A Replication of Perceived Usefulness and Perceived Ease of Use Measurement*

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ABSTRACT

This paper presents the results of a replication of construct measurement of perceived usefulness and ease of use. This replication extends the work of recent research which examined these constructs through structural equation modeling. This research uses a new data set for two different technologies in conducting the replication of the construct measurement. The results of the construct measurement for perceived usefulness and ease of use in this research are quite consistent with the results reported in recent research with minor variations. Perceived usefulness, and not ease of use, is a determinant of predicted future usage.

Subject Areas: MIS/DSS, Statistics, and Technology and Innovation.

INTRODUCTION

In the technology adoption model (TAM) [10], perceived usefulness and perceived ease of use of computer systems are two variables that influence behavioral intentions to use computer technology. Research has shown that perceived usefulness is a primary determinant and perceived ease of use is a secondary determinant of intentions to use technology [9]. As these variables are latent, structural equation modeling has been used to measure the relationship between usefulness, ease of use, and usage [1].

Recently, the ease of use and usefulness construct measurement is examined through the use of confirmatory factor analysis [15]. These authors respecify the original two factor usefulness and ease of use model as a three factor usefulness, ease of use, and effectiveness model based on the application of confirmatory factor analysis to the original data set of [1]. In conclusion, two areas of future research are mentioned in [15]. First, "no absolute measures for these constructs exist across varying technological and organizational contexts" [p. 525] and hence there is a need to replicate the research in [15] using a data set different from the original data set in [1]. Second, the IS community needs to further explore the nature and specific influences of factors that affect technology acceptance. Hence, the confirmatory measurement model replication needs to be extended to determine the effect of usefulness and ease of use on predicted future usage of technology.

In this research note, we extend the research study in [15] by:

1. Replicating the confirmatory factor analysis with different data;

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2. Determining the effect of perceived usefulness and ease of use constructs obtained in (1) above on the predicted future usage of information technology; and
3. Comparing the results in (1) and (2) above using the established criteria of [3]. Standard criteria values are presented based on a Monte Carlo study of several LISREL models used in previous research [3]. These criteria values are used in organizational research to evaluate the goodness-of-fit of LISREL model results (e.g., [12]).

The effect of perceived usefulness and ease of use on intent for current system usage has been studied in previous research [1] [9] [10]. The effect of perceived usefulness and ease of use on predicted future usage has been studied in [9]. However, to the author's knowledge, the effect of perceived usefulness and ease of use on predicted future usage through the use of structural equation modeling and the standard criteria in [3] has not been studied. The study of perceived usefulness and ease of use on predicted future usage would help not only to measure current intentions to use technology, but also to predict future intentions for technology usage. The prediction of future usage is valuable to management as it will help them understand acceptance and usage of the technology in future years.

RESEARCH SETTING AND DATA COLLECTION

Voice mail and customer dial up systems are chosen as two diverse communication technology channels for this research study. Voice mail is based on oral, voice communication while customer dial up system is based on written communication. An organization using voice mail and another using customer dial up agreed to participate in this study.

A survey instrument was designed to collect data on all the measures for the three constructs used in this study. A coordinator from each of the two organizations took an active part in the survey design, pretesting, pilot study, survey administration, and data gathering and validation.

The voice mail survey was distributed to 102 subjects and 75 responded for a response rate of 73.53 percent. The customer dial up survey was distributed to 200 subjects and 104 responded for a response rate of 52 percent.

Voice Mail System

The voice mail system is used by the customers of the organization to contact customer service personnel. The voice mail is a ROLM based system. Features include the ability to listen to messages, with the option of saving, deleting, or replying to each message. Messages can be recorded and sent to one user or a group of users. Messages can be marked urgent for special delivery or can be delivered at some time in the future. Personalized greetings can be changed at any time and individual user's phones can be set to answer or not answer at any time. Security features include password protected access to messages. The system is designed to allow the user to transfer out to a receptionist at any time.

