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동일 데이터를 이용한 구조방정식 툴 간의 비교분석

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A Comparison Analysis among Structural Equation Modeling (AMOS, LISREL and PLS) Using the Same Data

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요 약

구조방정식 모델링은 경로분석 및 확인적 요인분석을 동시에 수행해 주는 통계적 절차를 따르고 있다. 오늘날이 통계적 절차는 사회과학 분야의 연구자에게 필수적인 도구이다. 구조방정식 모델링 분석을 해주는 대표적인 도구로는 AMOS, LISREL 그리고 PLS가 있다. AMOS는 초보자가 사용할 수 있도록 편리한 그래픽 사용자 인터페이스를 제공해 주고 있다. PLS는 그래픽 사용자 인터페이스뿐만 아니라 정규분포에 대한 제약조건도 없다는 장점을 가지고 있다. 또한 사회과학 분야에서 가장 많이 사용하는 3가지 도구 (applications)를 비교분석 하였다. 구조방정식 모델링 기반 확인적 요인 분석은 IBM AMOS Ver 23, LISREL 8.70 및 SmartPLS 2.0을 사용하였다. 구조방정식 모델링 비교 분석 결과는 LISREL이 다른 분석 도구보다 종속 변수의 설명력이 가장 높음을 확인할 수 있었다. 분석 결과에 의해 제시된 경로계수 값 및 T 값은 3가지 분석 도구 모두 유사한 결과를 보이는 것으로 나타났다. 따라서 이러한 결과를 바탕으로 이론적 실무적 시사점을 제시하였다.

ABSTRACT

Structural equation modeling is pointing to statistical procedures that simultaneously perform path analysis and confirmatory factor analysis. Today, this statistical procedure is an essential tool for researchers in the social sciences. There are as AMOS, LISREL and PLS representative tools that can perform structural equation modeling analysis. AMOS provides a convenient graphical user interface for beginners to use. PLS has the advantage of not having a constraint on normal distribution as well as a graphical user interface. Therefore, we compared and analyzed the three most commonly used tools (applications) in social sciences. Based on structural equation modeling, confirmatory factor analysis was performed using the IBM AMOS Ver. 23, the LISREL 8.70 and the SmartPLS 2.0. The comparative results show that LISREL has the highest explanatory power of dependent variables than other analytical tools. The path coefficients and T-values presented by the analysis results showed similar results for all three analysis tools. This study suggests practical and theoretical implications based on the results.

키워드 : 에이모스, 리즈렐, 부분 최소 자승법, 경로 분석, 구조방정식 모델링

Keywords : Analysis of moment structures, Linear structural relations, Partial least squares, Path analysis, Structural equation modeling

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Ⅰ. INTRODUCTION

In social science research, there are many researches applying SEM (structural equation modeling) for empirical analysis. The paper applying structural equation modeling is an effective method for analyzing the causal relationship between latent variables and identifying the causal relationships between latent variables and the results [1]. Today tools for analyzing structural equation modeling include PLS (partial least squares), AMOS (analysis of moment structures), and LISREL (linear structural relations). Recently, research using PLS based on the partial least squares method is increasing.

By the way, the PLS analysis method is relatively uncompromising in terms of sample size and residual distribution compared to AMOS and LISREL, and the evaluation of the theoretical structural model and the evaluation of the measurement model at the same time [2]. In addition, despite the many advantages of structural equation modeling, researchers have difficulty in analyzing research hypotheses and model tests in analytical procedures [3]. Many scholars have suggested various statistical criteria and guidelines that should be accepted for analysis procedures and results in research applying structural equation modeling. Thus, many other researchers have questioned the reliability and validity of the research results [1].

Ⅱ. RESEARCH METHODOLOGY

Using AMOS, it can easily use structural equation modeling to test hypotheses of complex variable relationships and gain new insights from the data. And, LISREL is a proprietary statistical software package used in structural equation modeling for manifest and latent variables. Also, PLS is a statistical method that bears some relation to principal components regression, instead of finding hyper planes of maximum variance between the response and independent variables, it finds a linear regression model by projecting the predicted variables and the observable variables to a new space.

