Journal of the Association for Information Systems

Volume 2, Article 8
March 2002

Capturing the Technological Dimensions of IT Infrastructure Change: A Model and Empirical Evidence

Neal G. Shaw
Information Systems and Operations Management
University of Texas at Arlington
nshaw@uta.edu

Abstract

Information systems (IS) researchers have developed a substantial base of theoretical and empirical research for investigating phenomena associated with information technology (IT) infrastructure and IS implementation. The majority of prior studies have focused on perceptions of IS use, usefulness, support, and similar organizational and human aspects of implementation; however, recent empirical results suggest the importance of technical issues in IS implementation. As a first step toward providing more empirical research on the impact of technological issues in IS implementation, this paper reports on the development and test of a model that captures the dimensions of technological changes in IT infrastructure. Using a survey of 302 individuals who recently participated in a software upgrade, evidence is provided on the content validity, construct validity, and reliability of an instrument measuring four dimensions of perceived technological change in IS implementation: functionality, user interface, technical quality, and external compatibility. In addition, a sample application of the new model is provided which shows that technological changes in IT infrastructure affect user acceptance of information technology.

Keywords: IT infrastructure, IS implementation, system quality, technological change.

I. INTRODUCTION

Information is a corporate resource (Porter and Millar 1985). Consequently, firms have realized that an effective way to compete and profit is to utilize information (Clemons and McFarlan 1986; Hopper 1990; Rayport and Sviokla 1995). As with any resource, however, certain systems must be in place to allow the owner of the information to exploit its potential. In the case of information, an information technology (IT) infrastructure provides the means for a company to extend the information resource to its fullest potential. IT infrastructure is defined as the shared IT capabilities that support information flow in an organization. IT infrastructure has been shown to consist of many different parts, such as IT services, human IT infrastructure, and IT infrastructure components (Broadbent et al. 1996). Information systems (IS) researchers have studied IT services and human IT infrastructure in detail (e.g., Broadbent et al. 1996; DeLone and McLean 1992). Surprisingly, however, there have been relatively few works that have specifically aimed to study IT infrastructure components such as hardware, software, and communications technology (Benamati et al. 1997; Broadbent et al. 1996; Zmud 1997).

One reason that the implementation of technical components (e.g., hardware and software) of an IT infrastructure can be problematic is that it is often difficult for organizations to isolate sources of trouble in the implementation. IS researchers have been stymied by the same problems. For example, consider Kwon and Zmud's (1987) taxonomy which presents five major types of factors affecting IS implementation: user factors, environmental factors, organizational factors, task factors, and technological factors. In any given research project, it is difficult to isolate and identify the effect of these factors because of the confounding relationships that exist among them. Furthermore, studies that have shown the importance of human and cognitive issues (e.g., Griffith and Northcraft 1993, 1996) are difficult to reconcile with studies suggesting the importance of technical issues (e.g., Benamati 1997; Benamati et al. 1997). On the other hand, structural theories, which predict that technological changes can induce human and organizational changes (DeSanctis and Poole 1994; Leonard-Barton 1988; Orlikowski 1992), suggest that it is difficult to isolate the different types of issues; however, these theories also suggest that a thorough understanding of technological change in IS implementation can be used to predict and to assess the human and organizational impacts of an implementation. Thus, there is a need for accurate assessment and understanding of technological issues in an implementation, in order to facilitate the understanding of their relationships with other issues.

Although the IS implementation literature is quite extensive, the vast majority of implementation studies have focused on human and organizational issues instead of problems associated with technological change (Orlikowski and Iacono 2001; Shaw 2001). The lack of previous research on technical issues seems especially problematic given recent findings demonstrating large numbers of technical problems associated with the implementation of new information technologies (Benamati et al. 1997). In addition, classical diffusion theory suggests that inherent characteristics of an innovation—including technological characteristics—have a substantial impact on the diffusion process for the innovation (Fichman 1992; Rogers 1983). Similarly, studies based upon classical diffusion theory have suggested that technological factors represent one group of the major contextual factors that typically have a significant impact on the implementation of an information system in an organizational setting (Cooper and Zmud 1990; Kwon and Zmud 1987). To summarize the problems arising when existing IS theories are used to explain technological issues in IS implementation, Table 1 presents a summary of several theories that have been used to study technological aspects of IS implementation, along with a brief summary of the major strengths and limitations of each. It is important to note that Table 1 describes the summaries, strengths, and limitations of the theories not in general, but rather specifically in the case of understanding the technological issues associated with implementation.

Table 1. Theories Used to Study Technological Changes in IS Implementation

Theory	Summary	Strengths	Limitations
Structural theory (DeSanctis and Poole 1994; Leonard-Barton 1988; Orlikowski, 1992)	Argues that the implementation process is a mutual adaptation of technology and organization and that technology can induce structural changes in organizations.	Recognizes inherent need for understanding characteristics of technological innovations since the characteristics of the technology can drive organization structure.	Not clear how to decide whether a given technology has capability to induce change (i.e., is it "advanced" or not).
IS implementation theory (Cooper and Zmud 1990; Kwon and Zmud 1987)	Based on diffusion theory, proposes six phases of implementation and five categories of factors (including technology) that affect those phases.	Provides an accurate and succinct framework for conceptualizing processes and factors in implementation; delineates chronological process of implementation.	Relationship between technology and other categories of factors is unclear; limited focus on technological issues.
Classical diffusion theory (Fichman 1992; Rogers 1983)	Characteristics of an innovation (technology) being implemented affect the manner in which implementation takes place.	Explicitly recognizes the need to understand the specific characteristics of a technology to understand the manner in which it should be implemented.	Does not specify which aspects of technological innovations will be the primary drivers of adoption and diffusion.
Environmental impact theory (Benamati et al. 1997; Lederer and Mendelow 1990)	Organizations use coping mechanisms to deal with changes in the environment.	Provides a mechanism for understanding and coping with rapid technological changes caused by the implementation of new technology.	Unclear how characteristics of technology itself drives problems and coping mechanisms in implementation.

To accurately investigate the impact of technological changes, one must first assess the extent of change. Unfortunately, it is often difficult to measure the degree to which a new information system is different from an existing system on an objective scale. On the other hand, it is easier to collect data on individual perceptions of technological change and, in fact, it can be argued that subjective data is actually more valuable in this scenario because ultimately the perception of a new innovation is what determines the extent to which it will be utilized (Davis 1989). However, in order to effectively gather this type of data in a manner which allows for replication and consistent measurement of the underlying constructs, IS researchers are in need of a validated measurement instrument to measure the technological change associated with IT infrastructure change. Specifically, the measurement instrument should (Doll and Torkzadeh 1988; Doll et al. 1994; Straub 1989):

- Capture information associated with the technological change from one IT infrastructure component to another;
- Be short, easy to use, easily interpretable, and useful for both research and practice;
- Be useful across a large variety of IT infrastructure changes;
- Allow for study of technological factors and other dependent or independent variables; and
- Provide Likert scales for ease of use, usefulness, and standardization of measurement.

As a first step toward achieving these goals and addressing some of the research problems created by technical issues in IS implementation, this paper develops and tests a model for the measurement of perceived technological change in the implementation of IT infrastructure components. First, an initial model and measurement instrument is developed based upon theoretical and empirical results in previous IS research. Then, data are collected on a large number of software upgrades to investigate the various forms of validity necessary to establish the usefulness of the instrument. Finally, sample applications of the model and measurement instrument are explored in the context of user acceptance of an information system.