Customer Dial Up System

This system is provided to distributors of the organization's product. It gives the distributors most of the information that, in the past, they would have to obtain by

phone. The system is intended to provide the distributors with a direct link into the organization's pricing, inventory, packaging, and order systems without having to contact a single salesperson. This system is useful to the distributors because they have the ability to obtain information while they are on the phone with their customers. The information that the distributors find most useful include the cost and resale prices, immediate availability, inventory quantity, packaging, and returnable part status. This is an improvement over the prior method of taking all the information from the customer, calling the salesperson for the pricing and availability, waiting for the salesperson to gather all the data, and placing a return call to apprise the distributor on the status of each of the parts in question.

CONFIRMATORY MEASUREMENT MODELING OF PERCEIVED USEFULNESS AND EASE OF USE

Structural equation modeling is a statistical method that provides researchers with a comprehensive means of assessing and modifying theoretical models [4]. This approach is also referred to as the holistic construal of representing and testing organizational theories [5]. The model-building task can be thought of as the analysis of two conceptually distinct models [4] [14]. A confirmatory measurement, or factor analysis, model specifies the relations of the observed measures to their posited underlying constructs. Then, a confirmatory structural model specifies the causal relations of the constructs to one another.

This recommended two-step approach in model building [4] is followed in this research and the results are presented accordingly. First, the confirmatory measurement models for the perceived usefulness, ease of use, and predicted future usage constructs are developed and tested for the voice mail and customer dial up samples. Second, the effect of perceived usefulness and ease of use on predicted future usage is tested using the confirmatory structural model for the two samples.

Perceived Usefulness, Ease of Use, and Future Usage Measurement for Voice Mail

An instrument to measure perceived usefulness and ease of use is presented in [10]. The psychometric properties of the instrument have been confirmed by [1], [9], and [15]. A confirmatory factor analysis of all the measures in [10] resulted in a model with poor fit [1] [15] and suggested a need for respecification of the measurement model [15].

A confirmatory factor analysis of all the measures in [9] and [10] for voice mail sample resulted in the pattern of residuals that exceeded the cut-off value of 2.58 [14] as shown in Table 1.

As the standardized residuals for the usefulness scale measures "works more quickly," "improves performance," and "useful in job" are above 2.58 in more than one instance as shown in Table 1, these measures are eliminated. These measures also have residuals above 2.58 in their interactions with ease of use measures (Interaction clear and understandable and Easy to do). In addition, "Improves job performance" also has a residual above 2.58 in its interaction with "Job productivity." The usefulness construct for voice mail uses the two measures (Easier to do job, Job productivity) that are also confirmed in [15] and has Job effectiveness as the additional measure for usefulness.

Table 1: Pattern of residuals that exceeded the cutoff value.

Variables	A	B	C	D	E
A. Useful in job		3.824	2.607		
B. Work more quickly	3.824		2.767	2.614	2.728
C. Interaction clear and understandable	2.607	2.767			
D. Easy to do		2.614			3.125
E. Improves job performance		2.728		3.125	

The standardized residuals for "Easy to do" and "Interaction clear and understandable" for the ease of use scale are greater than 2.58 in their interactions with the three usefulness scale measures resulting in the elimination of these two variables. The ease of use construct for voice mail has flexibility as an additional measure to the three measures that are also confirmed (Easy to use, Learning to operate, Skillful) in [15]. Appendix 1 presents the measures used for perceived usefulness and ease of use in this research. The construct measurement for perceived usefulness and ease of use for voice mail has close agreement to the construct measurement of these two constructs in [15].

The resulting fit is evaluated using the goodness of fit index (GFI), Adjusted Goodness of Fit Index (AGFI), probability of chi-square value (PRCHI), root mean square residual (RMR) [14], and AIC [2]. These values (except AIC) are compared with the criteria used in [1] and the standard values expected based on a Monte Carlo study of several LISREL models used in previous research [3]. The criteria and standard values are shown in Table 2.