One of the programs that analyze the structural equation model, AMOS utilizes a different approach from SPSS statistic. SPSS statistic uses exploratory factor analysis and AMOS utilizes confirmatory factor analysis. Confirmatory factor analysis explains the latent variables describing the measured variables, and the parts not be explained is explained by measurement error. And exploratory factor analysis is a traditional factor analysis as a method to find out appropriate potential factors when there is no existing hypothesis or theory about potential factors [4].

On the other hand, in the confirmatory factor analysis, the analysis is performed in a state in which the number of factors (latent variables) and measurement variables constituting factors are already specified. This exploratory factor analysis is a factor analysis conducted by SPSS or SAS program. Therefore, confirmatory factor analysis is similar to the theoretical verification process [5] because it emphasizes the rationale of previous studies or theoretical background. Because of these characteristics, convergent validity, discriminant validity, and reliability analysis are performed after confirmatory factor analysis is completed. In addition, model fit is also identified [4].

Structural equation modeling techniques such as LISREL and PLS are second generation statistical tools for high quality statistical analysis of multivariate study models [6]. Structural equation modeling techniques can be classified into two types. LISREL is a common equation analysis based structural equation model and PLS is a structural equation model based on a principle component which is a total variance. PLS has several other features compared to LISREL. The PLS can be analyzed even if the number of samples is small, and there is no constraint on the normal distribution of the sample distribution [7]. In addition, PLS can also build models for formation indicators. And PLS adopts a method to minimize errors of internal variables.

Ⅲ. RESULTS AND CONCLUSIONS

The raw data used in this study is an extended technology acceptance model with variables added in the TAM (technology acceptance model). This basic data consider effects of smartphone based multimedia services on continue using intention named a criterion variable. Thus, this raw data collected 150 samples from the questionnaires of residents of Busan Gyeongnam and Jeonbuk area. The model based on this methodology is shown in Figure 1. Potential variables consist of four items each are perceived usefulness, perceived ease of use, and perceived enjoyment. And, moderator variables are constructed with perceived usefulness, perceived enjoyment, and perceived value. In addition, the dependent variable is the variable of continuous use intention. Therefore, it is composed of 5 factors and 20 measurement items.

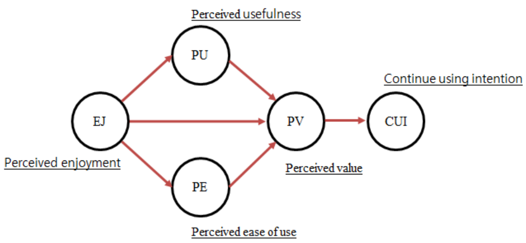

Fig. 1 Research model

On the other side, the purpose of this study is not to test the hypotheses of the research model, but to make comparative analysis using different statistical methodologies with the same basic data. Therefore, no hypothesis was set. In this study EFA (exploratory factor analysis) and reliability analysis by the varimax method are used to verify the validity of the measurement tools using the basic data based SPSS (statistical package for social science) respectively. The results of exploratory factor analysis and reliability analysis are listed Table 1.

Table. 1 Results of exploratory factor analysis

Clas.	F. L.	EJ	PV	PU	PE	CUI
EJ	EJ1	0.833				
	EJ2	0.883				
	EJ3	0.880				
	EJ4	0.840				
PV	PV1		0.788			
	PV2		0.800			
	PV3		0.641			
	PV4		0.725			
PU	PU1			0.862		
	PU2			0.845		
	PU3			0.735		
	PU4			0.668		
PE	PE1				0.623	
	PE2				0.698	
	PE3				0.872	
	PE4				0.843	
CUI	CU1					0.753
	CU2					0.776
	CU3					0.724
	CU4					0.643
Eigen value		9.667	1.905	1.662	1.569	0.933
Variance (%)		18.714	16.858	15.385	14.183	13.543
Cumulative (%)		18.714	35.572	50.957	65.140	78.682
Cronbach's α		0.953	0.898	0.888	0.844	0.879
KMO and Bartlett's Test						
Kaiser-Meyer-Olkin Measure of Sampling Adequacy						.870
Bartlett's Test of Sphericity			Approx. Chi-Square			2618.6
			Degree of freedom (df)			190
			Significance (sig.)			.000

