Testing a Causal Model of End-User Application Effectiveness

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ABSTRACT: The purpose of this exploratory research was empirically to examine several logical relationships between key variables in order to create a causal model of end-user application effectiveness. To test the hypotheses, a survey-based field study was conducted in forty large organizations with a total of 506 usable responses. The data were analyzed using the Partial Least Squares (PLS) multivariate path analysis statistical technique. The preliminary empirical evidence provides general support for most of the key relationships contained in the model. Both the model based on the original sample and the validation of that model, based on the holdback sample, had good overall fits to the data. Of the important contributions, the end-users' motivation to develop new applications was found to be the most significant, showing the strongest positive path coefficient with application utilization. Perceived organizational support of EUC was found to be indirectly related to improved end-user information satisfaction and application utilization. Given a limited set of organizational resources, we suggest that managers invest time and money in improving organizational support of EUC where the immediate payoff may not be readily evident.

KEY WORDS AND PHRASES: end-user computing, application development, information system effectiveness, user satisfaction, application utilization, partial least squares (PLS) modeling.

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1. Introduction

AS WE ENTER THE 1990s, end-user computing (EUC) continues to spread rapidly and relentlessly. Yet Ronen et al. [49] point out that the growth in end-user applications is not without its costs to the organization. They cite frequent errors in end-user applications, specifically: (1) mistakes in logic: (2) unreliable output; (3) unauditable applications; (4) inability to change or modify applications; and (5) an overall lack of comprehensibility.

Because of the importance of assessing the effectiveness of end-user applications, it has received much attention lately by various researchers, suggesting that certain user and organizational variables may have an impact on the effectiveness of end-user-developed applications [1, 6, 7, 26, 28, 34, 39, 43, 45, 46, 48, 57]. This study empirically examines the relationships among several of these variables in order to formulate and test an exploratory causal model of end-user application effectiveness. Benjamin predicted that by 1990, EUC will absorb as much as 90 percent of the total computing resource [6]. The current levels of investment in EUC indicate that his prediction is not far off. Many companies are now spending in excess of 60 percent of their information technology budgets on EUC activities, and some spend as much as 80 percent.[1] In surveys made over the past six years, the "facilitation and management of end-user computing" continues to rank in the top ten in terms of importance as perceived by Information Systems (IS) professionals [11]. Obviously, the area of EUC deserves to be well managed and researched. In fact, it demands it, because the inefficient management of such a critical area and its accompanying resources may have a profound impact on the future of many organizations.

The benefits of end-user computing have been discussed in depth by Benson [7], Hackathorn [26], Martin [38], Quillard et al. [43], Rivard and Huff [45], and, of course, Rockart and Flannery [48]. In summary, the IS staff can expect to receive the following benefits from EUC: (1) decreased backlog of IS application development projects; (2) a decrease in the proportion of IS resources spent on application maintenance and programming; (3) improved programmer job satisfaction; (4) improved user relations; and (5) a better use of limited resources. Of course, the end user also receives some very significant benefits from end-user computing, including: (1) direct control over their information, applications, and their general environment; (2) an improved relationship with the IS staff; (3) faster response to information requests; (4) increased decision-making effectiveness; (5) improved computer literacy; and (6) increased satisfaction with end-user-developed applications.

It's not all good news, however; researchers and practitioners have recently identified specific problems and/or risks that are associated with end users developing their own systems. One of these is embodied in the nature of the developers: the EUC developer generally lacks extensive computer training, especially in the area of systems development techniques. Rockart and Flannery [48] and Quillard et al. [43] independently reported that 60 percent of end-user developers are nontechnical, using the computer primarily as a tool to solve a problem or perform a task.

Davis [10] also discussed several dangers inherent in the development of end-user applications. First, the elimination of the separate user and analyst roles may lead to a neglect of training, documentation, or maintenance with regard to the user-developed application. Second, the user may not have the ability correctly to identify complete information requirements. Moreover, Alavi and Weiss [1] reported that end users may inadvertently apply the wrong analysis technique to a situation, or, in some cases, even attempt to solve the wrong problem.

