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A Primary Study of Attributes of Innovations during the Prediffusion Stage

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ABSTRACT

We provide a theoretical model for testing the adoption of information technology during the prediffusion stage (research and development and early trials) of an innovation. The model was tested using Linux based applications of Open Source Software (OSS). The results of surveying 1000 members of the Linux User Groups WorldWide (LUGWW) are presented. This study is significant because it provides empirical evidence that attributes of innovations correlate with adoption during the prediffusion stage (research and development) of an innovation. This extends diffusion of innovations research and has important implications for DOI theory and practice.

INTRODUCTION

The purpose of this study was to fully test the predictive ability of Diffusion of Innovations (DOI) theory. We investigate attributes of innovations during the prediffusion stage of an innovation; Rogers characterize this stage as when an innovation is in "research and development" or when test marketed or in early evaluation trials" (Rogers, 2003). Rogers indicated that previous studies performed on attributes of innovations by themselves were "incomplete" for testing the full predictive ability of DOI theory (Rogers, 2003). Past research on attributes of innovations was conducted only on innovations after they had been adopted and appear to be postdictive and not predictive studies (Rogers, 2003). Rogers further states that research on predicting an innovation adoption would be more valuable if data on the attributes of the innovation were gathered prior to or concurrently with, individuals' decisions to adopt the innovation. "One approach that would be useful for helping predict into the future would be to investigate the acceptability of an innovation in its prediffusion stage (research and development or early trials)." (Rogers, 1995, p.211) To complete this testing we constructed a theoretical structural model using attributes of innovations as the theoretical construct and investigate the acceptability of an information technology innovation during its prediffusion stage (research and development or early trials).

Attributes of Innovations during Prediffusion

Rogers states that the usefulness of research on the attributes of innovations is mainly to predict an innovation's rate of adoption and use (Rogers, 2003). "Most past research, however, has been postdiction, not prediction" (Rogers, 2003, p. 210). That is, the attributes of innovations are considered independent variables in explaining variance in the dependent variable rate of adoption of innovations. However, the dependent variable (*rate of adoption*) is measured in the past and independent variables (*attributes of innovations*) are measured in the present; so attributes can hardly be predictors of the rate of adoption (Rogers, 2003). According to Rogers, an ideal research design would measure the attributes of innovations at t_1 in order to predict the rate of adoption for these innovations at t_2. Several approaches are useful for helping predict into the future:

- Extrapolation from the rate of adoption of past innovations into the future for other similar innovations.
- Describing a hypothetical innovation to its potential adopters and determining its perceived attributes, to predict its rate of adoption.
- Investigating the acceptability of an innovation in its prediffusion stages or in early stages of diffusion such as when it is just being test-marketed and evaluated in trials.

As suggested, we select Rogers' third approach and investigate the acceptability of an innovation in its prediffusion stage (research and development or in early trials) to complete the testing of the predictive ability of innovation diffusion theory (Rogers, 1995).

Attributes in Theory

The perceived attributes of innovations are one of the most important explanations of the rate of adoption of an innovation (Rogers, 1995). "From 49 to 87 percent of the variance in rate of adoption is explained by five attributes as perceived by individuals, [this helps] to explain their different rate of adoption" (Rogers, 2003, p. 210). Rogers describes the five main attributes of innovations that individuals perceive in the decision-making process to adopt an innovation as:

- Relative advantage: the degree to which an innovation is perceived to be better than the idea it supersedes.
- Compatibility**:** the degree to which an innovation is perceived as being consistent with the existing values, past experiences and needs of potential adopters
- Complexity**:** the degree to which an innovation is perceived as being relatively difficult to understand or use.
- Observability: the degree to which an innovation is actually visible by others.
- Trialability: the degree to which an innovation may be experimented with prior to adoption (Rogers, 2003).