II. TECHNOLOGICAL DIMENSIONS OF IT INFRASTRUCTURE CHANGE

Existing theory in IS research suggests that the “success” of an information system is in fact a multidimensional construct composed of six interrelated constructs: system quality, information quality, system use, user satisfaction, individual impacts, and organizational impacts (DeLone and McLean 1992). Figure 1 shows a number of the implied relationships among these constructs (DeLone and McLean 1992; Seddon 1997). Based on this view of IS success, a change in IT infrastructure (e.g., via the implementation of a new infrastructure component), will cause a change in some or all of the dimensions of IS success (Shaw 1999, 2001).

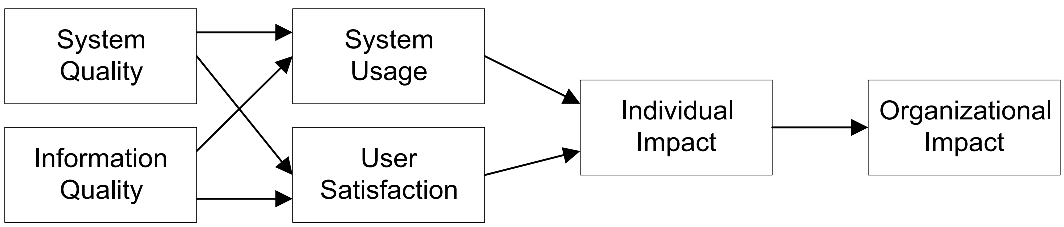


Figure 1. A Model of IS Success (adapted from DeLone and McLean 1992)

A substantial amount of theoretical and empirical research has investigated various measures of system quality in an information system (e.g., Barti and Huff 1985; Belardo et al. 1982; Franz and Robey 1986; Goslar 1986; Hiltz and Turoff 1981; Lehman 1986; Morey 1982; Srinivasan 1985); however, the focus of research in prior studies has been primarily on static measures of an IS at a given point in time. Missing are theoretical and empirical results on the characterization and measurement of changes in system quality as the result of the implementation of a component of an IS, and the need to address this shortcoming is especially prevalent given the increasing rapidity with which organizations are adopting and implementing new technologies (Benamati 1997; Benamati et al. 1997; Lederer and Benamati 1998; Shaw 1999, 2001; Zmud 1997).

THEORETICAL MODEL

Existing research has suggested that there are five major dimensions of system quality: functionality, user interface, performance of equipment, the environment, and system interaction (Igbaria and Chakrabarti 1990; Igbaria et al. 1995; Igbaria et al. 1990; Lucas 1975, 1978; Lucas et al. 1988). However, other studies have argued that the nature of a user's interaction with the system is not a dimension of system quality but rather a dimension of other factors such as system use and user satisfaction that capture the user's attitudes and/or behaviors toward the system (DeLone and McLean 1992; Seddon 1997). The latter view is adopted in this paper because of the interest in capturing changes to the technology associated with an IS. The technological changes brought about by the implementation of an IS undoubtedly affect the interaction with the system by the users. Future studies are needed to investigate the role of technological changes as an antecedent to changes in user interaction. Since the goal of the present research is to develop a model and measures of the dimensions of changes in technology in the implementation of an IS, the four dimensions of system quality were modified slightly to capture changes in system attributes. The resulting constructs examine changes in functionality, user interface, technical quality, and external compatibility. Figure 2 shows a summary model of these dimensions of technological change, and the following paragraphs provide more detail about the definitions, relationships, and boundaries that are part of the model.

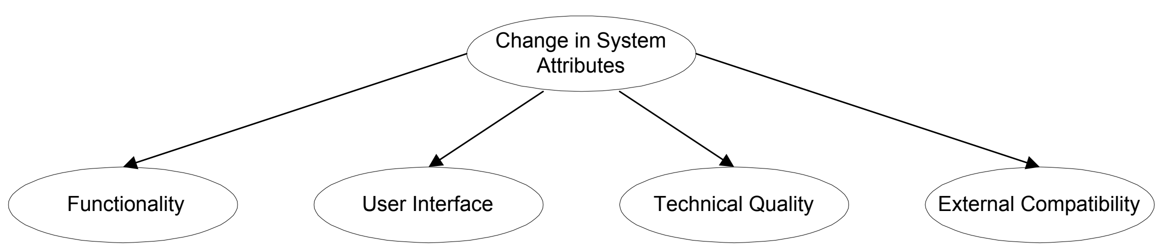


Figure 2: A Theoretical Model of the Technological Dimensions of IT Infrastructure Change

The change in functionality from one IT infrastructure component to another refers to the addition, subtraction, or modification of capabilities or features between an old component and a new component. For example, a new version of a software package might include additional functionality that was not in the previous version. Consider Microsoft Office '97, which added extensive web-based functionality that was not available in Office '95. The addition of web-based components in the software is an example of changing functionality.

The change in user interface that occurs as a result of a change in IT infrastructure is defined as a change in the manner in which input or output occurs in a new information system. As an example, consider the difference in the user interface of Microsoft Windows '95 and its predecessor, Windows 3.1. The difference in user screens, menus, mouse actions, naming conventions, and other characteristics were indicative of a substantial change in the user interface for that particular product. In general, since user interface issues such as perceived ease of use have been shown to impact user satisfaction and user acceptance (Davis 1989; Doll and Torkzadeh 1988; Doll et al. 1994; Venkatesh and Davis 1996), it is important to capture any changes in the user interface that might occur during the implementation of an IS.

Seddon (1997) defines one dimension of system quality as "whether or not there are 'bugs' in the system," and this dimension is related to the performance of equipment measure described in other research (Igbaria et al. 1995; Igbaria et al. 1990). Thus, the technical quality of a new IT infrastructure component is another dimension of the change that will be involved in the implementation of the components. Any changes in system quality due to the introduction of a new IT must be captured since technical quality is known to impact system use, user acceptance, and other outcome measures of a new IS (Conklin et al. 1982; Igbaria et al. 1990; Kriebel and Raviv 1980; Lucas 1978; Mahmood 1987).

Compatibility with the environment, or external compatibility, is used to capture the environmental changes in system quality associated with the introduction of a new IT infrastructure component. Compatibility is defined as the extent to which the new IS is able to interact with other components of the environment. The issues of compatibility and standardization have been addressed in the area of network externalities (Katz and Shapiro 1985, 1986), which suggests that IT innovations become more useful as the network of people using the product expands (Brynjolfsson and Kemerer 1996; Chio 1994; Katz and Shapiro 1985, 1986). Thus, external compatibility is an important dimension of technological change because it has the potential to affect the external network for a given IT innovation.

The conceptual model proposed in Figure 2 focuses specifically on the technological dimensions of IT infrastructure change. However, as other infrastructure theorists have noted, there are other aspects of change, including human, social, and organizational issues. These dimensions would be orthogonal to the overarching “change in system attributes” construct in the model. Non-technological dimensions of change would also have sub-dimensions. For example, a model of the human aspects of IT infrastructure change might include cognitive dissonance or user resistance. Thus, it is important to note that the proposed model in Figure 2 is only intended to capture technological dimensions, and other aspects of change are outside the intended scope of this model.