Our premise is that there may be certain user and organizational variables that may profoundly impact the effectiveness of end-user-developed applications in organizations today. In turn, those variables, when properly controlled, may lead to higher benefits and lower risks. There is a scarcity of literature that *empirically* examines the effectiveness issue of end-user applications within the corporate environment. Much of the published material on EUC to date consists of conceptual, descriptive surveys, or case-study-based research [1, 6, 8, 20, 25, 26, 27, 28, 48]. The focus of this exploratory research effort is to provide empirical evidence that identifies relationships that are critical to creating more effective end-user-developed applications.

This study addresses the effectiveness issue in several ways: first, by developing a conceptual model that consists of relevant variables from the user and organizational environments that have been reported to influence effectiveness; second, by empirically investigating possible relationships between the user and organizational variables, and the measures of end-user application effectiveness; and third, by examining the validity of the study questionnaire and the reliability of the instrument scales so as to initiate the development of improved instruments to measure end-user application effectiveness in the future.

2. A Descriptive Model for End-User Application Effectiveness

THIS SECTION PRESENTS OUR RESEARCH MODEL and the hypotheses that were tested in this research, as well as the theoretical basis for our propositions. The model (see Figure 1) is partially based on a framework that was proposed by Cheney, Mann, and Amoroso [8]. A review of recent relevant literature was conducted for the purpose of identifying additional theoretical relationships and arguing for their inclusion in the model because of their potential impact on the effectiveness of end-user applications.

Rather than attempt to examine all potential relationships between the factors and success measures, our model provides a structure that can be used to investigate the constructs that are central to end-user application effectiveness. We believe that this will result in a more manageable research effort, leading to more interpretable findings. The variables in the model that were investigated for their possible influence on end-user application effectiveness are illustrated in Figure 1 and described in Table 1.

The majority of the relationships tested were suggested by the recent literature [2, 6, 8, 19, 20, 22, 25, 27, 29, 31, 37, 38, 40, 43, 44, 46, 47, 48, 51, 53, 56, 60, 61]. A summary of the variables, their operationalizations, and reference instruments is presented in Table 2. In the remainder of this section, we present the propositions that were tested in this research. Following each proposition, the theoretical basis for the inclusion of the variable and their potential relationships are discussed.

