and responsibilities for loading data into a model or databases and maintaining the model - Lack of sufficient legal framework for integrating owners' view in design and construction	[3],[19],[20]

However, recent BIM-related studies have focused on presenting the necessity of BIM utilization through the research of BIM utilization cases and BIM-based application technology development cases[21,22,23] or technical solutions for BIM utilization. Therefore, as part of the attempt to activate BIM utilization, this study aims to derive implications by analyzing the relationship between the factors and BIM utilization based on research on the user and environmental factors that can have an impact on BIM utilization.

3. BIM acceptance and motivation factors

3.1 BIM acceptance in a construction project

As discussed in section 2.3, BIM is the technology that facilitates communication between the companies and the building of a collaboration system by field, through enabling users to integrate and manage information by supporting information sharing and compatibility throughout the entire life cycle of the building. Therefore, unlike other forms of IT, the acceptance of which should be considered from a individual perspective, BIM can be said to be accepted completely only when it is accepted both

from the individual perspective for the job performance but also from the organizational perspective to support information sharing and compatibility throughout the entire life cycle. That is, BIM can be accepted only when participants have the will to utilize the BIM tools and the information the BIM holds from the individual perspective (individual intention of BIM acceptance), and the organization in which the participants are engaged has the will to build a collaboration system using BIM (organizational intention of BIM acceptance).

3.2 Motivation factors for BIM acceptance

As discussed in Section 2.2, when the intrinsic compensation is considered important, including achievement and desire fulfillment that can be felt intrinsically when one performs a specific action, the factors are called intrinsic motivation factors. Action driven by intrinsic motivation factors is not done for extrinsic compensation but for the sake of the action itself. On the other hand, extrinsic and environmental factors are called extrinsic motivation factors, and include social pressure and extrinsic compensation. An action driven by extrinsic motivation factors is done to achieve a specific goal, such as acquisition of compensation or avoidance of punishment.

Based on the motivation factors above, the intrinsic motivation factors for BIM acceptance can be defined as the factors that can affect voluntary will and actions to utilize BIM by participants in a construction project, in an individual unit or in an organizational unit. In addition, the extrinsic motivation factors for BIM acceptance can be defined as environmental factors that affect voluntary will and actions to utilize BIM by participants in a construction project in an individual unit or in an organizational unit.

3.3 Measurement item for Intention of BIM acceptance and motivation factors

Detailed descriptions of the factors to be utilized in this research were collected through a review of previous studies on IT acceptance and motivation factors. The items repeated or the times to measure a specific IS were eliminated, and the items reflected of the unique construction-related work appropriate for the BIM acceptance in the construction field were determined. The validity of the measurement items derived through this process were tested through a face-to-face interview with the participants in the construction projects in which BIM would actually be utilized (CMer, designer, contractor, and engineer) and BIM service providers.

The measurement items of BIM acceptance are shown in Table 3. The measurement items of individual BIM acceptance include intention to use BIM tools and information to perform user tasks, intention to take time for the utilization, and intention to recommend BIM to colleagues or others in collaboration. On the other hand, the measurement items of organizational BIM acceptance include intention to encourage employees to use BIM, intention to recommend BIM to other organizations and intention to develop BIM application technology.

Table 3. Intention of BIM acceptance

Category	Measure
Individual intention of BIM acceptance	I have an intention to use BIM in order to perform my task.
	I have an intention to recommend BIM to others.
	I have an intention to take time to learn how to use BIM.
Organizational intention of BIM acceptance	My organization encourages employees of organization to use the BIM technology.
	My organization is active in working on BIM-based projects.
	My organization has an intention to recommend BIM to other organizations that we have a cooperative relationship with.
	My organization has an intention to participate in adopting and developing a BIM application technology.

The measurement items of motivation factors for BIM acceptance are as shown in Table 4.