MEASUREMENT INSTRUMENT

The primary contribution of this paper is the development and test of a measurement instrument to capture the technological dimensions of change in the implementation of IT infrastructure components. To this end, such an instrument was developed to measure the four dimensions given in Figure 2. Table 2 lists the items used to measure the dimensions. The following paragraphs expand further on the specific dimensions and give theoretical background on the measurement items used to capture the four constructs.

Table 2. Measures of the Technological Dimensions of IT Infrastructure Change

	Functionality
FT1	I can do more with the new software than with the old software.
FT2	The new software has capabilities that the old software did not have.
FT3	The new software has features that the old software did not have.
FT4*	The new software basically does the same things as the old software.
	User Interface
UI1	The user interface of the new software is different from that of the old software.
UI2*	The new user interface is basically the same as the old user interface.
UI3	The new user interface included changes in user screens.
UI4	The new user interface included changes in menu options.
UI5	The new user interface caused changes in how I use the software.
	Technical Quality
TQ1*	The new software had many technical problems, such as bugs, crashes, etc.
TQ2*	The new software caused many technical problems on my computer.
TQ3*	The new software caused many technical problems for my organization.
	External Compatibility
	In your opinion, how compatible is the new software package with …
EC1	… other software on your computer?
EC2	… the old software package that was replaced?
EC3	… other software packages in the company that are not on your computer?
EC4	… other software in the marketplace?
EC5	… the hardware in your computer?

*Indicates items that are reverse-scored.

There are two ways to measure the change in functionality from one IS to another. The first is to have some objective measure of the number of new features added during an implementation. The second is to capture user perceptions of the changes in functionality. Although both measurement approaches deserve further study, and both have applications in different contexts, this research measures individual perceptions of the change in functionality because of the difficulty in obtaining objective measures of changes in functionality, especially over a large sample in which all features might not be installed on the machine of each individual. Thus, it seems reasonable to use perceptions of change as a proxy measure, and in fact, individual perceptions are likely more important, given that the way individuals perceive the technology is more likely to influence their use of the technology, as opposed to some objective measure (Davis 1989; Davis et al. 1989; Dillon and Morris 1996; Lee et al. 1995; Szajna 1994). The items used to measure perceived change in functionality were then developed to capture respondent differences from one package to another on the basis of two overall measures (one reverse-scored) used to measure the overall change in functionality, one measure for capabilities of the software (what the software can do), and one measure for the features of the software (specific characteristics of the package). These four indicators comprise the perceived change in functionality construct.

As with a change in functionality, changes in the user interface can be measured objectively or as subjective measures based upon individual perceptions. As in prior studies, this research uses perceived measures of changes in the user interface, specifically including items to measure overall changes, user screens, and menus. The user interface construct was measured with five indicators. Two overall measures were used (one reverse-scored) to capture a holistic view of the user interface change. Also, specific elements of the change were captured, including changes in menus and user screens. Finally, a measure of the significance of the user interface changes was included as the final indicator of the nature of the user interface change.

In the case of technical quality, the measures of interest are related to the presence of bugs associated with the introduction of the new component (Seddon 1997) because these bugs would cause changes in individual perceptions of the IS. It could be argued that one should attempt to capture the differences in the number of bugs between the old system and the new system; practically, however, this is much more difficult than it appears, especially in terms of individual perceptions, because of a question about how to anchor the measurement scale. Specifically, if capturing differences in technical quality, how should one define the midpoint of the scale, which should theoretically represent the point at which a new IS has the exact same number of bugs as the old IS? Further, to be consistent with prior research on system quality, it is more important to capture the perceived changes in technical quality by measuring the characteristics of the new system. Thus, it was decided that the most effective measure would be one that elicited user perceptions of whether or not a new IS included many problems. The definition of "many" is left to the perception of the individual respondent because the perceived difference between many and few problems is the core of the response that is sought. The three indicators are intended to capture three dimensions of technical quality: one overall measure of perceived quality, one measure for the respondent's personal work environment, and one measure for the respondent's organizational work environment. The three distinct indicators are needed because user perceptions of IT implementation in their personal environment often differ from perceptions of their organizational environment (Kwon and Zmud 1987).

The measures of external compatibility are based on individual perceptions, and the measures are based on the characteristics of the new IS. Thus, the measures for external compatibility attempt to capture the changes in an IS due to the external environmental stimuli that affect system quality. Other environmental measures could have been chosen, but compatibility was used since it encompasses a large variety of other environmental issues including vendor coordination (Benamati et al. 1997; Lucas et al. 1988) and simultaneous component changes (Benamati et al. 1997). The five orthogonal dimensions of external compatibility were developed to capture information about compatibility with the other possible infrastructure components with which a given software package should interact.

III. RESEARCH METHOD

To investigate the usefulness and validity of the model and instrument designed to capture the technological dimensions of IT infrastructure change, an empirical study of software upgrades in organizations was conducted, since software upgrades are one of the most common types of IT infrastructure changes (Shaw 1999). A questionnaire was developed based upon the items given in Table 2. One additional construct, changes in user acceptance, was added to the questionnaire in an attempt to gather further evidence on the usefulness of the model. A complete discussion of this additional construct and its use is given in the applications section later in the paper. The questionnaire items are given in the appendix, and each item was measured on a five point Likert scale as given in the appendix. The empirical study was targeted at users whose organizations had been involved in a software upgrade within the prior 12 month period. Longer time periods were not accepted because of the potential for users to forget the circumstances of the upgrade. The study was not restricted to any one specific software package since the aim of the study was to capture the perceived differences in packages. However, given the randomly selected nature of the subjects and the variation in software packages, a number of additional data were collected during the study to control for potential confounding factors.

PRE-TEST AND PILOT TEST

The questionnaire was pre-tested using a convenience sample of university students. This demographic group was deemed acceptable for the pre-test given that the potential respondents were expected to come from a wide variety of backgrounds. It seems reasonable to assume that university students are somewhat representative of software upgrade participants, since a large majority of them are either involved in software upgrades of their own computers or have been involved in upgrades at their work sites. The pre-test consisted of interviews and repeated applications of various iterations of the questionnaire to obtain feedback on instructions, questionnaire length, and the format of the questionnaire. After completion of the pre-test, a pilot study was mailed to 250 potential respondents from the target population in order to test the instrument and data collection procedures. Using the results of the pilot study, the questionnaire was revised to eliminate redundant items, to increase usability, and to enhance construct validity and reliability.

DATA COLLECTION

Data were collected by mailing the questionnaire to 2,726 individuals who had recently registered one of several commercial software upgrades at their business address by returning the software registration card included in the packaged software. Respondents were allowed to return the survey via pre-paid envelope, and as an alternative they were allowed to complete the survey online. Simple t-tests indicated that there were not any significant differences between the paper-based responses and the responses received online. After a six-week waiting period, a second group of surveys were sent to subjects who did not respond to the original survey. In total, 343 surveys were returned as not deliverable. This number is relatively high in comparison to other completed surveys in the MIS literature. Upon further investigation, however, the high return-to-sender number is likely due largely to the randomness of subject selection and the extremely large respondent population. Previous surveys in this area have been much more targeted, thus inducing fewer undeliverable surveys.