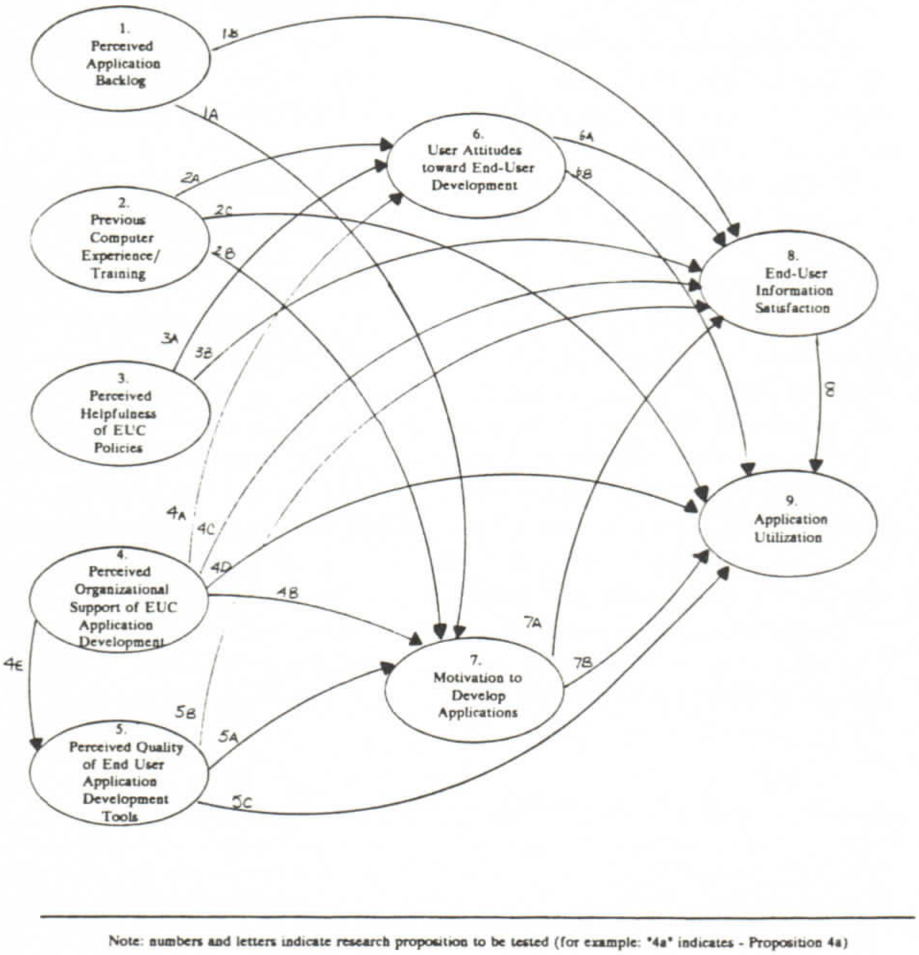


Figure 1. Research Model of End-User Effectiveness

2.1. Perceived Application Backlog

Proposition 1a: The larger the perceived application backlog, the greater a user's motivation to develop new end-user applications.

Proposition 1b: The larger the perceived application backlog, the greater the level of end-user information satisfaction.

Significant attention has been given to the backlog problem in recent years by IS practitioners and the academic community. IS managers face two growing problems: (1) an increasing number of requests for new applications, and (2) lengthening development cycles, due primarily to increasingly complex systems [6]. According to Martin [38], the arrival rate of requests for application development and maintenance is growing at 45 percent annually. These large backlogs stem from the shortage of

Table 1 Description of Model Hypotheses

PROPOSITION		RELATIONSHIP	VARIABLE(S)
1			PERCEIVED APPLICATION BACKLOG
	A	+	with Motivation to Develop New End-User Applications
	B	+	with End-User Information Satisfaction
2			PREVIOUS COMPUTER EXPERIENCE & TRAINING
	A		with User Attitudes toward End-User Development
	B	+	with Motivation to Develop New End-User Applications
	C	+	with Application Utilization
3			PERCEIVED HELPFULNESS OF EUC POLICIES
	A	+	with User Attitudes toward End-User Development
	B	+	with End-User Information Satisfaction
4			PERCEIVED ORGANIZATIONAL SUPPORT OF EUC APPLICATION DEVELOPMENT
	A	+	with User Attitudes toward End-User Development
	B	+	with Motivation to Develop New End-User Applications
	C	+	with End-User Information Satisfaction
	D	+	with Application Utilization
	E	+	with Perceived Quality of End-User Development Tools
5			PERCEIVED QUALITY OF END-USER APPLICATION DEVELOPMENT TOOLS
	A	+	with Motivation to Develop New End-User Applications
	B	+	with End-User Information Satisfaction
	C	+	with Application Utilization
6			USER ATTITUDES TOWARD END-USER DEVELOPMENT
	A	+	with End-User Information Satisfaction
	B	+	with Application Utilization
7			MOTIVATION TO DEVELOP EUC APPLICATIONS
	A	+	with End-User Information Satisfaction
	B	+	with Application Utilization
8			END-USER INFORMATION SATISFACTION
		+	with Application Utilization

systems development personnel. Alloway and Quillard [2] observed an average backlog of two to three years, but stated that the unofficial "invisible" backlog was 535 percent greater than the known backlog. The invisible backlog was made up of applications that the users stated they needed but had not as yet requested. The known backlog apparently misrepresents the demand for applications in terms of the number and types of systems desired. It therefore seems inappropriate to measure the actual applications backlog in an organization. In addition, individual users will have different perceptions of the actual backlog within the same organization, which may have an influence on their behavior. For the purposes of this study, the end user's perceptions of the application backlog were assessed on several dimensions that addressed:

a. the perceived reasonableness of the backlog;
b. the shortage of IS development personnel;
c. the prompt processing of applications requests;
d. avoidance of placing new requests; and
e. demand versus supply of IS resources.