Table 4. Factors of intrinsic motivation and extrinsic motivation

Category		Measure
Intrinsic Motivation	Self efficacy	I don't have any resistance to using BIM.
		I am familiar with using 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 towards a new information technology.
	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 a new information technology.
		My organization has technical capability of using a new information technology.
		My organization is aggressively pushing to use a new information technology.
Extrinsic Motivation	Organization Support	My organization supports enough resources (hardware and software) for BIM utilization.
		My organization provides proper education/training for BIM utilization.
		My organization provides incentives if we adopt or utilize BIM.
	Organization 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 Support	Industry or government provides economic benefits if we adopt BIM.
		Industry or government provides proper education/training if we adopt BIM.
		Industry or government provides economic support for adopting, developing, and using BIM application technology.
	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.
		We are required to adopt BIM to satisfy owner's requirements.

The intrinsic motivation factors of BIM acceptance include 'Self Efficacy' of individual belief that he/she can use BIM without difficulty, 'Personal Innovativeness' of individual attitude toward a new technology, 'Collective efficacy' of organizational belief that it can use BIM successfully, and 'Organizational Innovativeness' of organizational attitude toward a new technology. On the other hand, the extrinsic motivation factors of BIM acceptance include 'Organization Support' of the support level of resources, education and incentive for BIM utilization, 'Organization Pressure' of forceful requirement of BIM utilization, 'External Support' of support level of economic benefits for activation of BIM utilization at the national or organizational level, and 'External Pressure' of forceful requirement of BIM utilization in construction organizations at the national or industrial level.

4. Effects of intrinsic and extrinsic motivation factors on BIM acceptance

4.1 Research model

The research model was establish to analyze the effects of intrinsic and extrinsic motivation factors on BIM acceptance by participants in construction projects as shown in Figure 2.

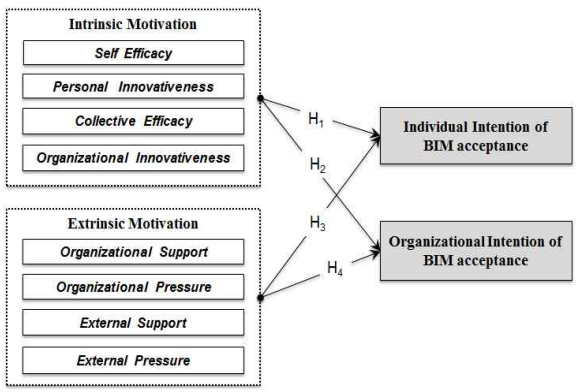

Figure 2. Research model

H_1: 'Intrinsic motivation factors' have positive effects on 'individual intention of BIM acceptance.'

H_2: 'Intrinsic motivation factors' have positive effects on 'individual intention of BIM acceptance.'

H_3: 'Extrinsic motivation factors' have positive effects on 'Individual intention of BIM acceptance.'

H_4: 'Extrinsic motivation factors' have positive effects on 'organizational intention of BIM acceptance.'

4.2 Data Collection

To verify the hypothesis, the intrinsic and extrinsic motivation factors and each intention of BIM acceptance were measured using the 7-point Likert Scale. The survey was conducted on designers, contractors, CMers, and engineers who actually use BIM. Data was collected for about 2 months (April 11, 2012 ~ June 12, 2012) via e-mail or postal mail. The statistical characteristics of the 114 samples are shown in Table 5.

Table 5. Characteristics of the respondents (n=114)

Category		Frequency	%
Sector of the respondent' Organization	Designer	36	31.58%
	CM	30	26.32%
	Contractor	33	28.95%
	Engineer	15	13.16%
Total		114	100%
Respondent's average experience	Construction Industry	Approx. 7.5 years	
	BIM	Approx. 1.2 years	
BIM related education or training		Approx. 24.12 hours	

4.3 Analysis results

The independence of the residual of the relationship between intrinsic and extrinsic motivation factors and individual and organizational intention of BIM acceptance is considered as confirmed when the Durbin-Watson value converges upon 2[24], and all the values converged upon 2 in this research, which means that independence of the residual of the basic assumption of the regression model is considered to have been met.