Table 3 presents the standardized loadings with their *T*-values indicated in parenthesis and squared multiple correlation values for the two factor model. The two factor confirmatory analysis solution of the seven variables for usefulness and ease of use has a chi-square of 14.47 with 13 degrees of freedom. The three factor model has a chi-square of 27.77 with 17 degrees of freedom. A significant chi-square reduction points to a model of better fit [4] [15]. The two factor model provides a significant chi-square reduction of 13.30 with 4 degrees of freedom (p=.01) over the three factor model pointing to the better fit of the two factor model. The AIC value of the two factor model is lesser than the AIC of the three factor model (Table 4) showing the better fit of the two factor model. Table 4 presents the PRCHI, GFI, AGFI, RMR, and AIC values associated with the two factor and three factor models.

The GFI and AGFI values of the two factor model are higher than the standard values for a sample size of 75 as shown in Table 2. The RMR and PRCHI values of the two factor model are slightly lesser than the standard values. The GFI, AGFI, RMR, and PRCHI values in Table 4 easily satisfy the criteria in [1].

The PRCHI, GFI, AGFI, and RMR values for the three factor model are lesser than the corresponding values for the two factor model. It is thus clear from the comparison in Table 4 that the two factor model has a better fit than the three factor model used in [15]. However, it should be noted that the three factor model does have an acceptable fit as it satisfies the criteria in [1].

Reliability, convergent validity, and discriminant validity are then tested for the two factor model. All the squared multiple correlations in Table 3 are quite high (>.6)

Table 2: LISREL model evaluation criteria

	PRCHI	GFI	AGFI	RMR
Anderson and Gerbing [3] standard values				
Sample size=75	.464	.936	.880	.05
3 measures	.461	.948	.902	.048
4 measures	.416	.918	.874	.054
Criteria used in Adams, Nelson, and Todd [1]				
Chi-square/*df* < 5	> .05	> .9	> .8	< 1.0

Table 3: Standardized loadings and squared multiple correlations.

Variables	Ease of use	Usefulness	Squared Multiple Correlation
Learning to operate	.824 (10.821)		.679
Flexibility	.779 (9.303)		.607
Skillful	.914 (11.958)		.836
Easy to use	.956 (12.748)		.915
Job productivity		.899 (12.321)	.808
Job effectiveness		.938 (16.19)	.880
Easier to do job		.974 (17.734)	.949

Table 4: Goodness of fit values for voice mail.

Research Study	PRCHI	GFI	AGFI	RMR	AIC
(2 factor model) Sample=75	.342	962	.918	.032	-11.53
(3 factor model) Sample=75	.102	.927	.846	.025	-6.23

which is indicative of high reliability [7] [12] [14]. The coefficient of determination for all the variables is .998 which signifies high reliability [7]. Convergent validity is assessed from the measurement model by determining whether each measure's estimated loading on its posited underlying factor is significant [4] (significant when T-value > 2 [14]). All the factor loadings in Table 3 are significant, thus demonstrating convergent validity.

Discriminant validity is assessed for two estimated constructs by constraining the estimated correlation between them to 1.0 and then performing a chi-square difference test on the values obtained for the constrained and unconstrained models [13]. The chi-square difference between the models always has one degree of freedom. A significantly lower chi-square value for the model in which the construct correlations are not constrained to one indicates that the constructs are not perfectly correlated and that discriminant

validity is achieved [5]. The chi-square difference is quite large and significant at 55. This result demonstrates discriminant validity between the two constructs.

Future Usage Construct for Voice Mail Sample

Appendix 1 presents the measures used for predicted future usage which are based on the research work of [8]. Table 5 presents the factor loadings for the predicted future usage construct. Both the squared correlations are quite high (>.6) signifying high reliability. The total coefficient of determination for this construct is .968 which indicates high reliability. The parameter estimates for both the measures are statistically significant showing convergent validity. Chi-square differences between future usage and ease of use is 45.23 and the chi-square difference between future usage and usefulness is 25.39. Discriminant validity is thus present as the future usage construct differed from the usefulness or ease of use constructs as demonstrated by these significant chi-square differences.