A total of 373 surveys were completed and returned, yielding an effective response rate of 15.7%. Additionally, only 302 of the 373 respondents indicated that they had actually participated in a software upgrade, which left a usable sample of 302 responses. The respondents who did not participate in an upgrade were mostly individuals who were not with the company at the time of the upgrade but who received a copy of the survey because they had taken over the job of the intended recipient. The final sample of 302 respondents indicated an average of 15 years experience using computers and worked for organizations with an average of 17,832 employees and $2.2 billion in annual revenue. Additional demographic information about the respondents and the software packages involved is given in Table 3.

Table 3. Characteristics of Respondents

Job Position		
End-user	87	28.8 %
IS	47	15.6 %
Management	139	46.0 %
IS Management	17	5.6 %
Not specified	12	4.0 %
Total	302	100.0 %
Industry		
Financial	22	7.3 %
Manufacturing	43	14.2 %
Educational	28	9.3 %
Government	17	5.6 %
Computers	98	32.5 %
Other	87	28.8 %
Not specified	7	2.3 %
Total	302	100.0 %
Software Package		
Windows 95	28	9.3 %
Windows 98	63	20.9 %
Word 97 only	43	14.2 %
Office 97	39	12.9 %
Other single packages	80	26.5 %
Multiple packages	44	14.6 %
Not specified	5	1.7 %
Total	302	100.0 %

The response rate for this survey is lower than the response rate in much MIS survey research, largely because of the nature of the subjects. In this research, the researchers deemed the low response rate a necessary trade-off to collect large amounts of information from a general population. The primary concern in studies with a low response rate is the possibility of some form of systematic non-response bias, and the researchers attempted to assess non-response bias by comparing responses to the first mailing of the questionnaire to responses from the second mailing of the questionnaire, with the implication that late responses would be representative of non-respondents. Demographic profiles indicated no significant differences between the groups of respondents. Also, t-tests on the means of functionality ($p = .116$), user interface ($p = .679$), quality ($p = .133$), and compatibility ($p = .127$) showed that there were no significant differences between the early and late respondents. This type of examination of non-response bias does not by any means eliminate the possibility of a systematic bias; however, in this particular study there is no reason to believe that the non-respondents exhibit any particular characteristics that would introduce bias into the study. Of course, it is still possible that such bias could exist, and results should be viewed accordingly.

DATA ANALYSIS

To assess convergent validity and discriminant validity using a variation of the multi-trait multi-method approach, an exploratory factor analysis was performed using the items in the four technological dimensions. Table 4 shows the factor loadings. Table 5 shows the correlations among the items, which can be used for the same analysis of convergent/discriminant validity. An exploratory factor analysis was used instead of a confirmatory factor analysis given that the items were developed from multiple literature bases and multiple contexts, and thus the strong theoretical base necessary for confirmatory factor analysis was not available. Items FT4, UI4, UI5, and EC5 were dropped from the analysis due to poor psychometric properties, specifically significant cross-loadings with other factors. Upon further inspection, item UI5 probably should not have been included in the original measurement scale, because it appears to measure an outcome of change in the user interface, rather than a measure of the degree of change. Item EC5 focuses on hardware, whereas the other EC items focus on software, and that is likely the reason for the poor loadings for that item. The remaining dropped items, FT4 and UI4, do not appear to be substantially different from the other items that measure the same construct; however, for some reason their psychometric properties were not as good as the other items. It is likely that this was an anomaly of the specific data set in this study. Future research is needed to examine further the theoretical adequacy and psychometric validity of these two rogue items. Of the remaining items, all exhibited excellent convergent validity as evidenced by their factor loadings. The lowest loading on an associated factor was .726, indicating that the factors all load highly on their associated factors, which provides evidence of adequate convergent validity. Discriminant validity can be assessed by investigating the extent to which items load on factors other than their associated factor. In this case, no item loads more highly on another factor than with its associated factor. Generally, if fewer than half of the items load more highly on other factors, the data exhibit adequate discriminant validity (Campbell and Fiske 1959), and thus we can conclude that reasonable discriminant validity is demonstrated for the constructs in this study. Additionally, all four constructs exhibit good reliability (internal validity), as evidenced by the Cronbach's alpha statistics presented in Table 6. All of the alpha measures meet the recommended standard of .70 (Nunnally 1978).

Table 4. Factor Loadings

	Technical Quality	User Interface	External Compatibility	Functionality
FT1	.197	.097	.160	**.728**
FT2	.118	.081	.122	**.836**
FT3	.089	.110	.077	**.828**
UI1	.027	**.832**	-.036	-.070
UI2	.073	**.789**	-.114	-.186
UI3	-.076	**.742**	.059	.261
TQ1	**-.873**	-.017	-.191	-.125
TQ2	**-.904**	.015	-.177	-.089
TQ3	**-.845**	.119	-.216	-.125
EC1	.208	-.016	**.765**	.034
EC2	.074	-.158	**.726**	.133
EC3	.135	-.052	**.856**	.069
EC4	.219	.095	**.752**	.097

Table 5. Correlation Matrix of Items

	FT1	FT2	FT3	UI1	UI2	UI3	TQ1	TQ2	TQ3	EC1	EC2	EC3
FT2	0.75											
FT3	0.61	0.71										
UI1	0.15	0.13	0.16									
UI2	0.08	0.05	0.07	0.75								
UI3	0.15	0.15	0.16	0.46	0.35							
TQ1	0.33	0.25	0.18	0.01	0.03	-0.03						
TQ2	0.31	0.24	0.18	0.00	0.01	-0.06	0.78					
TQ3	0.32	0.25	0.19	-0.06	-0.07	-0.12	0.72	0.78				
EC1	0.29	0.24	0.16	0.04	-0.04	-0.04	0.34	0.37	0.37			
EC2	0.26	0.23	0.14	-0.08	-0.16	-0.04	0.26	0.20	0.32	0.52		
EC3	0.24	0.22	0.19	-0.03	-0.08	-0.03	0.26	0.29	0.31	0.58	0.52	
EC4	0.35	0.27	0.21	0.06	0.04	0.01	0.38	0.34	0.34	0.59	0.40	0.65

Table 6. Reliability of Scales

Construct	Number of Items	Cronbach's Alpha
Functionality	3	.870
User Interface	3	.781
Technical Quality	3	.916
External Compatibility	4	.817

Table 7 shows the correlations among the four dimensions of technological change, and the user interface construct is not highly correlated with the other dimensions of change. This result can be interpreted in two ways, one of which suggests that changes in the user interface of software packages are interpreted by users differently than their interpretation of other factors expected to be related to technology. Such a view suggests that characteristics of the user interface should be analyzed and interpreted with other constructs such as user acceptance and user satisfaction, rather than as a measure of system quality. The alternative explanation for the low correlation of the user interface construct is simply that measurement problems might have prevented the user acceptance factor from loading as it should have; however, the user acceptance construct and its measures exhibited reasonable psychometric properties, both independently and in conjunction with the other factors, and so it seems likely that there is a meaningful reason that the user interface construct was not highly related to the other dimensions of technological change. A detailed investigation into the properties of this construct would appear to be a rich area for future theoretical and empirical research.