First, the KMO index (.870), measures the number of measured variables and the number of data, is higher than the general standard of (.8), the Bartlett's test of sphericity results showed that there is a correlation between any of the measured variables with p = .000, so this data is suitable for factor analysis. Principal component analysis of factor analysis generally extracts factors with factor loading value of (.5) or more and eigen value of (1.0) or more. Therefore, we can see that most of the construction concept is not deviated. Cronbach's α coefficient was used to test the reliability of the respondent's internal consistency. The reliability test, based on the Cronbach's α coefficients of (.6) or higher, which is generally used in the social sciences. The Cronbach's α coefficients of the five conceptual variables constructed through the research model are all (.8) or more, showing very high reliability, proving that there is no problem in the (CFA) confirmatory factor analysis procedure. The results of confirmatory factor analysis, convergent validity, and discriminant validity analysis using AMOS tools is shown in Table 2. As the result of the confirmatory factor analysis, the path coefficients of the measurement variables constituting the latent variables exceeds (.7) than a general standard.

Table. 2 Confirmatory factor analysis using AMOS

Clas.	Var.	Estimate	SRS	E. Var.	CR	AVE
PU	PU4	0.671	0.450	0.550	0.889	0.671
	PU3	0.748	0.560	0.440		
	PU2	0.939	0.882	0.118		
	PU1	0.890	0.792	0.208		
	Sum	3.248	2.684	1.316		
PE	PE4	0.845	0.714	0.286	0.858	0.602
	PE3	0.734	0.539	0.461		
	PE2	0.799	0.638	0.362		
	PE1	0.720	0.518	0.482		
	Sum	3.098	2.410	1.590		
EJ	EJ4	0.870	0.757	0.243	0.951	0.830
	EJ3	0.924	0.854	0.146		
	EJ2	0.941	0.885	0.115		
	EJ1	0.907	0.823	0.177		
	Sum	3.642	3.319	0.681		
PV	PV4	0.835	0.697	0.303	0.900	0.693
	PV3	0.786	0.618	0.382		
	PV2	0.897	0.805	0.195		
	PV1	0.808	0.653	0.347		
	Sum	3.326	2.772	1.228		
CUI	CU4	0.818	0.669	0.331	0.878	0.643
	CU3	0.856	0.733	0.267		
	CU2	0.742	0.551	0.449		
	CU1	0.786	0.618	0.382		
	Sum	3.202	2.570	1.430		
Goodness of Fit		Measured Value		Cutoff		
RMR		0.161		≤.10		
RMSEA		0.123		≤.10		
GFI		0.731		≥.90		
AGFI		0.653		≥.80		
NFI		0.805		≥.90		
CFI		0.855		≥.90		
IFI		0.856		≥.90		

SRS: Standard lambda squared

The AVE (average variance extracted) which tests the convergent validity was higher than the general standard (.5). Because CR (construct reliability) is also larger than the general criterion of (.7), convergent validity was achieved. Indicators for evaluating model goodness of fit are RMR (root mean square residual, RMSEA (root mean square error of approximation), AGFI (adjusted goodness of fit index), CFI (comparative fit index), NFI (normed fit index), IFI (incremental fit index) and NFI (normed fit index), respectively. The model fit of the total measurement model can evaluated good if RMR, RMSEA ≤ (.10), AGFI ≥ (.80), and GFI, CFI, IFI, NFI ≥ (.90), respectively. In this study, the fitness index was analyzed as RMR (.161), RMSEA (.123), GFI (.731), AGFI (.653), NFI (.805), CFI (.855), and IFI (.856), respectively. Although the model fit is partially unsatisfactory, but the overall fit is interpreted as conforming to the acceptance criteria.