Next, to review the multicollinearity between independent variables, we analyze the correlation between independent variables by using Pearson's correlation coefficient. As indicated in Table 6, the correlation between variables was shown at 0.01, which is statistically significant, and it is believed that the multicollinearity needs to be verified.

Table 6. Result of correlation analysis

	Intrinsic Motivation	Extrinsic Motivation
Intrinsic Motivation	1	0.549
Extrinsic Motivation		1

Table 7 is the diagnosis result of multicollinearity. The tolerance limit exceeded 0.1, the various inflation factor (VIF) was below 10, and maximum condition index was under 30, and thus multicollinearity is confirmed [25].

Table 7. Diagnosis of multicollinearity

	Condition Index	Tolerance	VIF
Intrinsic Motivation	9.445	0.699	1.431
Extrinsic Motivation	12.288	0.699	1.431

Multiple regression analysis was conducted to verify the hypothesis regarding the effect of the intrinsic and extrinsic motivation factors on individual and organizational intention of BIM acceptance, and the results are shown in Tables 8 and 9.

1) Motivation factors and individual intention of BIM acceptance (H_1, H_3)

As shown in Table 8, the F value of the model showing the effect of the motivation factors on individual intention of BIM acceptance was shown to be 39.966, and the regression model formula estimated at a 0.01 significant level was

statistically significant. R^2 was 0.408, and the motivation factors explained about 41% of the individual intention of BIM acceptance. Intrinsic motivation factors had a significant influence on the individual intention of BIM acceptance, while extrinsic motivation factors did not.

To understand which factor of the intrinsic motivation factors had a significant effect, the effect of each of the intrinsic motivation factors (self efficacy, individual innovation, collective efficacy, and organizational innovation) on the individual intention of BIM acceptance was verified (Table 9). Only self efficacy was shown to have a significant impact. On the other hand, the extrinsic motivation factors did not have a significant influence on the individual intention of BIM acceptance, and R^2 was 0.184 in the regression analysis result, which has a low explanatory power as well.

Through the analysis results, it was revealed that it is necessary to make users have the belief that they can use BIM without difficulty for their job rather than to provide extrinsic pressure and support in order to arouse voluntary will and motivation at the individual level.

2) Motivation factors and organizational intention of BIM acceptance (H_2,H_4)

As shown in Table 8, the F value of the model showing the effect of the motivation factors on organizational intention of BIM acceptance was shown to be 46.704, and the regression model formula estimated at a 0.01 significant level was statistically significant. R^2 was 0.447, and the motivation factors explained about 45% of the organizational intention of BIM acceptance. Not only intrinsic motivation factors but also extrinsic motivation factors had a significant impact on the organizational intention of BIM acceptance. In terms of importance, intrinsic motivation factors were found through standardized coefficient to be more influential on the organizational intention of BIM acceptance.

To understand which factor of the intrinsic and extrinsic motivation factors had a significant effect, the effect of intrinsic (self efficacy, individual innovation, collective efficacy, organizational innovation) and extrinsic motivation factors (organizational support, organizational pressure, external support and external pressure) on the organizational intention of BIM acceptance was examined(Table 9), and it was found that self efficacy and organizational innovation of the intrinsic motivation factors, and organizational support, organizational pressure and external pressure of the external motivation factors had a significant impact.

Through the analysis results, it was found not only that individual belief of BIM utilization but also organization confidence in a new form of IT was needed. An organizational policy or a business process that forcibly require employees to use BIM should be presented, and the benefits and support of resources to encourage employers to use BIM are needed as well.

5. Conclusion

BIM in construction projects is not a simply an object of curiosity as a new technology, but is expanding its base to the world, and nations are providing a BIM Guide to encourage companies to use BIM. However, to ensure that BIM is utilized on a continuous rather than a temporary basis, the participants in the construction projects should be motivated to use it. For this reason, this study aims to determine which motivation factors affect the BIM acceptance of the participants, and which effect there is among the factors.