Perceived Usefulness, Ease of Use, and Future Usage Measurement for Customer Dial Up System

A confirmatory factor analysis of all the measures in [9] and [10] for customer dial up data resulted in the pattern of residuals that exceeded the cut-off value of 2.58 [14] as shown in Table 6.

It is clear from the pattern of residuals above that all the variables in Table 6 need to be eliminated. The usefulness construct for customer dial up uses "Easier to do job," "Job productivity," and "Job effectiveness" as its measures. The ease of use construct for customer dial up uses "Easy to use," "Learning to operate," "Skillful" and "Flexible" as its measures. The measures for both constructs are the same for voice mail and customer dial up technologies.

The two factor confirmatory analysis solution of the seven variables for usefulness and ease of use has a chi-square of 13.38 with 12 degrees of freedom. The three factor model has a chi-square of 28.77 with 17 degrees of freedom. The two factor model provides a significant chi-square reduction of 15.39 with 5 degrees of freedom (p=.01) over the three factor model pointing to the better fit of the two factor model. The AIC value of the two factor model is lesser than the AIC of the three factor model (Table 8) showing the better fit of the two factor model. Table 7 presents the standardized loadings with their T-values indicated in parenthesis and squared multiple correlation values for the two factor model. Table 8 presents the PRCHI, GFI, AGFI, RMR, and AIC values associated with the two and three factor models.

The GFI and AGFI values for the two factor model are higher than the standard values for a sample size of 75. The RMR and PRCHI values for the two factor model are slightly lesser than the standard values. The GFI, AGFI, RMR, and PRCHI values easily satisfy the criteria in [1]. The PRCHI, GFI, AGFI, and RMR values for the three factor model are lesser than the corresponding values for the two factor model. Hence, it is clear that the two factor model has a better fit than the three factor model used in [15].

The reliability and convergent and discriminant validities are then assessed. All the squared multiple correlations in Table 7 are quite high (>.6) which is indicative of high

Table 5: Standardized loadings and squared multiple correlations.

Variables	Standardized Loadings	Squared Correlation
Likelihood of future use	.983 (9.103)	.967
Probability of future use	.802 (6.557)	.644

Table 6: Pattern of residuals that exceeded the cutoff value.

Variables	A	B	C	D	E
A. Useful in job		3.086	2.626		
B. Work more quickly	3.086				2.854
C. Interaction clear and understandable	2.626			4.077	
D. Easy to do			4.077		-3.025
E. Improves job performance		2.854		-3.02	

Table 7: Standardized loadings and squared multiple correlations.

Variables	Ease of Use	Usefulness	Squared Multiple Correlation
Learning to operate	.833 (9.421)		.694
Flexibility	.662 (6.501)		.682
Skillful	.956 (10.725)		.915
Easy to use	.883 (9.711)		.780
Job productivity		.973 (19.23)	.947
Job effectiveness		.926 (17.222)	.857
Easier to do job		.945 (19.015)	.893

reliability. The coefficient of determination for all the variables is .998 which signifies high reliability. All the factor loadings in Table 7 are significant, thus demonstrating convergent validity. The chi-square difference of 39.54 is indeed significant, demonstrating discriminant validity between the two constructs.

Future Usage Construct for Customer Dial Up Sample

Table 9 presents the factor loadings for the predicted future usage construct. Both the squared correlations are greater than .6 signifying high reliability. The total coefficient of determination for this construct is .972 which indicates high reliability. The parameter estimates for both measures are statistically significant showing convergent validity. Chi-square difference between future usage and ease of use is 35.46, and between future usage and usefulness is 18.41. Both these values are significant and hence discriminant validity is present between future usage and usefulness or ease of use constructs.

Table 8: Goodness of fit values for customer dial up sample.