However, these attributes of innovations described by Rogers as succinct perceptions of innovations have raised questions about their validity for studying adoption in *all* situations (Rogers, 1983). It has been debated that these attributes of innovations may not be the ones of particular interest in *all* cases (Moore & Benbasat, 1990). A review of previous studies shows a

disposition toward other attributes being investigated not just those identified by Rogers (1983). Please refer to Moore and Benbasat (1991), Taylor and Todd (1995), Agarwal and Prasad (1997), Karahanna, Straub and Chervany (1999), Van Slyke, Lou, and Day (2002), Carter and Belanger (2004), Akbulut and Motwani, (2005), Wood and Moreau, (2006), Compeau, Meister and Higgins, (2007) and Gounaris and Koritos (2008). The question that has persisted is how can five generalized, albeit succinct, perceived characteristics of innovations are applied universally. Rogers emphasizes that, for the most part, the attributes of an innovation could still be described by his five elements (Rogers, 2003).

Other Attributes

Moore and Benbasat and others in their research on attributes of innovations identified three additional attributes that they elicited from users. Please refer to Davis (1986), Davis, Bogozzi and Warshaw (1989), Moore and Benbasat (1990, 1991). They elicited these attributes from users during their development of a test instrument for information system innovations where complex organizational decision-making was involved; they are *image, results demonstration and voluntariness.* The definitions of those attributes are:

- Image: the degree to which it is important to be seen using.
- Result Demonstration: the degree to which an innovation is perceived as providing tangible evidence of its benefits.
- Voluntariness: the degree to which use of an innovation is entirely voluntarily.

Agarwal and Prasad (1997), Carter and Belanger (2004), Chiasson and Lavato (2001) Karahanna, Straub and Chervany (1999) made use of these attributes in their studies. Van Slyke, Lou and Day (2002) did not include *image* because Rogers considered that attribute covered under relative advantage (Rogers, 2003). We follow that method and do not include *image* in this study. This was done to provide external controls for our study. A theoretical structural model to test seven attributes of innovations during prediffusion stages: *relative advantage, compatibility, complexity, result demonstration, trialability, observability and voluntariness* was developed. Other attributes are also continuing to be identified, Wood and Moreau, (2006) Compeau, Meister and Higgins, (2007) and Gounaris and Koritos (2008).

ELEMENTS OF DIFFUSION

There are four elements of Diffusion of Innovations. They are the innovation, channels of communications, time and a social system (Rogers, 2003). These four elements are identifiable in every diffusion research study and in every diffusion program. Rogers defines an *innovation* as an idea, practice, or object that is perceived as new to an individual or another unit of adoption. He defines *communication channels* as the means by which messages about an innovation get from one individual to another formal mass communications or informal interpersonal communications. *Time* is defined as that period when individuals adopt an innovation. A *social system* is defined as set of interrelated units that are engaged in joint problem solving to accomplish a common goal. They may be individuals, informal groups, organizations and/or subsystems. These elements supply the framework to understand the development of the theoretical structural model of the study.

THEORETICAL MODEL

The framework consists of the four elements of diffusion of innovations. They are (1) the innovation (Open Source Software that is in research and development or early trials); (2) the channels of communications (formal and informal); (3) the time (prediffusion stage) and (4) a social system (LUGWW). Our model investigates the correlation between *attributes of innovations* and *use intention* within the aforementioned theoretical framework during prediffusion stage (research and development or early trials). Our investigation of attributes is similar to past studies. However, it is important to emphasize that the "stage" of the diffusion of the innovation is very different is our study. We investigate *attributes of innovations* and *use intention* during the prediffusion stage (research and development) and not during the diffusion stage (full commercialization) of an innovation. By studying *attributes* and *intention to use* during prediffusion stage (research and development or early trials) according to Rogers the results of that study would be truly predictive not postdictive, after the innovation has already been adopted as in previous studies (Rogers, 2003). We use the independent variables: *relative advantage, compatibility, and complexity, result demonstration, observability, trialability, and voluntariness.* The dependent variable in our study is *intention to use. Intention to* use during prediffusion (research and development or early trials) is defined as the degree to which an individual indicates their likelihood of adopting an innovation based on its research and development information. Agarwal and Prasad (1997, 2000), Carter and Belanger (2004), Moore and Benbasat (1991), Karahanna, Straub and Chervany (1999) and Van Slyke, Lou and Day (2002) also employed and measured a similar dependent variable. However *intention to use* in their studies was attributed to information collected during the full commercialization of the innovation they studied not on information they collected during the research and development or early trials of their innovation."