Table 7. Correlations and Descriptive Statistics for Constructs

	Functionality	User Interface	Technical Quality
User Interface	0.16*		
Technical Quality	-0.31*	0.04	
External Compatibility	0.32*	-0.05	-0.42*

* Indicates correlations significant at the .05 level.

‘

	Mean	Std. Dev.
Functionality	12.2	2.83
User Interface	9.6	3.10
Technical Quality	7.4	3.55
External Compatibility	14.9	3.53

IV. APPLICATIONS OF THE DIMENSIONS OF TECHNOLOGICAL CHANGE

The dimensions of technological change developed in the preceding section appear to have reasonable measurement properties, and thus they contribute to the development of theory and practice in IS by establishing guidelines for capturing constructs which have previously not been studied independently. The following paragraphs discuss a sample theoretical application of the instrument, along with suggestions for future theoretical and empirical research. Also, practical applications of the instrument are explored.

THEORETICAL APPLICATIONS

As an example application of the technological dimensions of IT infrastructure change, consider Figure 3, which shows an instance of the DeLone and

McLean (1992) model of IS success in which system quality affects user acceptance of an information system. Although it is not the goal of this paper to examine and test this model thoroughly, four sample hypotheses are presented below along with a structural equation model using the data from the study described earlier to illustrate the usefulness of the proposed measurement instrument in IS research.

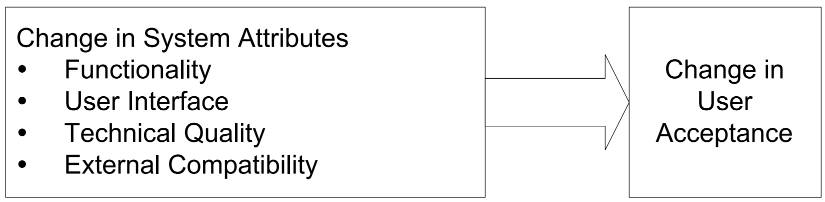


Figure 3. A Sample Theoretical Application of the Technological Dimensions of IT Infrastructure Change

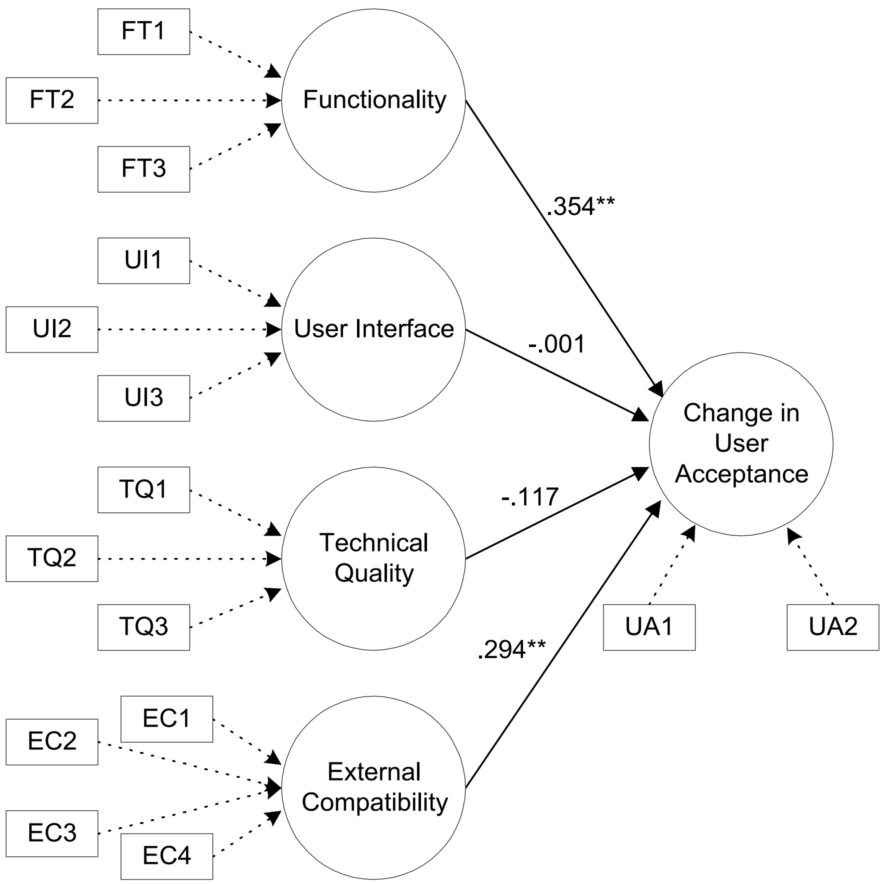
Although it was not highly correlated with the other three dimensions, the user interface construct is included here for completeness. That is, as discussed previously, it is quite possible that confounding factors or measurement error prevented the interface construct from loading properly, and these problems, if they exist, might indeed be corrected in future research. Thus, it seems reasonable to present the applications of the user interface construct; however, results associated with that construct should be interpreted in light of the factor loadings and correlations presented earlier.

- H1: *Changes in the functionality of a software package affect the user acceptance of that software package.* Variations in the functionality of a software package have been shown to be associated with changes in user perceptions of benefits of the software package (Shaw 2001). Since perceived usefulness and perceived benefits are known to be closely related measures of outcome success (Seddon 1997), it is reasonable to expect that changes in functionality of a software package will affect the perceived usefulness and thus user acceptance of the package.
- H2: *Changes in the user interface of a software package affect the user acceptance of that software package.* Technology acceptance model (TAM)

research suggests that perceived ease of use of a software package will affect the perceived usefulness of the software, which in turn is an element of the overall user acceptance of the software (Davis 1989; Davis et al. 1989; Venkatesh and Davis 1996, 2000). Thus, if the user interface of the software were to change, perceived ease of use is likely to change as well. According to the TAM, user acceptance would also vary depending upon the extent of the user interface change.

- H3: *Changes in the technical quality of a software package affect the user acceptance of that software package.* Varying measures of system quality including output quality and result demonstrability have been shown to be antecedents of user acceptance of information technology (Venkatesh and Davis 2000). Consequently, one would also expect that changes in technical quality (e.g., bugs) of an information system would be associated with changes in the user acceptance of that same system.
- H4: *Changes in the external compatibility of a software package affect the user acceptance of that software package.* Research on network externalities in IS suggests that as the number of users of a software package increases, the utility of the software product also increases (Brynjolfsson and Kemerer 1996; Chio 1994; Katz and Shapiro 1985, 1986; Wang et al. 1996). Larger technology networks facilitate the sharing of organizational data and the reuse of knowledge concerning operation of the software itself. Accordingly, one would expect that if the level of compatibility with other packages changes, the level of user acceptance would change because the perceived usefulness of the software package would change, according to the TAM (Davis 1989).

The items used to measure the user acceptance (UA) construct are given in the appendix, and the construct exhibits reasonable measurement properties, with a Cronbach's alpha value of .810. Figure 4 presents a path model used to examine the empirical validity of the theoretical model given in Figure 3, along with the standardized path coefficients. The model indicates good model fit, with the goodness-of-fit index (GFI) of .938 and the adjusted goodness-of-fit index (AGFI) of .909 above the recommended level of .90, the comparative fit index of .978 and the nonnormative fit index (NNFI) of .971 above .95 (Bentler 1990; Bentler and Bonett 1980; Hu and Bentler 1999; Tucker and Lewis 1973), the root mean square error of approximation (RMSEA) of .0467 below .05, and the ratio of chi-square to degrees of freedom of 1.52 below 2 (Carmines and McIver 1981; Hayduk 1987; Kline 1998). Support is provided for hypotheses H1 and H4, indicating that the strongest determinants of user acceptance are changes in functionality and changes in external compatibility.



