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ENVIRONMENTAL FACTORS OF ACCEPTANCE ORGANIZATION AFFECTING INTENTION TO ACCEPT BIM

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ABSTRACT

The purpose of this study is to analyze factors affecting BIM(Building Information Modeling) acceptance of architecture design firms in Korea. An empirical test was conducted to verify the hypothesis using the Technology Acceptance Model. Also, the factors that influence the acceptance intention of Building Information Modeling were analyzed. This study set up 'organizational innovativeness', 'organizational slack resource' and 'organizational maturity about information system' as exogenous variables. And it set up 'BIM's perceived usefulness' and 'BIM's perceived ease of use' as parameters. How the exogenous variables affect the parameters and the effect on the outcome variable, which is 'intention to accept BIM', were analyzed. Through this, it was verified that 'BIM's perceived usefulness' and 'BIM's perceived ease of use' affect 'intention to accept BIM'. The results of this study can be used to develop a method for introducing BIM and to analyze the user's acceptance intention for BIM.

Keywords: Building Information Modeling, Intention to Accept BIM, Technology Acceptance Model, Organizational Culture.

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1. INTRODUCTION

1.1. Background and purpose of study

Building Information Modeling (Hereinafter, BIM) is a new approach to design, construction, and facility management in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format [1]. BIM is used to solve problems that arise throughout construction projects and as a basis for smooth decision

making. In addition, since the information generated in the previous stage can be prevented from being missed and errors, the information generated in the design stage can be smoothly transferred to the construction stage or later stage [2].

The global BIM market was $ 4 billion in 2016, with an average annual growth rate of 19.3% by 2025. Korea also applied BIM design to projects totaling 6 trillion 135.4 billion won from 2009 to 2016. Despite the advantages of BIM and the policy of expanding the use of BIM, 'the lack of confidence in improving performance when using BIM', 'the burden of users for the use of new tools', 'the burden of the cost of purchasing hardware to use BIM' and ‘the burden of the cost of purchasing BIM software’ have hindered BIM activation.

For this reason, designers design with 2D design tools and then request BIM design to BIM specialists. This is the cause of low productivity and cost waste of the construction design. In order for users to incorporate BIM into their work and continue to use it, they need to motivate them to accept it. This study analyzed the factors affecting the introduction of BIM based on the Technology Acceptance Model (Hereinafter, TAM) established by Davis [3]. Through this, this study will lay the foundation for establishing guidelines and directions for the future introduction of BIM.

1.2. Methods and procedures of the study

This study investigated the factors affecting BIM acceptance in the field of architectural design. The study flow to achieve the study purpose is as follows.

- Compose survey items to measure the degree of BIM acceptance and the factors affecting BIM acceptance.
- Survey is conducted for architecture designers using BIM.
- Verify the validity of composition and reliability of BIM acceptance factors through factor analysis of collected data and Cronbach α coefficient.
- Analyze the relationship between the factors derived through regression analysis and BIM acceptance.

2. CONCEPT OF TECHNOLOGY ACCEPTANCE MODEL AND REVIEW OF PRECEDENT STUDY

The process of adopting new technologies or adopting innovative products has been described as TAM. The TAM is based on ‘Theory of Reasoned Action’ by Ajzen and Fishbein [4]. Davis developed the TAM of Figure 1 to illustrate the acceptance intention of the computer, which was an innovative product at the time. He mentioned that the acceptance intention should be made when adopting the technology or innovative products and the acceptance intention is influenced by the attitude toward the object [3]. The initial TAM has been used as tools to identify factors that influence the adoption of new information technology. The current TAM is widely used in a variety of fields to adopt personal media, services and products. The validity of the TAM has led researchers to become interested in exogenous variables that affect the perceived ease of use and perceived usefulness [5].

Since then, many researchers have been applied to the studies in various fields, including word processors, e-mail, the Internet, Enterprise Resource Planning systems and electronic commerce [6] [7].