Obviously, the larger these two (formal and invisible) backlogs are, the greater a user's motivation to develop their own applications. Motivation to develop end-user applications for the purpose of this study is defined as an internal force where the attractiveness and expectation of the outcome (i.e., application effectiveness) out-

Table 2 Summary of Theoretical Relationships

VARIABLE	OPERATIONALIZATION	REFERENCE INSTRUMENTS
Perceived application backlog	perceived usefulness of backlog shortage of IS development personnel prompt processing of application requests avoidance of placing new requests demand versus supply of IS resources	Alloway & Quillard [2] Benjamin [6] Martin [38] Lucas [37]
Previous computer experience	using operating systems using computer hardware accessing data and telecommunications defining information requirements designing outputs and inputs developing files structures	Yaverbaum [60] Vitalari [56] Rivard & Huff [46] Lee [34]
Past computer ttaining	hardware concepts and software packages data retrieval systems analysis and modeling techniques graphics electronic mail	Nelson & Cheney [40] Guimaraes & Gupta [25] Fuerst & Cheney [19] Ginzberg [22]
Perceived helpfulness of EUC policies	equipment compatibility technical walkthroughs documentation standards obtaining vendor support negotiating vendor contracts data backup procedures application quality reviews	Gerrity & Rockart [20] Rockart & Flannery [48] Quillard, et al. [43]
Perceived organizational support of end-user application development	guidance in selection of hardware/software user specific training programs access to corporate data development assistance from IS or IC staff existence of information center	Cheney, et al. [8] Hammond [27]
Perceived quality of end-user application development tools	user friendliness of software tools flexibility of software tools ability of software to handle different formats access to end-user software tools	Reimann & Waren [44] Rivard & Huff [46]
User attitudes toward end-user development	expectations of EUC benefits top management encouragement of EUC perceptions of organizational environment beliefs about usefulness of EUC	Rivard & Huff [46] Zmud [61] Lucas [37] Ginzberg [22]
Motivation to develop applications	level of end-user enthusiasm likelihood that rewards will result from EUC	Zmud [61] Robey [47]
End-user information satisfaction	accuracy, timeliness, reliability, and completeness of the system's output precision, currency, and relevancy of the information product volume of output flexibility of application user confidence in application	Ives, et al. [31] Ilvari [29] Treacy [53]
Application utilization	intended versus actual utilization: making decisions, looking for trends, planning, taking action, finding problems, historical reference, budgeting, controlling and guiding activities, reporting to superiors, aiding in increasing productivity, cutting costs	Fuerst & Cheney [19] Lucas [37] Srinivasan [51]

An "overall" assessment question was measured for each of the study variables.

weighs the risks [36]. As Martin states, users will take development into their own hands when faced with an impossible backlog situation [38]. Cheney, Mann, and Amoroso [8] proposed that the probability of EUC success, as measured by user information satisfaction, should be enhanced when the application development backlog is perceived to be large. This proposition will also be tested.

2.2. Previous Computer Experience and Training

Proposition 2a: The greater the degree of the user's previous experience and training with computers, the more positive a user's attitude toward end-user application development.

Proposition 2b: The greater the level of a user's previous experience and training with computers, the greater that user's motivation to develop new end-user applications.

Proposition 2c: The greater the level of a user's previous experience and training with computers, the greater the level of application utilization.