χ^2 / df = 1.52, GFI = .938, AGFI = .909, CFI = .978, NNFI = .971, RMSEA = .0457

**Indicates statistical significance (p-value = .000 in all cases).

Figure 4. A Sample Application of the Technological Dimensions of IT Infrastructure Change

PRACTICAL APPLICATIONS

Practitioners have often lamented the difficulties associated with designing, developing, and maintaining IT infrastructures (Brancheau et al. 1996), and the technological changes associated with the process of maintaining IT infrastructures have been shown to be an especially frustrating issue with which managers and executives must cope (Benamati et al. 1997; Lederer and Benamati 1998). Since system quality has been shown to be an antecedent of user acceptance, system usage, individual impacts, and other measures of IS success, the measurement of various aspects of system quality is indeed a useful contribution for practitioners. Specifically, one immediate application of the measures of technological change is that they allow practitioners to establish benchmarks for various IT infrastructure components. For example, the management of an implementation of a specific software package in an organization could be improved by investigating the technical properties of the software package before the installation. Then, if the package was expected to induce significant technological change, potentially compensatory factors such as training and support could be used to offset the effects of technological change.

LIMITATIONS

The current study has a number of limitations, most of which are typical issues associated with any type of survey research. Specifically, this research sampled a large number of users from a large number of organizations. Future research is needed to determine whether the dimensions of technological change developed in this paper would exhibit the same measurement properties if a large study were undertaken to evaluate the technological changes perceived by a large number of users in one organization. Such a study, when combined with the current one, would certainly add to the validity and usefulness of the instrument by controlling for a number of organizational and environmental variables that can impact technological changes. Further, since the instrument measures *perceived* changes, it is possible that the perceptions of technological change might differ substantially from the actual nature of the change. In fact, due to variations in the way that users perceive and use software (Karahanna et al. 1999; Straub et al. 1995), it is quite likely that there is some difference between actual and perceived values, and future studies are needed to determine the extent of the difference.

Another limitation is the possibility of some type of common method bias, or the possibility that the relationships among constructs observed in the study were the result of questions that were asked in the same manner from all respondents. To some extent, the potential for this type of bias is alleviated by the different forms of the survey instrument, both paper and electronic, as discussed earlier. Also, the theoretical grounding of the relationships in the study make the issue of common method bias much less problematic than in a truly exploratory study, for example. However, as in most survey research, the possibility of common method bias does exist, and results should be interpreted accordingly. Finally, only technological dimensions of change were assessed in this study. As mentioned in the first section of the paper, prior research has discussed the difficulty in isolating the various categories of factors in the implementation of an information system. This particular problem is in fact one of the motivations of the present research. That is, only after gaining a thorough understanding of technological issues can researchers begin to investigate their impact and relationship with human and structural issues. Since the scope of this study was limited to technological dimensions of change, it is likely that some confounding effects of human and organizational issues might have impacted the data analyses in the paper. Future researchers should endeavor to combine the model and instrument in this paper with more organization-centric models to examine the correlations and other confounding effects among them.

V. CONCLUSIONS

The need for an increased focus on the technological dimensions of IT infrastructure change is becoming ever greater with the rapid proliferation of new technologies in organizations (Lederer and Benamati 1998). The model and the instrument developed in this paper provide a useful first step in the theoretical and empirical investigation of technology-related factors that affect IT implementations. Additionally, the importance of these factors has been empirically demonstrated since they can directly affect user acceptance of an information system. Specifically, there are three major contributions of this research that can be used by researchers and by practitioners:

- A model of changes in system attributes including dimensions of technological change: Theoretical and empirical evidence is provided to suggest technological changes in IT infrastructure can be viewed as a second order construct with four first order constructs. Empirical testing questioned the appropriateness of user interface changes in this context, implying that perhaps changes in the user interface are best modeled in terms of user acceptance and user satisfaction with an information system.
- An instrument to measure the dimensions of technological change: An empirically validated measurement instrument is provided for use by researchers and practitioners in assessing technological changes in IT infrastructure.
- Empirical evidence suggesting the validity of the instrument and its usefulness in studying IS phenomena: The data collected demonstrate not only the validity of the instrument and its items, but also the utility of the constructs as viable components in the existing model of IS success (DeLone and McLean 1992; Seddon 1997).

IMPLICATIONS FOR PRACTICE

To perform effective cost-benefit analysis of an IT infrastructure component change such as a software upgrade, IT managers need to be able to gauge effectively the impact of a technological change *before* the change takes place in order to aid in software selection and evaluation (Shaw 2001). Further, to compare alternatives in technological change (such as upgrading versus not upgrading), managers would like to be able to measure the extent to which users will perceive change as well as the manner in which they will react to it. The four dimensions of technological change proposed in this paper provide managers with an approach to the measurement of the extent of technological change that can be used prior to an IT implementation. Focus groups can be used to gather data on the specific dimensions, and results can be extrapolated to a user population. Thus, software packages can be quickly and effectively compared prior to an implementation.

IMPLICATIONS FOR RESEARCH

The conceptual model and empirical evidence presented here provide a basis for future theoretical and empirical research on technological change in organizations. The four dimensions of technological change can be used as antecedents to user outcome measures such as those in the technology acceptance model (TAM) (Davis 1989; Davis et al. 1989; Venkatesh and Davis 1996). A critical issue in future theoretical development will be to reconcile the importance of measures of perceived technological change with other antecedents to technology acceptance such as subjective norm, image, and job relevance (Venkatesh and Davis 2000). It is unclear how these two sets of measures relate both theoretically and empirically. It is likely that some combination of the measures of technology itself along with user perceptions of the work environment will combine to be very thorough predictive measures of technology acceptance. In fact, although empirical testing is needed, one would expect that the measures of perceived technological change would be able to explain a large portion of the variation in technology acceptance that is not explained by the behavioral approach advocated by TAM2 (Venkatesh and Davis 2000).

The most surprising result in the study is the lack of correlation between the user interface construct with the other three dimensions of technological change. Similarly, the user interface construct was by far the worst antecedent of the surrogate user acceptance measures used in this study. A likely explanation for this result is that changes in the user interface are at a different “level” than the other constructs. For example, perhaps perceptions of user interface change would be best conceptualized as an antecedent to perceived ease of use in the TAM, in which case perceived ease of use would be correlated with the other three dimensions of technological change. Accordingly, a thoroughly insightful study would be one that attempts to investigate the relationships among the TAM constructs and the four dimensions of technological change.

In summary, the effects of technological changes caused by the introduction of new IT infrastructure components have not been studied in detail by IS researchers. The development of a model and instrument to measure technological changes allows for the study of the causes and effects of those changes. Researchers can use the constructs and measures developed in the paper to study the dimensions of technological change and their effect on other factors in IT infrastructure. Similarly, a salient approach to future research would be one that investigates the antecedents of technological change. That is, it would be interesting to be able to model any factors that caused changes in the degree to which users perceived changes in functionality, compatibility, etc. Further, the distinct components that comprise technological change can be used to isolate and study more detailed research questions. Alternatively, practitioners can use the instrument to measure, study, and predict the effects of an upcoming infrastructure change on the organization. In either case, the model and instrument provided serve as a viable starting point for the further investigation of IT infrastructure change.