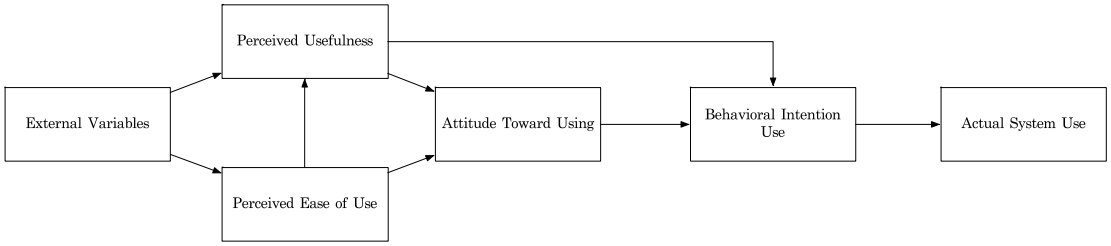

Figure 1 Technology Acceptance Model

3. STUDY MODEL AND STUDY HYPOTHESIS

3.1. Study model

This study composed the factors affecting BIM acceptance by using the TAM of Davis [3]. Figure 2 is a study model designed for this study of BIM. This study model analyzes the direct influence that the environmental factors of acceptance organization as exogenous variables affect the intention to accept BIM. And, it analyzes that the parameters of BIM's perceived usefulness and perceived ease of use affect acceptance intent.

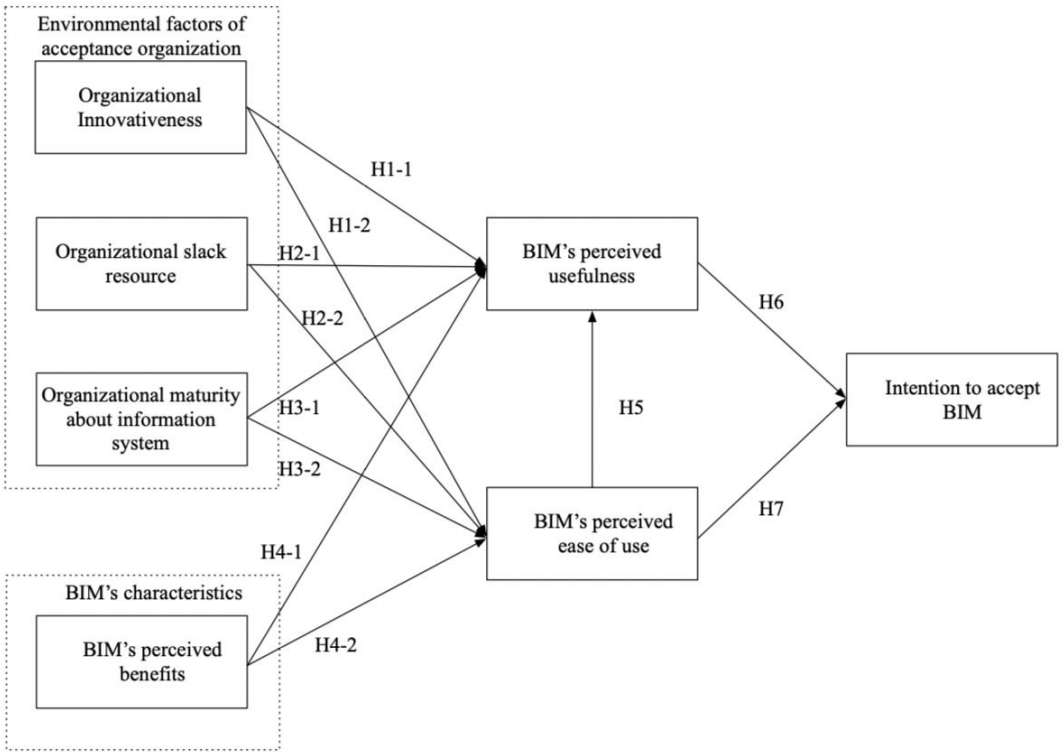

Figure 2 Study model

3.2 Study hypothesis

3.2.1. Organizational innovativeness

This study anticipates that organizational innovativeness will have a positive impact on the acceptance of BIM. Therefore, it adopted the innovativeness of the acceptance organization as the recipient's environmental variable for BIM's acceptance intention.

- Study Hypothesis 1 (H1-1): 'Organizational innovativeness' will have a positive effect on 'BIM's perceived usefulness'.

- Study Hypothesis 2 (H1-2): 'Organizational innovativeness' will have a positive effect on 'BIM's perceived ease of use'.