A user's experience in using computers may critically influence the effectiveness of end-user computing. Vitalari [56] classified computer experience into three categories that included the development, operation, and maintenance of computer applications. Rivard and Huff [46] reported that the heterogeneity of users' computer background was a significant variable in explaining why some viewed a tool as easy to use while others perceived the same tool as difficult to use. Kasper and Cerveny [33] concluded that users with a higher degree of computer experience had developed a significantly greater number of applications. Yaverbaum [60] reported an increase in the internal motivation to use computers as the number of years of computing experience grew. Regarding utilization, Fuerst and Cheney [19] found a strong relationship between system usage and the experience of the system users. Finally, Lee [34] found a positive relationship between previous computer experience and the use of microcomputer systems.

As in the Yaverbaum study, we measured individual user experiences with computers on the following multiple dimensions:

a. using operating systems;
b. using computer hardware;
c. accessing data and using telecommunications;
d. defining information requirements;
e. designing outputs and inputs;
f. developing file structures.

Similar to the experience variable, past user training with computers has been purported to be related both to user motivation and to user utilization. Hackathorn [26] found the presence of training and education to be strongly associated with the general success of the end-user computing environment. Guimaraes and Gupta [25] tested the impact of training on a variety of variables related to personal computing and support services finding several significant positive relationships, including motivation. Fuerst and Cheney [19] reported a significant correlation between user training and utilization. Past computer training for this study included instruction in such topic areas as hardware concepts, software packages, data retrieval, systems analysis and modeling techniques, graphics, and electronic mail [40].

2.3. Perceived Helpfulness of EUC Policies

Proposition 3a: The greater the perceived helpfulness of EUC policies, the more positive a user's attitude toward end-user development.

Proposition 3b: The greater the perceived helpfulness of EUC policies, the greater the level of end-user information satisfaction.

Managing the growth in end-user computing will of necessity require the formulation of new policies. Sufficient policies have not kept pace with the rapid growth of the EUC field [1, 45, 54]. Several authors have recommended the formulation and enforcement of end-user policies encompassing a variety of controls [1, 28, 43, 48, 57]. Benjamin [6] concluded that the rapid growth in EUC will eventually force IS management to develop comprehensive policy and control mechanisms that will manage the demand for services. Gerrity and Rockart [20] suggested a set of integrated policies, standards, and guidelines to ensure the highest-quality technical environment. We believe we will find significant interactions between EUC policies and user attitudes and end-user information satisfaction.

Our instrument collected data concerning the existence and helpfulness of end-user policies in the following areas: equipment compatibility, technical walkthroughs, documentation standards, negotiating vendor contracts and obtaining vendor support, data backup procedures, and application quality reviews.

2.4. Perceived Organizational Support of End-User Application Development

> *Proposition 4a*: The greater the degree of perceived organizational support of end-user application development, the more positive a user's attitude toward end-user application development.
>
> *Proposition 4b*: The greater the degree of perceived organizational support of end-user application development, the greater a user's motivation to develop new applications.
>
> *Proposition 4c*: The greater the degree of perceived organizational support of end-user application development, the greater the level of end-user information satisfaction.
>
> *Proposition 4d*: The greater the degree of perceived organizational support of end-user application development, the greater the level of application utilization.
>
> *Proposition 4e*: The greater the degree of perceived organizational support of end-user application development, the greater the degree of the perceived quality of end-user development tools.

Organizational support of end-user computing, in the form of hardware, software, data, processes, and people, has been cited as a strategy that will increase the likelihood of EUC success [8]. Support as we operationalized it included: (1) guidance for the selection of hardware and software; (2) user-specific computer training programs; (3) access to corporate data for the development and operation of specific applications; and (4) assistance from the IS staff in the development and maintenance of end-user-developed applications. Hammond [27], among others, stated the need to support EUC through an organizational information center.

Lucas [37] reported significant correlations between organizational support and five variables that were related to system success. We believe it is logical to argue that the degree of organizational support is related to the quality of EUC tools as perceived by end users. Several researchers [7, 43, 48] have proposed that for learning to occur in an end-user computing environment, support must be provided to users. Jobber and

Watts [32] and Lucas [37] concluded that the more positive the perception of organizational support, the greater the degree of system utilization.