Research Study	PRCHI	GFI	AGFI	RMR	AIC
(2 factor model) Sample=104	.342	.952	.887	.026	-10.62
(3 factor model) Sample=104	.062	.918	.827	.025	-5.23

Table 9: Standardized loadings and squared multiple correlations.

Variables	Standardized Loadings	Squared Correlation
Likelihood of future use	.902 (8.452)	.914
Probability of future use	.842 (6.361)	.710

Table 10: Goodness of fit values for structural models.

Research Study	PRCHI	GFI	AGFI	RMR
Voice mail sample	.257	.946	.897	.05
Customer dial up	.215	.926	.880	.034

Construct Reliability

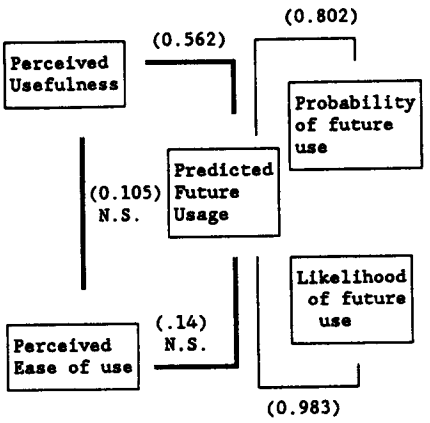
Cronbach alpha values for the three constructs used in voice mail are obtained. The alpha for perceived usefulness is .9637, alpha for perceived ease of use is .9027, and alpha for future usage is .8561. The alpha values for customer dial up sample are .9551 for usefulness, .9234 for ease of use, and .8638 for future usage. The alpha values for usefulness and ease of use constructs in this research are quite close to the alpha values for the instruments in [9] and [11].

THE EFFECT OF PERCEIVED USEFULNESS AND EASE OF USE ON PREDICTED FUTURE USAGE

The best structural model is obtained through sequential chi-square difference tests starting with the null model which has no common factors and proceeds with the comparison of alternative models in a decision tree fashion [4]. Figure 1a presents the confirmatory structural model results for voice mail data and Figure 1b presents the model for customer dial up sample.

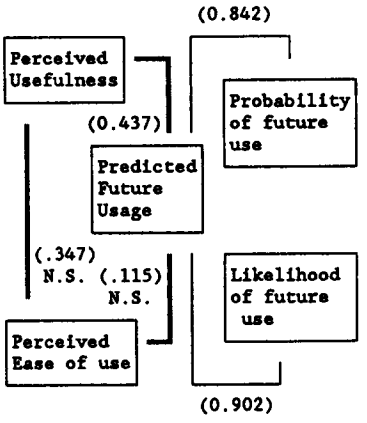
The goodness of fit of the models in Figures 1a and 1b are evaluated and the results are shown in Table 9. The voice mail model has a chi-square value of 26.73 with 23 degrees of freedom and the customer dial up model has a chi-square of 28.83 with 22 degrees of freedom.

Figure 1a: Confirmatory structural model for voice mail sample.



*N.S.—Not Significant

Figure 1b: Confirmatory structural model for customer dial up sample.



*N.S.—Not Significant

The GFI and AGFI values of voice mail and customer dial up models are higher than the standard values for a sample size of 75. The RMR value of voice mail is the same as the standard value, and the RMR for customer dial up is lesser than the standard value in Table 2. The PRCHI value for voice mail and customer dial up, however, is lesser than the standard value for PRCHI in Table 2.

Bentler and Bonett [6] provide an incremental fit index (RHO) which represents the increment in fit obtained by using k common factors rather than none. The model with no common factors is called the null model. If Q_0 is the ratio of the chi-square to its

degrees of freedom for the null model and Q_k is the ratio of the chi-square to its degrees of freedom for the k factor model (our research model has three factors), then *RHO* is:

$$RHO = (Q_0 - Q_k) / (Q_0 - 1).$$

The *RHO* value for the voice mail model is .951507159 and the *RHO* value for customer dial up is .922621263. Acceptable *RHO* value for a sample size of 75 is 1.05 [3]. The standard *RHO* values for three measures for a factor is 1 and for four measures is 1.01 [3].