Therefore, our model expresses that during "prediffusion stage" research and development or early trials when measures between *attributes of innovations* and *use intention* are high, individuals will also be more likely to adopt the innovation.

RESEARCH HYPOTHESIS

Testable theoretical hypotheses were developed from operationalizations of the theoretical construct *attributes of innovations* (seven) and *use intention* when an innovation is in prediffusion (research and development or early trials). It is:

H_{1a}: Attributes of innovation of new information technology at prediffusion stage (research and development or early trials) are positively associated with an individual's intention to use that technology in the future.

For precision in measurement sub hypotheses for each theoretical construct were also posited. Each construct represents an attribute of innovation that was tested as an independent variable. These independent variables were measured against the dependent variable *intention to use*.

RESEARCH METHODOLOGY

An international survey was conducted using 1000 members of Linux Users Groups WorldWide (LUGWW) members (http://lugww.counter.li.org). Subjects included participants from Australia, Canada, Ireland, India, United Kingdom, United States, and Russia who use Open Source Software that is in research and development or early trials. Invitations were sent to individual project members from list servers of local chapters whose officers indicated a willingness to participate in our study. We provided access codes for security and control. Four versions of OSS license agreements were used as research and development or early trial innovations. They were the General Public License (GPL), the Lesser General Public License (LGPL), the Berkley Software Development License (BSD) and the Massachusetts Institute of Technology License (MIT). These are the *classic licenses* of OSS developers that were used most commonly used before the Mozilla Public License release in 1998. The Open Source Initiative (OSI) certify that these software licenses permit free redistribution, modification and derived works to be available under the same terms as the license of the original software. The "latest versions" of these licenses are considered by them to be in prediffusion stage (research and development or in early trials). They are not mass marketed nor are they fully commercialized innovations. Some forms of these licenses are used by commercial organizations such as Red Hat, SUSE and Mandrake to provide support for their distribution of the OSS/Linux Operating System (Linux) software. However, the majority of these licenses are used to distribute open source software for research and development. Open Source developers now use these licenses to distribute their research and development software ubiquitously for free.

Demographic and Social System Behavior

Demographic questions preceded the survey. These questions collected the data relating to respondent's profession, position, years of experience, gender and age. Social system behavior questions were then presented. The demographic and social system behavior inquiries were included to determine if any other variables might correlate with *use intention.* These questions

centered on when, where, why, how and with whom the innovation was discussed or encountered. Inquiries regarding the use of OSS license agreements followed.

Survey Items

Attributes were measured using Moore and Benbasat's 34-item survey instrument. Moore and Benbasat (1991), Agarwal and Prasad (1997), Carter and Belanger (2004), Chiasson and Lavato (2001), Karahanna, Straub and Chervany (1999) and Van Slyke, Lou and Day (2002) also used this survey instrument. Additionally, validated items of Agarwal and Prasad (1997), Carter and Belanger (2004), Chiasson and Lavato (2001), Karahanna, Straub and Chervany (1999) and Van Slyke, Lou and Day (2002) were added to Moore and Benbasat's instrument (Moore & Benbasat, 1991). Our final questionnaire was a 39-item prevalidated survey instrument, consistent with the previous studies. Validity and reliability measurements for each construct were measured.

Survey Administration

We pilot tested the survey by emailing 100 LUGWW members; 23 responded. Feedback on the number of questions, format of scales, and question ambiguity was analyzed. Only a few changes were required to clarify ambiguity. One thousand subjects were invited to participate in our study. One hundred and two responses were returned within the three-week response time for our study. All 102 surveys had completed records and all respondents were OSS users. That equated to a 10.2% response rate. Three (3) responses were received after the deadline and were not used. No significant difference was observed from t-tests performed to determine non-response bias. However, even with these tests, non-response bias could still exist and needs to be taken into consideration when interpreting these results. Overall, 56% of the responses were received from within the United States. Table 1 provides a demographic summary of respondents.

Table 1: Channels of Communication and Social System Behavior Summary.