VI. ACKNOWLEDGMENTS

This research was supported in part by a grant from the National Aeronautics and Space Administration (NASA) Office of Space Science. The author wishes to thank the organization and its directors for their generous support of this research effort.

VII. REFERENCES

Barti, H., and Huff, S. "Change, Attitude to Change, and Decision Support System Success," *Information and Management* (9:5), 1985, pp. 261-268.

Belardo, S., Karwan, K . R., and Wallace, W. A. "DSS Component Design Through Field Experimentation: An Application to Emergency Management," in *Proceedings of the Third International Conference on Information Systems,* 1982, pp. 93-108.

Benamati, J. *Managing Information Technology in a Changing Information Technology Environment*, Unpublished Ph.D. Dissertation, University of Kentucky, 1997.

Benamati, J., Lederer, A. L., and Singh, M. "Changing Information Technology and Information Technology Management," *Information and Management* (31), 1997, pp. 275-288.

Bentler, P. M. "Comparative Fit Indexes in Structural Models," *Psychological Bulletin* (107:2), 1990, pp. 238-246.

Bentler, P. M., and Bonett, D. G. "Significance Tests and Goodness of Fit in the Analysis of Covariance Structures," *Psychological Bulletin* (88:3), 1980, pp. 588-606.

Brancheau, J. C., Janz, B. D., and Wetherbe, J. C. "Key Issues in Information Systems Management: 1994-95 SIM Delphi Results," *MIS Quarterly* (20:2), 1996, pp. 225-236.

Broadbent, M., Weill, P., O'Brien, T., and Neo, B. S. "Firm Context and Patterns of IT Infrastructure Capability," in *Proceedings of the Seventeenth International Conference on Information Systems,* J. I. DeGross, S. Jarvenpaa, and A. Srinivasan (eds.), Cleveland, OH, 1996, pp. 174-194.

Brynjolfsson, E., and Kemerer, C. F. "Network Externalities in Microcomputer Software: An Econometric Analysis of the Spreadsheet Market," *Management Science* (42:12), 1996, pp. 1627-1647.

Campbell, D. T., and Fiske, D. W. "Convergent and Discrimination Validation by the Multitrait-Multimethod Matrix," *Psychological Bulletin* (56:1), 1959, pp. 81-105.

Carmines, E. G., and McIver, J. P. "Analyzing Models with Unobserved Variables: Analysis of Covariance Structures," in G. W. Bohmstedt and E. F. Borgatta (eds.) *Social Measurement*, Thousand Oaks, CA: Sage Publications, 1981, pp. 65-115.

Chio, J. P. "Network Externality, Compatibility Choice, and Planned Obsolescence," *Journal of Industrial Economics* (42), 1994, pp. 167-181.

Clemons, E. K., and McFarlan, F. W. "Telecom: Hook Up or Lose Out," *Harvard Business Review,* 1986, pp. 91-97.

Conklin, J. H., Gotterer, M. H., and Rickman, J. "On-Line Terminal Response Time: The Effects of Background Activity," *Information and Management* (5:3), 1982, pp. 169-173.

Cooper, R. B., and Zmud, R. W. "Information Technology Implementation Research: A Technological Diffusion Approach," *Management Science* (36:2), 1990, pp. 123-139.

Davis, F. D. "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly* (13:3), 1989, pp. 319-339.

Davis, F. D., Bagozzi, R. P., and Warshaw, P. R. "User Acceptance of Information Technology: A Comparison of Two Theoretical Models," *Management Science* (35:10), 1989, pp. 982-1003.

DeLone, W. H., and McLean, E. R. "Information Systems Success: The Quest for the Dependent Variable," *Information Systems Research* (3:1), 1992, pp. 60-95.

DeSanctis, G., and Poole, M. S. "Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory," *Organization Science* (4:4), 1994, pp. 1-36.

Dillon, A., and Morris, M. "User Acceptance of Information Technology: Theories and Models," *Annual Review of Information Science and Technology* (31), 1996.

Doll, W. J., and Torkzadeh, G. "The Measurement of End-User Computing Satisfaction," *MIS Quarterly* (12:2), 1988, pp. 259-274.

Doll, W. J., Xia, W., and Torkzadeh, G. "A Confirmatory Factor Analysis of the End-User Computing Satisfaction Instrument," *MIS Quarterly* (18:4), 1988, pp. 453-461.

Fichman, R. G. "Information Technology Diffusion: A Review of Empirical Research," in *Proceedings of the Thirteenth International Conference on Information Systems,* J. I. DeGross, J. D. Becker, and J. J. Elam (eds.), Dallas, TX, 1992, pp. 195-206.

Franz, C. R., and Robey, D. "Organizational Context, User Involvement, and the Usefulness of Information Systems," *Decision Sciences* (17:3), 1986, pp. 329-356.

Goslar, M. D. "Capability Criteria for Marketing Decision Support Systems," *Journal of MIS* (3:1), 1986, pp. 81-95.

Griffith, T. L., and Northcraft, G. B. "Cognitive Elements in the Implementation of New Technology: Can Less Information Provide More Benefits," *MIS Quarterly* (20:1), 1996, pp. 99-110.

Griffith, T. L., and Northcraft, G. B. "Promises, Pitfalls, and Paradox: Cognitive Elements in the Implementation of New Technology," *Journal of Managerial Issues* (5:4), 1993, pp. 465-482.

Hayduk, L. A. *Structural Equation Modeling with LISREL*, Baltimore, MD: Johns Hopkins University Press, 1987.

Hiltz, S. R., and Turoff, M. "The Evolution of Computer Behavior in a Computerized Conferencing System," *Communications of the ACM* (24:11), 1981, pp. 739-751.

Hopper, M. D. “Rattling SABRE—New Ways to Compete on Information,” *Harvard Business Review,* 1990, pp. 118-125.

Hu, L., and Bentler, P. M. “Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives,” *Structural Equation Modeling* (6:1), 1999, pp. 1-55.

Igbaria, M., and Chakrabarti, A. “Computer Anxiety and Attitudes Toward Micro-computer Use,” *Behavior and Information Technology* (9:3), 1990, pp. 229-241.

Igbaria, M., Guimaraes, T., and Davis, G. B. “Testing the Determinants of Micro-computer Usage Via a Structural Equation Model,” *Journal of Management Information Systems* (11:4), 1995, pp. 87-114.

Igbaria, M., Parasuraman, S., and Pavri, F. “A Path Analytic Study of the Determinants of Microcomputer Usage,” *Journal of Management Systems* (2:2), 1990, pp. 1-14.

Karahanna, E., Straub, D. W., and Chervany, N. L. “Information Technology Adoption Across Time: A Cross-Sectional Comparison of Pre-Adoption and Post-Adoption Beliefs,” *MIS Quarterly* (23:2), 1999, pp. 183-213.

Katz, M., and Shapiro, C. “Network Externalities, Competition, and Compatibility,” *American Economic Review* (75), 1985, pp. 424-440.