Table. 3 Confirmatory factor analysis using LISREL

Cla.	CUI	PV	PU	PE	EJ
CUI	1.000				
PV	0.790	1.000			
PU	0.420	0.530	1.000		
PE	0.480	0.610	0.540	1.000	
EJ	0.490	0.620	0.480	0.480	1.000
Goodness of Fit	Measured Value		Cutoff		
RMR	0.090		≤.10		
RMSEA	0.120		≤.10		
GFI	0.730		≥.90		
AGFI	0.660		≥.80		
NFI	0.920		≥.90		
CFI	0.940		≥.90		
IFI	0.940		≥.90		
CN	59.50		≥.200		

Next, Based on the same data, the analysis results obtained by using the LISREL tools are shown in Table 3 below. The table shows the correlation between the variables used in the analysis through the structural equation model. In general, when the coefficient of correlation is more than (.80), it can be considered that there is a multi-collinearity problem. In this study, there is no correlation exceeding (.80) in the correlation between the variables. Therefore, it seems that there is no problem in multi-collinearity.

In order to verify the fit of the structural equation model in this study, we used GFI, AGFI, RMSEA, RMR, NFI, CFI, IFI, and CN, respectively. In this study, the fitness index was analyzed as RMR (.090), RMSEA (.120), GFI (.730), AGFI (.660), NFI (.920), CFI (.940), and IFI (.940), respectively. As a result of the analysis, except for adjusted goodness of fit index and comparative fit index, all of the indicators were proved to be in conformity with the acceptance criteria. Based on the results of this analysis the study model has proven to be suitable.

Structural equation modeling techniques can be classified into two types. One is a common factor analysis based structural equation model such as LISREL and the other is a structural equation model based on total distributed principal components such as PLS [8].

Table. 4 Confirmatory factor analysis using PLS

Clas.	Var.	O. L.	1	2	3	4	5
CUI (1)	CU1	0.856	**0.859**				
	CU2	0.830					
	CU3	0.892					
	CU4	0.856					
EJ (2)	EJ1	0.930	0.568	**0.936**			
	EJ2	0.949					
	EJ3	0.949					
	EJ4	0.917					
PE (3)	PE1	0.825	0.473	0.458	**0.834**		
	PE2	0.873					
	PE3	0.766					
	PE4	0.866					
PU (4)	PU1	0.851	0.543	0.463	0.522	**0.869**	
	PU2	0.892					
	PU3	0.893					
	PU4	0.838					
PV (5)	PV1	0.848	0.701	0.571	0.540	0.543	**0.877**
	PV2	0.923					
	PV3	0.851					
	PV4	0.885					
CR			0.918	0.966	0.901	0.925	0.930
AVE			0.738	0.877	0.695	0.755	0.769
Cronbach's α			0.881	0.953	0.855	0.892	0.900

Next, Next, Based on the same data, the analysis results obtained by using the PLS tools are shown in Table 4 below. First, in general the correlation between each measurement variable and the factor is evaluated, If the cross loadings value is more than (.5), it is estimated convergent validity. Therefore, the cross loadings value of all constructive concepts is over (.7), so it can be evaluated as having convergent validity.

The discriminant validity analysis should have a low correlation between the measurements obtained when two different concepts are measured. If the square root of the average variance extracted value is larger than the correlation coefficient between the concepts, the evaluated as having a discriminant validity [9]. The reliability evaluation is evaluated to be reliable when the Cronbach's α value and the CR value of the measured variables are generally (.7) or more and the AVE value is (.5) or more. The results of the analysis showed that the Cronbach's α value and the composite reliability value of all concepts were (.8) or more and the average variance extracted value was (.6) or more. Therefore, all items of the measurement variable can be evaluated as being reliable. The R^2 value of latent variables can be used to evaluate the fitness. If the R^2 value is .26 or "higher", it is classified as above, if it is less than .13-.26, it is classified as "middle" if it is less than .02 - .13, it is classified as "lower". As a result, the perceived usefulness, perceived ease of use, perceived value, and continued use intention were .336, .210, .467, and .491, respectively. As a result, the analysis showed higher fitness. Here is a summary of confirmatory factor analysis based on structural equation modeling between analysis tools.