Category	**Frequency**	**Percent**		**Frequency**	**Percent**
Employee Classification			**Age**		
IT Professional	61	59.8	<21	4	3.9
Administrative/Other	14	13.7	21-30	41	40.2
Functional	12	11.8	31-40	26	25.5
Other	15	14.7	Other	31	30.4
Industry			**Gender**		
Professional & Technical	31	30.4	Male	97	95.1
Education	22	21.6	Female	5	4.9
Information	17	16.7			
Other	30	31.3	**Years of Experience**		

Legal Structure		
Corporation	35	34.3
Government	20	19.6
Proprietorship	20	19.6
Other	25	25
Employees		
0-499	53	52
500-999	17	16.7
1,000-4,999	13	12.7
Other	19	18.6
Time Period began using OSS		
1996-2000	54	52.9
1991-1995	28	27.5
1985-1990	11	10.8
Other	9	8.8
Talk to Colleagues about OSS regularly		
Yes	102	100
0-10	50	49.5
11-20	23	22.8
21-30	23	22.8
31+	5	4.9
Attended OSS presentation		
Yes	82	80.4
No	20	9.6
Participate in OSS Projects		
Yes	54	52.9
No	48	47.1
Use OSS at Home		
Yes	102	100
No		
Prior OSS Use		
Yes	102	100
No		

RESULTS

A seven-point Likert-type scale was used to record responses to each measurement of the theoretical construct on the survey instrument. The answers provided represent the degree of respondent's agreement or lack of agreement with their perceptions of the innovation. Most scales on the survey were adapted from the instrument developed and validated by Moore and Benbasat (Moore & Benbasat, 1991). Cronbach's Coefficient Alpha was used to check the reliability of each construct scale. (Cronbach, 1970) Scale reliability range from 0.72 to 0.94 indicating that they all exhibit an acceptable level of reliability (Alpha>0.70). Nunnally (1978), Moore and Benbasat (1990), Agarwal and Prasad (1997, 2000) and Van Slyke, Lou and Day (2002) reported a similar range of scores for their scales. Our results support the assertion that attributes of innovations perform in a similar manner during prediffusion stages and diffusion stages of innovations. Performing confirmatory factor analysis, with one analysis performed for each scale further validated the scales. Due to the limitations imposed by the sample size, a single factor analysis including all measurement items was not performed. Each factor analysis used a maximum likelihood extraction, a promax rotation and extracted all factors with eigenvalues greater than one. In all scales the analysis indicated that the scale items associated with a given construct loaded on a single factor. This can be interpreted as meaning that each set of scale items measures a single construct factor. Table 2 provides a breakdown of the reliability and validity results.

Table 2: Reliability and Validity Measures.

	Primary Diffusion Studies			Prediffusion Study	
Variables	**Reliability**	**Validity**	**vs.**	**Reliability**	**Validity**
Independent					
Relative Advantage	0.95	0.70		0.94	0.71
Compatability	0.87	0.58		0.87	0.58
Complexity	0.81	-0.29		0.81	-0.27
Result demonstration	0.83	0.44		0.83	0.44
Observability	0.73	0.39		0.73	0.36
Trialability	0.84	-0.20		0.84	-0.23
Voluntariness	NA	NA		0.72	0.32
Dependent					
Intention to Use	NA	NA		0.73	-0.10

Reliability: alpha (n = 270) > 0.70 is an acceptable level [14]
Validity: Discriminant Functional Coefficients [x^2 (7) = 132, $p < 0.001$]

Theoretical constructs were operationalzed as mean responses to a number of items designed to measure the subject's agreement or lack of agreement with their perceptions of the innovation. A single value was computed for each construct by computing a mean value of each subject's responses corresponding to all items for the scale. Note that a number of items were reverse worded on the instrument. These items were re-coded before the mean was computed (see Table 3).

Table 3: Attribute Average Mean.

Variable	**Mean**	**Std. Deviation**
RELATIVE ADVANTAGE (R)	5.90	0.14
COMPATIBILITY (P)	5.87	0.13
COMPLEXITY (C)	5.34	0.41
RESULT DEMONSTRATION (D)	5.96	0.21
OBSERVABILITY (O)	5.56	0.19
TRIALABILITY (T)	6.08	0.51
VOLUNTARINESS (V)	5.22	0.35
INTENTION TO USE (I)	6.12	0.37

Regression models were created that included additional measures of the survey as possible covariates. They included demographic items and social group activity. This was done to determine if any of these measures should be included in the regression equation used to test the central hypothesis. Table 4 provides the results of the regression model tests of demographic items and social system behavior as covariates.