3.2.2. Organizational slack resource

Precedent studies have shown that organizations with the slack resource are highly innovative [8]. Therefore, the organizational slack resource can be used to introduce BIM, an innovative system. In this study, the organizational slack resource was adopted as the recipient environmental variables for BIM's acceptance intention.

- Study hypothesis 3 (H2-1): 'Organizational slack resource' will have a positive effect on 'BIM's perceived usefulness'.
- Study hypothesis 4 (H2-2): 'Organizational slack resource' will have a positive effect on 'BIM's perceived ease of use'.

3.2.3. Organizational maturity about information system

Grover and Goslar said that the higher the organizational maturity, the more flexible the information system and the higher the information strength of the organization [9].

Therefore, the higher the organizational maturity of information system, the less the burden of introducing and using BIM. In this study, the degree of maturity of the information system was adopted as the environmental variable of the recipient about BIM's acceptance intention.

- Study Hypothesis 5 (H3-1): 'Organizational maturity about information system' will have a positive effect on 'BIM's perceived usefulness'.
- Study Hypothesis 6 (H3-2): 'Organizational maturity about information system' will have a positive effect on 'BIM's perceived ease of use'.

3.2.4. BIM's perceived benefits

Tsai et al. said that perceived benefits were significantly associated with usefulness [10]. BIM has the variety and complexity to deal with data of unstructured objects as well as with data of standardized objects. In addition, there are advantages to storing and exchanging building object information.

Therefore, it has greater value than traditional 2D design tools. In this study, it was determined that BIM's perceived benefits had a significant relationship with the acceptance of BIM. The perceived benefits were adopted as environmental variables of the acceptance organization.

- Study Hypothesis 7 (H4-1): 'BIM's perceived benefits' will have a positive effect on 'BIM's perceived usefulness'.
- Study hypothesis 8 (H4-2): 'BIM's perceived benefits' will have a positive effect on 'BIM's perceived ease of use'.

3.2.5. Relationship between perceived usefulness, perceived ease of use and intention to accept

The effect of the key variables of the TAM on the perceived usefulness, perceived ease of use, and intention to accept has been verified through precedent studies. As a representative precedent study, Davis explained that existing studies in the field of information systems are the leading variables of 'perceived usefulness' and 'perceived ease of use' [3].

In this study, the following hypotheses were established to verify the relationship between 'BIM's perceived usefulness', 'BIM's perceived ease of use' and 'intention to accept BIM', which are the parameters of TAM.

- Study Hypothesis 9 (H5): 'BIM's perceived ease of use' will have a positive effect on 'BIM's perceived usefulness'.
- Study hypothesis 10 (H6): 'BIM perceived usefulness' will have a positive effect on 'intention to accept BIM.
- Study hypothesis 11 (H7): 'BIM's perceived ease of use' will have a positive effect on 'intention to accept BIM'.

4. STUDY METHOD

4.1. Variables and measurement items

Variables whose reliability and validity were verified through precedent studies were modified to use the 'intention to accept BIM' for analysis.

'Organizational innovativeness' consisted of four items using "the degree to which one organization within a social system embraces innovation before another" defined by Goldsmith and Hofacker [11], and Gatignon and Robertson [12].

'Organizational slack resource' consisted of three items, using "resource that could be relocated and potentially used to achieve organizational goals" defined by George [13].

'Organizational maturity about information system' used 'chief executive officer's involvement about information system plan', 'degree of introduction and dissemination of information technology' and 'information system performance criteria based on organizational goals rather than costs' as presented by Benbasat et al. [14]. In this study, "Organizational maturity about information system" is defined as "Maturity of information system within organization" and composed of four items.

'BIM's perceived benefits' are based on the evidence presented by Gutman [15]. It was defined as "the degree of perception that BIM will achieve higher value because it has a relative advantage over existing tools" and composed of four items.

Davis defined 'perceived ease of use' as "the degree to which individuals believe that it will not be difficult to use a particular system" [3]. In this study, based on the definition of "perceived ease of use" defined by Davis, it was defined as "the degree of believing that using BIM would not be difficult" and composed of three items.

Davis defined 'perceived usefulness' as "the degree to which potential users believe that using a particular information technology or system will improve their job performance" [3]. In this study, based on the definition of 'perceived usefulness' defined by Davis, it was defined as "the degree of thinking that using BIM would improve job performance" and composed of four items.