Katz, M., and Shapiro, C. “Technology Adoption in the Presence of Network Externalities,” *Journal of Political Economy* (94), 1986, pp. 822-841.

Kline, R. B. *Principles and Practice of Structural Equation Modeling*, New York: Guilford Press, 1998.

Kriebel, C. A., and Raviv, A. “An Economics Approach to Modeling the Productivity of Computer Systems,” *Management Science* (26:3), 1980, pp. 297-311.

Kwon, T. H., and Zmud, R. W. “Unifying the Fragmented Models of Information Systems Implementation,” in R. Boland and R. Hirschheim (eds.), *Critical Issues in Information Systems Research*, New York: John Wiley, 1987, pp. 227-251.

Lederer, A. L., and Benamati, J. “What’s New? The Challenges of Emerging Information Technologies,” *Journal of Database Management* (9:1), 1998, pp. 33-34.

Lederer, A. L., and Mendelow, A. L. “The Impact of the Environment on the Management of Information Systems,” *Information Systems Research* (1:2), 1990, pp. 205-222.

Lee, S. M., Kim, Y. R., and Lee, J. “An Empirical Study of the Relationships Among End-User Information Systems Acceptance, Training, and Effectiveness,” *Journal of Management Information Systems* (12:2), 1995, pp. 189-202.

Lehman, J. A. “Organization Size and Information System Sophistication,” *Journal of Management Information Systems* (2:3), 1986, pp. 78-86.

Leonard-Barton, D. “Implementation as Mutual Adaptation of Technology and Organization,” *Research Policy* (17), 1988, pp. 251-267.

Lucas Jr., H. C. "Empirical Evidence for a Descriptive Model of Implementation," *MIS Quarterly* (2:2), 1978, pp. 27-41.
Lucas Jr., H. C. "Performance and the Use of an Information System," *Management Science* (21:8), 1975, pp. 908-919.
Lucas Jr., H. C., Walton, E. J., and Ginzberg, M. J. "Implementing Packaged Software," *MIS Quarterly* (12:4), 1988, pp. 537-549.
Mahmood, M. A. "Systems Development Methods: A Comparative Investigation," *MIS Quarterly* (11:3), 1987, 3, pp. 293-311.
Morey, R. C. "Estimating and Improving the Quality of Information in a MIS," *Communications of the ACM* (25:5), 1982, pp. 337-342.
Nunnally, J. C. *Psychometric Theory* (2nd edition), New York: McGraw-Hill Book Company, 1978.
Orlikowski, W. J. "The Duality of Technology: Rethinking the Concept of Technology in Organizations," *Organization Science* (3:3), 1992, pp. 398-427.
Orlikowski, W., and Iacono, C. S. "Desperately Seeking the 'IT' in IT Research: A Call to Theorizing the IT Artifact," *Information Systems Research* (12:2), 2001, pp. 121-134.
Porter, M. E., and Millar, V. E. "How Information Gives You Competitive Advantage," *Harvard Business Review,* 1985, pp. 149-160.
Rayport, J. F., and Sviokla, J. J. "Exploiting the Virtual Value Chain," *Harvard Business Review,* 1995, pp. 75-85.
Rogers, E. M. *Diffusion of Innovations*, New York: The Free Press, 1983.
Seddon, P. "A Respecification and Extension of the DeLone and McLean Model of IS Success," *Information Systems Research* (8:3), 1997, pp. 240-253.
Shaw, N. G. *The Transparent Evolution of Information Technology Infrastructure Components*, Unpublished Ph.D. Dissertation, Texas Tech University, 1999.
Shaw, N. G. *Strategies for Managing Computer Software Upgrades*, Hershey, PA: Idea Group Publishing, 2001.
Srinivasan, A. "Alternative Measures of System Effectiveness: Associations and Implications," *MIS Quarterly* (9:3), 1985, pp. 243-253.
Straub, D. "Validating Instruments in MIS Research," *MIS Quarterly* (13:2), 1989, pp. 146-165.
Straub, D., Limayem, M., and Karahanna-Evaristo, E. "Measuring System Usage: Implications for IS Theory Testing," *Management Science* (41:8), 1995, pp. 1328-1342.
Szajna, B. "Software Evaluation and Choice: Predictive Validation of the Technology Acceptance Instrument," *MIS Quarterly* (18:3), 1994, pp. 319-324.
Tucker, L. R., and Lewis, C. "A Reliability Coefficient for Maximum Likelihood Factor Analysis," *Psychometrika* (38:1), 1973, pp. 1-10.
Venkatesh, V., and Davis, F. D. "A Model of the Antecedents of Perceived Ease of Use: Development and Test," *Decision Sciences* (27:3), 1996, pp. 451-481.

Venkatesh, V., and Davis, F. D. “A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies,” *Management Science* (46:2), 2000, pp. 186-204.
Wang, Y.-M., Gallaugher, J., and Vasudevan, S. “The Determinants of Network Growth: The Case of Online Commercial Information Networks,” in *Proceedings of the Seventeenth International Conference on Information Systems,* J. I. DeGross, S. Jarvenpaa, and A. Srinivasan (eds.), Cleveland, OH, 1996, pp. 235-248.
Zmud, R. “Editor’s Comments,” *MIS Quarterly* (21:1), 1997.

VIII. ABOUT THE AUTHOR

Neal G. Shaw is an assistant professor of Information Systems in the Department of Information Systems and Operations Management in the College of Business Administration at the University of Texas at Arlington (UTA). He joined the faculty at UTA after receiving his doctoral degree in information systems from Texas Tech University in 1999. Dr. Shaw’s research focuses on the implementation of information technology (IT) in organizations and its impact on IT infrastructure and supply chain management. His work has been published or accepted in journals such as *Decision Support Systems*, *IEEE Transactions on Software Engineering*, and *Communications of the AIS*, in addition to other academic and professional publications. Also, he has received research grants from NASA and has received awards for teaching excellence.

Appendix
Questionnaire Items

Functionality (1 = strongly disagree, 5 = strongly agree)
FT1 I can do more with the new software than with the old software.
FT2 The new software has capabilities that the old software did not have.
FT3 The new software has features that the old software did not have.
FT4* The new software basically does the same things as the old software.

User Interface (1 = strongly disagree, 5 = strongly agree)
UI1 The user interface of the new software is different from that of the old software.
UI2 The new user interface is basically the same as the old user interface.
UI3 The new user interface included changes in user screens.
UI4* The new user interface included changes in menu options.
UI5* The new user interface caused changes in how I use the software.

Technical Quality (1 = strongly disagree, 5 = strongly agree)
TQ1 The new software had many technical problems, such as bugs, crashes, etc.
TQ2 The new software caused many technical problems on my computer.
TQ3 The new software caused many technical problems for my organization.

External Compatibility (1 = highly incompatible, 5 = highly compatible)
In your opinion, how compatible is the new software package with …
EC1 … other software on your computer?
EC2 … the old software package that was replaced?
EC3 … other software packages in the company that are not on your computer?
EC4 … other software in the marketplace?
EC5* … the hardware in your computer?

User Acceptance (1 = strongly disagree, 5 = strongly agree)
UA1 I am comfortable using the new software.
UA2 When I use the new software, I no longer think of it as new.
UA3* If I had a choice, I would prefer to have the old software back.

*Indicates items that were dropped from the final analysis.

Journal of the Association for Information Systems