Table 4: Results of Covariant Significance Level Tests.

Question	**Covariate Construct**	**Significance**
Q_A	Labor Category (IT Professionals)	0.884

Q_B	Industry (Professional, Scientific & Tech	0.778
Q_C	Legal Entity (Corporation)	0.844
Q_D	Number of Employees (1-499	0.613
Q_E	Years of Work Experience (1-10)	0.983
Q_F	Used FOSS before Survey (Yes)	1.000[1]
Q_G	Age Group (21-30)	0.986
Q_H	Gender (Male)	0.334
Q_ I	Found OSS During Years (1996-2000)	0.626
Q_J	Attended OSS Presentation (Yes)	0.614
Q_K	Read Advertisements about OSS (Yes)	0.689
Q_ L	Talked to Colleagues about OSS (Yes)	1.000[1]
Q_M	Uses OSS at Home (Yes)	1.000[1]
Q_N	Uses OSS at Work (Yes)	0.785
Q_O	Participates In OSS Projects (Yes)	0.918
Q_P	Participates in OSS User groups (Yes)	0.785

[1]Note: Significance =< 1.000

Questions F, L and M [sig. =< 1.00] were classified as covariates. We included them in our regression model along with the other attributes of innovations for hypothesis and sub-hypothesis testing.

DATA ANALYSIS AND FINDINGS

The regression equation used as the basis for the test corresponds to a main least effect model. When the sample data were fit to this model the following regression equation results:

$$I=2.037R+2.092P+3.514C+1.163D+2.831O+2.003T+4.823V+4.246F+4.365L+4.336M. \quad (1)$$

In order to evaluate H_1, which states that attributes of innovations will be related to intent to use; the F test (ANOVA) was used to determine whether at least one of the terms in the model was significant. The F static value of 38.781 (degrees of freedom =7/102) that resulted is significant at an alpha <. 001. This indicates that the null hypothesis of no term in the regression model being significant can be rejected. There is an association between the attributes of innovation, additional measures and use intention during prediffusion or in early stages of diffusion.

Regression analysis was chosen as the appropriate method to test the hypotheses related to relationships between perceived attributes of innovations and intention to use the innovation in the sample data of this survey. However, a number of assumptions in regression underlie the tests used in regression analysis (Babbie, 1998). Therefore, as recommended by Babbie (1998), procedures were performed to see if the data collected meet these assumptions:

- Independent error term: Since the data analyzed in this study are not time-series, there is little chance that the value of one error term would impact the value of any other. Accordingly, the error terms can be considered independent.

- Normality: examining a normal probability plot checked the normality assumption.

- This plot graphs the expected value of residuals against actual residual values. Subsequently in the case of these data the plot is close to a straight line and the normality assumption can be considered satisfied.

- Expected value of e is zero: To check this assumption, each independent variable referred to in the hypothesis was plotted against error terms. When there is no discernible pattern to these plots, this assumption can be considered satisfied. Since there was no discernible pattern to any of these plots this assumption is satisfied.

- Multicollinearity: To check for multicollinearity, variance inflation factors (VIF) were calculated for each beta term in the regression model. When the largest of the VIF exceeds ten, then severe multicollinearity is present. However, the largest VIF was 2.89, indicating that there is little concern for problems due to multicollinearity.

The final step in the analysis was to test the significance of the attributes and covariates as theoretical constructs of the theory. These tests correspond to the Sub Hypotheses H_{1b}– H_{1k}. The null hypotheses tested, the static and significance level as indicated whether the sub hypothesis is supported (alpha<0.05) (see Table 5).

Table 5: Results of Sub Hypotheses Tests.