We hypothesize from existing research in organizational support that supported end-user computing environments will yield higher positive user attitudes, a greater degree of motivation to develop new applications, and higher levels of user information satisfaction [31, 33, 34, 43, 48]. Although not previously studied, intuitively we also hypothesize that the greater the degree of support, the greater the perceived level of quality of EUC tools. It makes sense in our opinion that if an organization supports EUC with an information center or some other form of resources, the perceived quality of the EUC tools they acquire should be greater than for those organizations that do not support EUC. Organizational support was operationalized in terms of the following dimensions:

a. guidance available for hardware and software selection;
b. instruction and training available for EUC tools;
c. access to corporate data for application development and utilization;
d. presence and quality of an information center(s).

2.5. Perceived Quality of End-User Application Development Tools

> *Proposition 5a*: The greater the degree of perceived quality of end-user application development tools, the greater a user's motivation to develop new end-user applications.
>
> *Proposition 5b*: The greater the degree of perceived quality of end-user application development tools, the greater the level of end-user information satisfaction.
>
> *Proposition 5c*: The greater the degree of perceived quality of end-user application development tools, the greater the level of application utilization.

End-user application development tools include those resources through which the end user can facilitate the development of a working, integrated application. Benjamin's [6] list of the types of hardware needed for the end-user environment includes microcomputers, mainframes, terminals, support printers, data storage facilities, and telecommunication networks. Software tools include fourth-generation languages, procedural languages, specific application packages, productivity generators, reusable codes, statistical analysis software, modeling software, and graphical tools. Reimann and Waren's [44] criteria for evaluating the quality of end-user application development tools were used for this study. They included the facets of user friendliness, flexibility, and the ability to handle different formats.

Many authors have stressed the importance of the quality of user-friendly tools for successful EUC environments [38, 39, 44, 48]. Rivard and Huff [45] paid particular attention to the correlation between the quality of end-user tools and a user's motivation to develop new applications. If a relationship exists between the quality of EUC tools and end-user satisfaction, we also feel that there is a similar relationship that exists with application utilization. This observation is based upon several comments that were made by knowledgeable practitioners: notably, members of an Industrial

Advisory Board and several members of the Society for Information Management (SIM). The comments were made by SIM members at their annual conference.

2.6. User Attitudes toward End-User Development

> *Proposition 6a*: The more positive a user's attitude toward end-user development, the greater the level of end-user information satisfaction.

> *Proposition 6b*: The more positive a user's attitude toward end-user development, the greater the level of application utilization.

The literature is vague and contradictory in reporting on the relationship between user attitudes and utilization. While Schewe [50] concluded that there is no significant relationship between attitudes and system usage behavior, Robey [47] conversely reported that user attitudes strongly correlate with system use. Tait and Vessey [52] proposed that as user attitudes toward a new system improve, the likelihood of system success increases. However, they failed to show a significantly strong relationship between user attitudes and system success, as measured by user information satisfaction.

Ginzberg [22] found that users who held realistic expectations or attitudes toward newly implemented information systems were more satisfied with the system and used it more than users whose pre-implementation expectations were unrealistic. Rivard and Huff [46] found a small correlation between user attitudes and overall user satisfaction. Baroudi et al. [5] discovered that user attitudes toward an information system will influence behavior with respect to the use of the system and its outputs. Lucas [37] also reported a significant relationship between the attitude of the individual toward the information system and the use of that system.

2.7. Motivation to Develop Applications

> *Proposition 7*: The greater a user's motivation to develop new applications, the greater the level of application utilization.

Motivation is defined as a person's internal force to behave in a certain way. According to Vroom, the force is a function of the attractiveness of an outcome (i.e., application effectiveness) and the expectation that application development will lead to a certain outcome [36]. Motivation is the reason why a person carries out certain activities.