Finally, statistical significance can be verified through the t-value provided through path analysis of the structural model. The results of path analysis using AMOS, LISREL and PLS, which is an analysis tool of structural equation modeling, are shown in Table 5 below. As mentioned earlier, in this study hypothesis testing is omitted because it is meaningless. Among the studies in social sciences, it is of utmost concern to identify the effect of independent variables on dependent variables. The results of comparative analysis of three structural equations modeling analysis tools are as follows.

First, the analysis application LISREL and PLS provides the path coefficient, T-value, and R^2, but AMOS does not present the R^2 value. The value of R^2 means the explanatory power of the construct. Therefore, AMOS has the disadvantage that it must be described as T-value instead of R^2 value. If you are not satisfied, you have to choose another alternative. As a result of using all three analytical tools, we can say that both advantages and disadvantages exist.

Second, looking at the analysis results in detail, it can be confirmed that the indicator has not much difference in size. The comparative results show that LISREL has the highest explanatory power of dependent variables than other analytical tools. The path coefficients and T-values presented by the analysis results showed similar results for all three analysis tools.

Lastly, the purpose of this study was to compare analyze three representative analytical applications using structured equation modeling using the same data. Therefore, we have not found any special superiority among the three analysis tools.

REFERENCES

[1] I. J. Kim, G. Y. Min and H. S. Shim, "The Structural Equation Modeling in MIS: The Perspectives of Lisrel and PLS Applications," *Journal of Information Technology Services*, vol. 10, no. 2, pp. 203-221, Jun. 2011.

[2] H. Baumgartner, and C. Homburg, "Applications of Structural Equation Modeling in Marketing and Consumer Research: A Review," *International Journal cf Research in Marketing*, vol. 13, no. 2, pp. 139-161, Apr. 1996.

[3] W. W. Chin, *The Partial Least Squares Approach to Structured Equation Modeling*. G. Marcoidids (Ed), New Jersey, NJ: Erlbaum Associates, 2015.

[4] C. H. Choi and Y. Y. You, "The Study on Comparative Analysis of the Same Data through Regression Analysis Model and Structural Equation Model," *Journal of Digital Convergence*, vol. 14, no. 6, pp. 67-175, Jun. 2016.

[5] C. D. Stapleton, *Basic Concepts and Procedures of Confirmatory Factor Analysis*, Paper Presented at the Annual Meeting of the Southwest Educational Research Association, Austin, :TX, 1997.

[6] R. P. Bagozzi, and C. Fornell, *Theoretical Concepts, Measurements, and Meaning*, In C. Fornell (Ed.), A Second Generation of Multivariate Analysis: Measurement and Evaluation, New York, NY: Praeger, 1982.

Table. 5 Path comparison analysis among AMOS, LISREL, and PLS

Clas.	AMOS		LISREL			PLS		
Paths	Path Coef.	T-value	Path Coef.	T-value	R^2	Path Coef.	T-value	R^2
EJ→PE	0.478	5.320	0.480	5.150	0.230	0.458	4.365	0.210
EJ→PU	0.342	3.504	0.280	3.240	0.360	0.283	2.198	0.336
PE→PU	0.276	3.030	0.410	4.230		0.393	3.777	
EJ→PV	0.343	3.565	0.370	4.440	0.530	0.337	2.779	0.467
PU→PV	0.197	1.972	0.170	1.960		0.256	1.988	
PE→PV	0.354	3.865	0.340	3.600		0.252	2.577	
PV→CUI	0.879	8.876	0.790	8.510	0.630	0.701	11.801	0.491

[7] W. W. Chin, *The Partial Least Squares Approach to Structural Equation Modeling*, In G. A. Marcoulides (Ed.), New Jersey, NJ: Lawrence Erlbaum, 2015.
[8] S. T. Nam and C. Y. Jin, "Factors Influencing on Continuous Usage Intention of Smartphone Based on the TAM (Technology Acceptance Model)," *Journal of the Korea Institute of Information and Communication Engineering*, vol. 21, no. 11, pp. 2076-2082, Nov. 2017.
[9] V. Sujatha, "Auditing of Storage Security on Encryption TORAGE SECURITY ON ENCRYPTION," *Asia-pacific Journal of Convergent Research Interchange*, vol. 3, no. 2, pp. 1-9, Jun. 2017.

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