'Intention to accept' was defined as 'the degree of willingness to introduce BIM" and measured four items.

Table 1 lists the parameters and measurement items set in this study.

Table 1 Setting parameters and measurement items

Parameters (Code)	Measurement items (Code)
Organizational innovativeness (A)	Our organization tends to stay up to date on new emerging technologies (A1).
	We are always interested in knowing that nothing is more comfortable or more beneficial than the products or services we use today (A2).
	Our organization is interested in new technologies or trends (A3).

Parameters (Code)	Measurement items (Code)
	Our organization tends to accept new things better than other companies (A4).
Organizational slack resource (B)	It is easy for our organization to secure sufficient free capital in preparation for the introduction of BIM (B1).
	It is easy for our organization to secure enough manpower ready for the introduction of BIM (B2).
	It is easy for our organization to secure software and hardware infrastructure for BIM (B3).
Organizational maturity about information system (C)	Our organization's work computerization level is high (C1).
	Our organization shares a comprehensive and integrated database (C2).
	Our organization has a department that supports the use of BIM (C3).
	Our organization has BIM experts (C4).
BIM's perceived benefits (D)	BIM will enable design productivity improvements compared to existing design tools (D1).
	BIM will enable real-time analysis of design adequacy (D2).
	BIM will enable the design analysis of various engineering fields compared to existing design tool (D3).
	BIM will enable the analysis of complex data compared to existing design tools (D4).
BIM's perceived ease of use (E)	Our organization will easily become skillful in using BIM (E1).
	Our organization will be able to respond appropriately to various situations when using BIM (E2).
	Our organization will be able to explain to people around us how to use BIM (E3).
BIM's perceived usefulness (F)	If BIM is used in our organization, we will be able to exchange design information quickly (F1).
	If we use BIM in our organization, we may obtain useful and interesting information (F2).
	The design information exchanged through BIM will be very useful to our organization (F3).
Intention to accept BIM (G)	Our organization wants to take advantage of the innovative capabilities of BIM (G1).
	Our organization will benefit from our work using BIM in the future (G2).
	Our organization will use BIM (G3).
	Our organization has intention to use BIM if it is possible (G4).

4.2. Surveys and characteristics of samples

Since BIM is a tool for designing buildings, a survey was conducted of the design departments. A survey of 50 architectural designers was conducted on whether BIM was introduced and why BIM was introduced. Out of fifty respondents, insincere respondents and four outliers were excluded. Finally, 46 survey data were used for analysis. Details of the samples are given in Table 2.

Table 2 Whether to introduce BIM and the purpose of BIM introduction

Classification	Survey items	Number of respondent	Rate (%)
Whether to introduce BIM	I am using BIM.	7	15.2
	I am considering or considering the introduction of BIM.	26	56.5
	I do not intend to introduce BIM yet.	13	28.3
	Total	100	100
Reason for BIM introduction	I introduce to respond to changing trends in the design industry.	4	8.70
	I introduce BIM to strengthen my competitiveness in the design industry.	9	19.57
	I introduce BIM for customer satisfaction.	6	13.04
	I introduce BIM to create new business.	6	13.04
	I introduce BIM for business innovation.	2	4.35
	I introduce BIM to improve productivity.	6	13.04
	I introduce BIM to innovate business processes.	8	17.39
	I introduce BIM according to company policy.	1	2.17
	Other	4	8.70
	Total	46	100

4.3. Analysis method and result

In this study, SPSS Modeler and SmartPLS 2.0 were used to verify the hypothesis. SPSS Modeler was used to analyze descriptive statistics and frequency of respondents. And, SmartPLS 2.0 was used to analyze the reliability of the study model and to verify the study hypothesis.

4.3.1. Convergence validity and reliability analysis of study model

Factor analysis was conducted to verify the convergence validity and reliability of the variables used in this study. Principal component analysis and orthogonal rotation were applied to extract the components of latent variables. An exploratory factor analysis was conducted to identify factor loading, eigenvalue and variance of the survey items. Seven factors were extracted, and the eigenvalues of the extracted factors are greater than 1.0 as shown in Table 3. And, it was analyzed to have a persuasive force equivalent to about 60.0% of the whole dispersion.