Construct	Sub Hypothesis	Sig.	Supported
RELATIVE ADVANTAGE	H_{1b}	0.007	Yes
COMPATABILITY	H_{1c}	0.008	Yes
COMPLEXITY	H_{1d}	0.027	Yes
RESULT DEMONSTRATION	H_{1e}	0.016	Yes
OBSERVABILITY	H_{1f}	0.036	Yes
TRIALABILITY	H_{1g}	0.057	Yes[1]
VOLUNTARINESS	H_{1h}	0.071	No
USED FOSS BEFORE SURVEY	H_{1i}	0.056	Yes[1]
TALKED TO OTHERS ABOUT FOSS	H_{1j}	0.056	Yes[1]
USED FOSS AT HOME	H_{1k}	0.056	Yes[1]

[1] Note: On further analysis this borderline variable was supported.

As shown in Table 5 the hypothesis related to Relative Advantage (H_{1b}), Compatibility (H_{1c}), Complexity (H_{1d}), Result Demonstrability (H_{1e}), Observability (H_{1f}), Trialability (H_{1g}) were supported, while Voluntariness (H_{1h}) was not supported. This was probably due to the fact that this construct is not binary, or in other words, that voluntariness is not an "either-or" perception. The results support this assertion. The mean response to the scales was 5.22 with 4.0 being a neutral response. The scores were also distributed normally (skewness was 0.04). The levels of significance for Trialability (H_{1g}), Used OSS Before Survey (H_{1i}), Talked to Others About OSS (H_{1j}) and Used OSS at Home (H_{1k}) were slightly over the cut-off point for significance (Sig.=0.05). Borderline appearances of these variables lead us to test to determine if under additional conditions these variables might be significant. Power analysis tests for effect of sample size indicated that with this sample probability of results showing greater significance

rises when sample size was increased beyond 500 respondents (probability more than 50%). Cluster analyses (K-Means) of these variables with intention to use suggested convergence also occur. Borderline variables were supported through the application of these additional tests.

LIMITATIONS OF THE STUDY

One limitation is from the methodology used. Our methodology is not appropriate for claims of causal relationships because only voluntary responses to participate in the study were collected. A different methodology must be conducted to investigate actual causality. A second limitation is that our study used Open Source Software innovations. The exact stage of these innovations may vary because the boundaries of the stages in the theory are not precise measurements and may be determined by vague observation. It would not be possible to obtain universal agreement on the stage of these innovations because these innovations have a unique feature in that they are in the public domain and not subject to normal regulations. Further research is necessary to verify whether our findings hold true for other prediffusion innovations. It may be reasonable to expect that these findings hold true in the context of information systems and technology.

Third, our unit of analysis was the individual. Therefore, results are limited to generalizations about individuals only. Generalizing our results to adoption by organizations is beyond the focus of our study. Also only three covariates were included in our regression module. Further analysis might find other covariates to include in the model. This may provide more evidence of social system functions correlating with attributes of innovations to support the predictive ability of innovations diffusion theory. Locating the covariates, however, was not one of our objectives. Lastly, our results were obtained from testing *intention to use*, even though indicators of actual use were collected. There may be potential relationships between intention to use and actual use, however causality between them requires certainty.

DISCUSSION

There are telling relationships between an individual's perceptions of attributes of innovations and their intention to use during prediffusion that can be concluded from our results. In detail, individual's perception of attributes of innovations, relative advantage (0.007), compatibility (0.008), complexity (0.027), result demonstration (0.017), observability (0.036) and trialability (0.057) have significant relationships with intentions to adopt an innovation during pre-diffusion or in early stages of diffusion. Voluntariness (0.071) was not supported in the social system. Said differently, relative advantage (0.007) and compatibility (0.008) of innovations during pre-diffusion are superior forecasters than are perceptions of complexity, result demonstrability, observability and trialability during prediffusion. This is identical to the outcomes obtained by the previously published studies during full diffusion. Relative advantage and compatibility have received the most consistent support as factors that influence use and adoption of an innovation during diffusion. (Herbert & Benbasat, 1994) Voluntariness (0.071) was uncertain in our study.

There were also meaningful relationships found with intention to use an innovation and social activity during pre-diffusion. Covariate F - Used OSS Before Taking Survey (1.000); Covariate L - Talked to Colleagues about OSS (1.000) and Covariate M - Using OSS at Home were also

found beneficial indicators of use intention along with attributes of innovations. Additionally, individuals who work in the Professional, Scientific or Technical industry as IT Professionals between 21 to 30 years of age with only 1 to 10 years of experience and who participate in OSS Projects is the profile that is consistent with early adopters of this innovation. Our observation of the demographics and social system behavior during prediffusion strengthens the support for the theory to be predictive (Jones, Berry & Yi-Fang Ku, 2003).