The total coefficient of determination for the structural equations among the factors is only .353 for voice mail and .258 for customer dial up sample, respectively. This result indicates that perceived usefulness and ease of use are not the only factors that impact predicted future usage. There are other constructs that influence future usage that are not accounted for in this research.

The association between ease of use and usefulness is not significant in our research findings. The correlation between these constructs are .105 for voice mail and .347 for customer dial up sample. Associations of higher magnitude between ease of use and usefulness for voice mail are obtained in [1]. However, the goodness of fit for their chi-square models are much lower than the expected standard goodness of fit values in [3].

SUMMARY AND DISCUSSION

"The tendency of IS researchers to become complacent or discouraged with progress in a specific area after conducting what would be considered a limited number of studies in other domains should be challenged. We should begin to focus on replication, refinement, and development of models and measures" [1, p. 245]. "Measurement models must be rigorously assessed and, if necessary, respecified" [15, p. 525]. This research presents the results of a replication of the construct measurement of perceived usefulness and ease of use followed by the effect of these two constructs on predicted future usage.

The results of the construct measurement for perceived usefulness and ease of use in this research are quite consistent with the results in [15] with minor variations. As the construct measurement is quite robust and holds good for both voice mail and customer dial up technologies from two organizations, information systems researchers can use the perceived usefulness and ease of use constructs in varying technological and organizational contexts. However, minor changes may be necessary in some of the variables used in measuring these constructs.

Organizational research in its presentation of LISREL model results provide comparison of the results with the standard criteria in [3] (see also, [12]). MIS research should also provide such a comparison. Our model results do fare well in comparison to the criteria of [3] and the criteria used in [1].

The results of this study also indicate that perceived usefulness is a determinant of predicted future usage for both voice mail and customer dial up technologies. Earlier studies have shown that perceived usefulness is a determinant of behavioral intentions to use technology and system usage [1] [9] [10].

Perceived ease of use did not have a significant effect on predicted future usage. There could be two reasons for this finding. First, both voice mail and customer dial

up systems are communication technologies which are much easier to use than software packages such as Harvard Graphics or spreadsheets that were studied in [1]. Even though we do not have an empirical study to support this reasoning, we base our reasoning on the experience of users with these technologies and our experience in teaching these technologies in the classroom. One reason for the relative ease of use could be that voice mail or customer dial up systems come with far less user documentation than software packages like Harvard Graphics. If the technology by its inherent nature is relatively easy to use, ease of use would have less or no impact on usage. Second, both voice mail and customer dial up systems were in use for about 18 months before this study. Ease of use is an important determinant of usage only in the earlier stages of the use of the system and becomes non-significant with prolonged exposure to the system [9]. [Received: March 29, 1993. Accepted: December 5, 1994.]

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APPENDIX 1
Perceived Usefulness, Ease of Use, and Predicted Future Usage Measures

Scale Used

1	2	3	4	5	6	7
Strongly Agree	Moderately Agree	Slightly Agree	Neutral	Slightly Disagree	Moderately Disagree	Strongly Disagree

Perceived Usefulness

1. Using voice mail (customer dial up) increases productivity.
2. Using voice mail (customer dial up) enhances my effectiveness on the job.
3. Using voice mail (customer dial up) makes it easier to do my job.

Perceived Ease of Use

4. Learning to operate voice mail (customer dial up) was easy for me.
5. I find voice mail (customer dial up) to be flexible to interact with.
6. It was easy for me to become skillful at using voice mail (customer dial up).
7. I find voice mail (customer dial up) easy to use.

Predicted Future Usage

1. I predict I will use voice mail (customer dial up) on a regular basis in the future.

1	2	3	4	5	6	7
Likely						Unlikely

2. I predict I will use voice mail (customer dial up) on a regular basis in the future.

1	2	3	4	5	6	7
Likely						Unlikely

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