Table 3 Result of factor analysis (Rotated component matrix)

Variables	Measurement items	Components						
		A	B	C	D	E	F	G
A	A1	.26	.06	.03	.15	-.06	-.07	.82
	A2	.14	-.03	.16	.19	.09	-.02	.86
	A3	.11	.30	-.05	.10	.13	-.01	.86

Variables	Measurement items	Components						
		A	B	C	D	E	F	G
	A4	.09	.21	.37	-.13	-.05	.17	.69
B	B1	.66	.27	.23	-.04	.02	.13	.32
	B2	.68	.13	.04	.02	.26	.22	.10
	B3	.80	.26	.03	.17	.12	.15	.20
	B4	.75	-.15	.16	.18	.15	.18	.12
C	C1	.18	.34	.05	.11	.12	.83	-.05
	C2	.22	.04	.19	.06	.20	.89	.02
	C3	.19	.05	.15	.13	.18	.90	.02
D	D1	.03	.20	.13	.72	.17	.25	.18
	D2	.06	.17	.03	.85	.06	.21	.02
	D3	.10	.12	.16	.86	.08	-.05	.07
	D4	.16	.29	.22	.74	-.11	-.06	.12
E	E1	.09	.11	.72	.19	.31	.14	.14
	E2	.13	.19	.80	.25	.10	.11	.12
	E3	.14	.22	.80	.12	.21	.15	.09
F	F1	.17	.32	.10	.15	.77	.18	.07
	F2	.24	.23	.19	.08	.80	.09	-.08
	F3	.12	.06	.30	-.05	.80	.26	.11
G	G1	.26	.72	.27	.24	.10	.01	.04
	G2	.08	.76	.15	.19	.19	.17	.13
	G3	.05	.73	.15	.32	.21	.17	.30
	G4	.08	.64	.15	.30	.38	.20	.20

To confirm the convergent validity and reliability of the variables presented in this study, confirmatory factor analysis was performed. According to Fornell and Larcker, the satisfaction of the overall model fit of the study model is that Average Variance Extracted (Hereinafter, AVE) value is 0.5 or more, Cronbach's Alpha is 0.7 or more, and composite reliability should be 0.7 or more [16]. Also, according to Kim and Cho, the community value indicating the suitability of a measurement model should be at least 0.5 or more [18]. Cohen classifies the R Square values that represent the goodness-of-fit of the path model into upper (0.26 or more), medium (0.13 or more and less than 0.26), and lower (0.02 or more and less than 0.13). Tenenhaus et al. classified goodness-of-fit of the model into upper (0.36 or more), medium (0.25 or more and less than 0.36), and lower (0.1 or more and less than 0.25), and suggested criteria as at least 0.1 or more [20]. As shown in Table 4, the AVE values of the variables in this study are all above the standard value of 0.5. And, both Composite Reliability (Hereinafter, CR) and Cronbach's Alpha of the factors are above the standard value of 0.7. Therefore, the calculated values correspond to the criteria set forth by Fornell and Larcker [16], and the convergence validity and reliability of the factors satisfies the criteria.

Table 4 Result of Convergence validity and reliability analysis

Code of variables	Code of Measurement items	AVE	CR	R Square	Cronbac-h`s Alpha	Commun-ity
A	A1	0.72	0.91	-	0.87	0.72
	A2					
	A3					
	A4					
B	B1	0.71	0.91	-	0.87	0.71
	B2					
	B3					

Code of variables	Code of Measurement items	AVE	CR	R Square	Cronbac-h`s Alpha	Commun-ity
	B4					
C	C1	0.89	0.96	-	0.94	0.89
	C2					
	C3					
D	D1	0.65	0.88	-	0.82	0.65
	D2					
	D3					
	D4					
E	E1	0.79	0.92	0.40	0.87	0.64
	E2					
	E3					
F	F1	0.77	0.91	0.33	0.85	0.82
	F2					
	F3					
G	G1	0.74	0.92	0.47	0.88	0.74
	G2					
	G3					
	G4					
Goodness-of-fit of the model: 0.54						

Correlation analysis was performed to verify the discriminant validity of the study model. As Kim et al. [17] insisted, the correlation coefficients all met less than 0.7, which is the standard value. In addition, as the standard Straub et al. [21], and Gefen and Straub [22] presented, the factor loading of this model was larger than the cross loading of other variables. Therefore, it was confirmed that the measurement items used in this study have discriminant validity.