The following are the research findings found

Table 8. Result of multiple regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients (ß)	t	p-value
		B	standard error			
Individual Intention of BIM Acceptance	Intrinsic Motivation	0.868	0.109	0.689	7.954	0.000***
	Extrinsic Motivation	-0.104	0.109	-0.082	-0.952	0.343
D-W=1.753, R_2 =0.408, F=39.966, p.=0.000						
Organizational intention of BIM acceptance	Intrinsic Motivation	0.659	0.111	0.497	5.941	0.000***
	Extrinsic Motivation	0.346	0.111	0.260	3.113	0.002**
D-W=1.724, R_2 = 0.447, F=46.704, p.=0.000						

*** p<0.001, ** p<0.01

through the analysis. Unlike other information technologies, BIM enables users to integrate and manage information through supporting information sharing and compatibility throughout the entire life cycle by building a collaboration system for each field. It is defined that BIM can be accepted only when users should have the will to use BIM to perform their job (individual intention of BIM acceptance) and the organization the users engage in has the will to introduce BIM (organizational intention of BIM acceptance). In the regression analysis results, the coefficient of determination was higher than 0.4, which means it had more than 40% explanatory power[26], and the hypothesis of the research was found to be valid. At the individual level, motivation to accept BIM

Table 9. Result of multiple regression analysis

Model		Unstandardized Coefficients		Standardized Coefficients (β)	t	p-value
		B	standard error			
Individual Intention of BIM Acceptance	Self Efficacy	0.734	0.118	0.678	6.229	0.000***
	Personal Innovativeness	0.026	0.114	0.024	0.228	0.820
	Collective Efficacy	-0.010	0.096	-0.010	-0.107	0.915
	Organizational Innovativeness	0.117	0.084	0.133	1.399	0.165
D-W=1.761 R_2 = 0.556, F=34.056, p.=0.000						
Individual Intention of BIM Acceptance	Organizational Support	0.446	0.115	0.432	3.871	0.000***
	Organizational Pressure	0.006	0.113	0.006	0.055	0.957
	External Support	-0.272	0.106	-0.275	-2.563	0.012
	External Pressure	0.199	0.098	0.207	2.022	0.046
D-W=1.741 R_2 = 0.184, F=7.380, p.=0.000						
Organizational intention of BIM acceptance	Self Efficacy	0.508	0.138	0.446	3.668	0.000***
	Personal Innovativeness	-0.137	0.134	-0.122	-1.022	0.309
	Collective Efficacy	0.153	0.113	0.148	1.354	0.179
	Organizational Innovativeness	.310	0.098	0.336	3.161	0.002**
D-W=1.760 R_2 = 0.385, F=21.886, p.=0.000						
Organizational intention of BIM acceptance	Organizational Support	0.465	0.104	0.428	4.471	0.000***
	Organizational Pressure	0.351	0.102	0.344	3.435	0.001**
	External Support	0.140	0.089	0.139	1.574	0.118
	External Pressure	-0.256	0.096	-0.247	-2.675	0.009**
D-W=1.754 R_2 = 0.398, F=19.666, p.=0.000						

*** p<0.001, ** p<0.01

should be boosted by factors influencing voluntary will to use BIM in the construction projects, such as individual or organizational belief that users can successfully perform their job with BIM and individual or organizational confidence in the utilization of a new technology. Moreover, motivation should be boosted by the environmental factors, such as support for BIM utilization in the form of resources, training, and incentives; forcible requirement of BIM utilization through a company policy at the organizational level; and, forcible requirement of BIM utilization through an ordering or contract system at the national or industrial level.

The motivation factors and the priority of the factors presented to activate BIM utilization in this study can be utilized as fundamental data in establishing a strategic plan for BIM utilization. However, this study focused only on the intrinsic and extrinsic motivation factors influencing BIM acceptance by participants in construction projects in order to understand the direct effect of the motivation factors on BIM acceptance. However, to increase the explanatory power, more parameters should be added, including utility, usability, and user satisfaction presented in the conventional IT acceptance model to present a more extended BIM acceptant model, and the model should be verified in the future.

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