IMPLICATIONS FOR THEORY

We observed that perception of attributes of innovations foreshadow identical results during prediffusion stages (research and development and early trials) as they do during diffusion stages (full commercialization). Relative Advantage (0.007), Compatibility (0.008), Complexity (0.027), Result Demonstration (0.017), Observability (0.036) and Trialability (0.057) levels of significance in our study agree with the results obtained during the other studies of attributes of innovations. Please refer to Agarwal and Prasad (1997), Carter and Belanger (2004), Chiasson and Lavato (2001), Herbert and Benbasat (1994), Karahanna, Straub and Chervany (1999), Moore and Benbasat (1991) and Van Slyke, Lou and Day (2002). This is an indication that the theory tested positive for predictiveness. We determine our results to be confirmation of attributes of innovation ability to predict rates of adoption during research and development stages (prediffusion). This conclusion is *ad interim* because we concentrated on one innovation, OSS. Further research and development (prediffusion) stage studies would be required to substantiate that the implications of our study hold for other innovations as well. One study is not enough to finalize discussions about this aspect of Diffusion of Innovations. Certainty needs to be determined.

Additionally, we observed that certain messages and social activity such as Question F – (Having Used OSS Before Survey), Question L – (Talked to Colleagues About OSS) and Question M – (Used OSS at Home) displayed construct properties similar to those of perceptions of attributes of innovations during research and development (prediffusion). We determine this as confirmation that *certain messages* and *social system behavior* occurs during research and development, as well as during commercialization as indicated by Rogers (2003). Establishing that connection was not our primary intent; however, it was beneficial to confirm this phenomenon. On further investigation, it is possible that links with perceptions of attributes of innovations and other theoretical constructs such as *certain messages* and *social system behaviors* can be established to provide quicker insight into developing *rates of adoption* for information technology innovations (Lu, Liu, Yu & Yao, 2005; Ojala & Nahar, 2006). We therefore determine our observation of the relationships of *attributes of innovations, certain messages* and *social system behavior*, with the stated limitations, as additional general support for diffusion of innovations.

IMPLICATIONS FOR PRACTICE

We provide some new evidence for practice based on the sound elements of Diffusion of Innovations. With our observations we extend the studies that indicate attributes of innovations can reliably be used to determine rates of adoption during prediffusion. The rate of innovation increases daily. Uncertainty is an issue. To deal with that, we can continue to measure attributes

during research and development stages. We can be reassured that we can reliably use attributes of innovations to predict potential adoption rates for specific information system innovations. While performing these studies, it may also be possible to look into changes in the social systems of information technology development to conjure new innovations (Nath & Murphy, 2004). This might help clear up some uncertainty regarding innovations. This could assist with adoption problems.

CONCLUSION

Our evidence from the current study suggests identical behavior of attributes of innovations during all stages of diffusion including prediffusion stages (research and development and evaluation trials) as suggested by Everett M. Rogers (2003). Attributes of innovations can now be looked upon as very reliable predictors of future rates of adoption during all stages of diffusion. With this, we have full corroboration of the ability of attributes of innovation to predict rates of adoption from beginning to end. We make important theoretical contribution toward establishing this evidence for Diffusion of Innovations theory. The understanding of the role of attributes of innovations in innovation diffusion has been increased. Our evidence also confirms the significance of *relative advantage* and *compatibility* in explaining more about adoption than other attributes of innovations. Further, *certain messages* and *social system behaviors* were identified as covariates during the prediffusion stages (research and development and early trials). This is significant because it reports a correlation among attributes of innovations and social behavior during the early stages of diffusion. This study therefore enlarges the possibilities we have to deal with perceptions of attributes of information technology innovations. A perception of attributes of innovations is becoming more complex throughout the world (Lee & Asllani, 2003). Thus, we strengthen the usefulness of the theory of diffusion of innovations today.

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