Table 5 Results of discriminant validity analysis

Code of variables	1	2	3	4	5	6	7
A	0.86						
B	0.44	0.81					
C	0.41	0.43	0.84				
D	0.40	0.45	0.14	0.94			
E	0.57	0.31	0.27	0.28	0.85		
F	0.54	0.41	0.37	0.39	0.44	0.88	
G	0.53	0.44	0.20	0.46	0.27	0.52	0.89
Note: The bold in the correlation matrix is the square root of the mean variance extracted value							

4.3.2. Hypothesis verification

To verify the statistical significance of the study model presented in this study, a bootstrapping analysis was performed using SmartPLS 2.0. The path-coefficient and the t-value were used to verify the hypotheses set in this study.

Organizational innovativeness: The study hypothesis ‘H1-1 (t = 0.57)’ and the study hypothesis ‘H1-2 (t = 1.88)’ were not statistically significant. Therefore, the study hypothesis ‘H1-1’ and study hypothesis ‘H1-2’ were rejected.

Organizational slack resource: The study hypothesis ‘H2-1 (t = 2.10, p <0.05)’ was statistically significant. The study hypothesis ‘H2-2 (t = 2.18, p <0.05)’ was also statistically significant. Therefore, both study hypotheses ‘H2-1’ and ‘H2-2’ relating to organizational slack resource were adopted.

Organizational maturity about information system: The study hypothesis ‘H3-1 (t = 2.18, p <0.05)’ was statistically significant. The study hypothesis ‘H3-2 (t = 1.07)’ was not statistically significant. Therefore, the study hypothesis ‘H3-1’ was adopted and the study hypothesis ‘H3-2’ was rejected.

BIM’s perceived benefits:

The study hypothesis ‘H4-1 (t = 0.14)’ was not statistically significant. However, the study hypothesis ‘H4-2 (t = 2.73, p <0.01)’ was statistically significant. Therefore, the study hypothesis ‘H4-1’ was rejected and the study hypothesis ‘H4-2’ was adopted.

Relationship between BIM’s perceived usefulness, BIM’s perceived ease of use and intention to accept BIM: The study hypotheses ‘H5 (t = 3.58, p <0.001)’, ‘H6 (t = 2.83, p <0.01)’ and ‘H7 (t = 2.74, p <0.01)’ were all consistent with the study results of the existing technology acceptance model. Therefore, it is shown that they support the study results of Davis's [3] technology acceptance model.

Table 6 and Figure 3 show the hypothesis verification results obtained through the PLS analysis.

Table 6 Results of hypothesis verification using path-coefficient and t-value

Hypothesis	Path (Code of variables)	Path-coefficient	t-value	p-value	Standard Error	Adoption status
H1-1	A → F	-0.06	0.57	0.285	0.10	Rejected
H1-2	A → E	0.21	1.88	0.031	0.11	Adopted
H2-1	C → F	0.24*	2.18	0.015	0.11	Adopted
H2-2	C → E	* 0.22	2.10	0.019	0.10	Adopted
H3-1	B → F	0.21*	2.18	0.015	0.10	Adopted
H3-2	B → E	0.13	1.07	0.143	0.12	Rejected
H4-1	D → F	-0.01	0.14	0.444	0.10	Rejected
H4-2	D → E	0.28**	2.73	0.003	0.10	Adopted
H5	E → F	0.37***	3.58	0.0002	0.10	Adopted
H6	F → G	0.35**	2.83	0.002	0.12	Adopted
H7	E → G	0.36**	2.74	0.003	0.13	Adopted
Note: p < .05 , **p < .01, ***p < .001, ns : insignificant at the .05 level.						

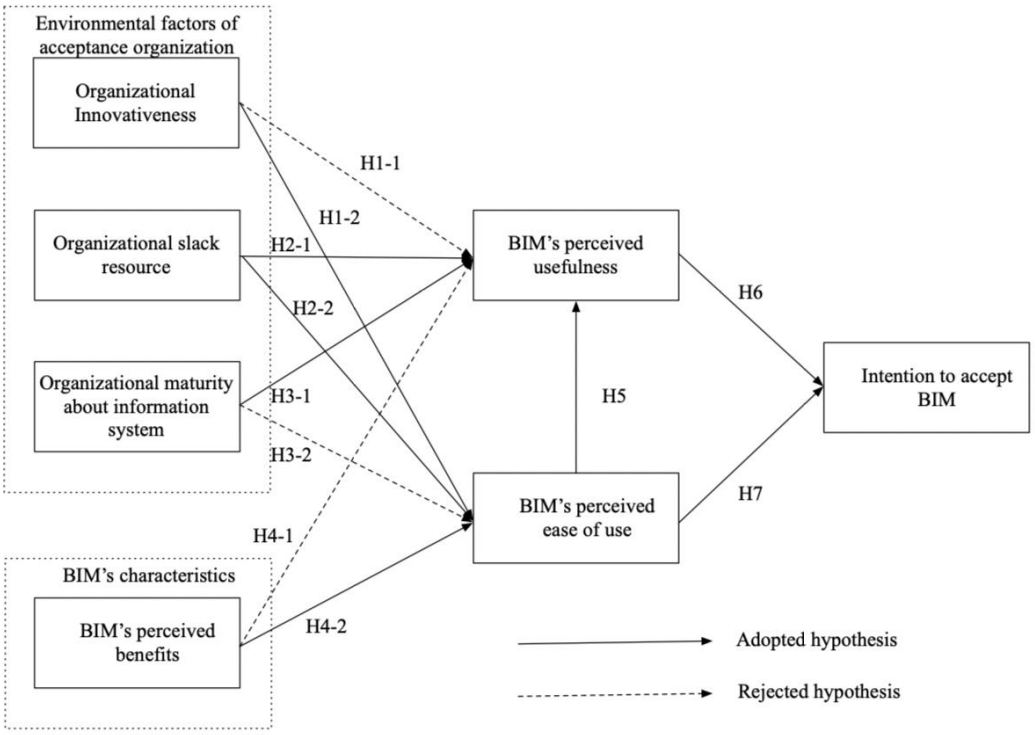

Figure 3 Results of study model verification

5. CONCLUSION

The purpose of this study was to analyze factors affecting the acceptance of BIM using the TAM proposed by Davis [3]. The exogenous variables set the environmental factors of the acceptance organization: 'organizational innovativeness', 'organizational slack resource' and 'organizational maturity about information system'. The parameters were set to 'BIM's perceived benefits', 'BIM's perceived usefulness' and 'BIM's perceived ease of use'. And, it was analyzed that how exogenous variables influenced the parameters of 'BIM's perceived usefulness' and 'BIM's perceived ease of use'. It also analyzed the effect on the outcome variable, 'intention to accept BIM'.

The results of this study are summarized as follows.

'Organizational innovativeness' has no positive effect on 'BIM's perceived usefulness' and 'BIM's perceived ease of use'. On the other hand, 'organizational slack resource' has a positive effect on both 'BIM's perceived usefulness' and 'BIM's perceived ease of use'. In addition, 'organizational maturity about information system' also has a positive effect on 'BIM's perceived usefulness'.

However, there was no positive effect on 'BIM's perceived ease of use'. 'BIM's perceived benefits', a characteristic of BIM, did not have a positive effect on 'BIM's perceived usefulness'. However, it has been shown to have a positive effect on 'BIM's perceived ease of use'. On the other hand, of the environmental factors of the acceptance organization, 'organizational innovativeness' did not affect both 'BIM's perceived usefulness' and 'BIM's perceived ease of use'. This is judged to have differences from precedent studies that treat recipient's innovativeness as the individual level because the recipient's innovativeness is close to personal inclination. 'Organizational maturity about information system' only affects 'BIM's perceived usefulness'. This led to that while the information system in the company can help improve the performance of the organization, it could be predicted that learning is needed to

accommodate the new design tool, BIM. While 'BIM's perceived benefits' affect 'BIM's perceived ease of use', it did not appear to affect 'BIM's perceived usefulness'.

Rogers said that in order to grow from the initial recipient to the early recipient of innovative products, the acceptant or the acceptance organization must be able to accept the burden of initial uncertainty [23]. However, through this study, it was able to confirm that the factor that organizations consider at the stage of BIM application is 'BIM's perceived benefits' rather than 'organizational innovativeness'.

The results of this study can be used to analyze the acceptance intention of organization which is planning to introduce BIM.

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