Zmud [61] proposed a model for MIS success by examining the individual differences of system users. He suggested that the motivation to use the system again could be either a moderator or another surrogate measure of MIS success. Because end-user computing is primarily a development environment, we took the motivation concept a step further and hypothesized that if end users are highly motivated to develop new applications, they will also be more inclined to use existing end-user applications.

2.8. End-User Information Satisfaction and Application Utilization

> *Proposition 8*: The greater the level of end-user information satisfaction, the greater the degree of application utilization.

The effectiveness of end-user applications is defined as the degree to which an application achieves its goal from the perspective of the end user. Measurement approaches for IS effectiveness include user information satisfaction, system utilization, incremental decision performance, cost-benefit analysis, and information economics [51, 54, 60, 61]. Most of the recent research in this area has employed either systems utilization or user information satisfaction as the dependent variable of interest. They have most frequently been used as surrogate measures for the variable information systems application success [4, 19, 30, 37].

Effectiveness (i.e., goal achievement) and information systems application success are essentially the same concept, and therefore information satisfaction and application utilization are viable surrogate measures for both [23, 45]. Bailey and Pearson [4] defined user information satisfaction (UIS) as a multidimensional attitude of the user toward different aspects of an information system. Ives, Olson, and Baroudi [31] and Iivari [29] described user information satisfaction as the perceived effectiveness of an information system. The two major constructs of UIS are information output quality (i.e., content, accuracy, format, media, etc.), and system quality (i.e., integrity, availability, response time, etc.) [51, 54].

The availability of previous measurement instruments and the ease of measuring user information satisfaction were the two main reasons why we chose it as one of our two measures of EUC effectiveness. Treacy [53] concluded that:

> Starting with the factors discovered by Ives, Olson, and Baroudi—a more precise, unambiguous, and complete causal model of UIS should be developed. This model would result in a diagnostic model of UIS that could have important implications for the management of end-user computing.

Hence, the end-user satisfaction measure for this study was derived and modified from the Ives, Olson, and Baroudi short-form instrument [31]. A newer and perhaps better instrument for measuring end-user information satisfaction was developed by Doll and Torkzedeh [13], but unfortunately it was not available at the time of this study.

System utilization is a behavioral measure of user acceptance when users are not obligated to use the system. Lucas's [37] research on IS performance identified a strong relationship between system and IS effectiveness as measured by the reported use of the IS over time. Ives and Olson [30] concluded that system utilization can be a good surrogate of IS effectiveness. Ein-Dor and Segev [14] also explain why system utilization is a good surrogate for IS effectiveness:

> The literature suggests a number of criteria for success. . . .These criteria are clearly dependent; profitability is correlated with performance, application to major problems and actual use. We claim that a manager will use some of the criteria, and that use is highly correlated with them. Thus we choose *use* as a prime criterion of MIS success.

Twelve measures of application utilization were used in this research effort, as derived from the Fuerst and Cheney [19] study.

The relationship between satisfaction and utilization has been debated in the literature for over a decade. Srinivasan [51] concluded that a strong association between the two measures may not always exist, yet he suggested both surrogates be included in future research. Baroudi et al. [5] described user information satisfaction as an attitude toward the information system while system utilization was classified as a behavior. Based again on our discussions with end users and SIM members, we assumed that high information satisfaction will lead to high utilization, which is why we chose the direction we did for the proposed relationship between these two variables. Obviously, it could be argued that either there is no relationship between the two, or that the reverse is true—high utilization will yield high end-user information satisfaction.

3. Methodology

TO TEST THE HYPOTHESES, a survey-based field study of multiple large organizations was implemented. The questionnaire was distributed to 965 end users in 40 firms. The number of questionnaires returned totaled 597, yielding an initial response rate of 62 percent. From that, 91 respondents were discarded, because they failed to answer one or more groups of questions or they did not actually develop their own applications, bringing the sample to 506. The final response rate, of 53 percent, was considered reasonable given the lengthy instrument.

3.1. The Sample

The organizations chosen for the study met the following criteria: (a) they were large Fortune 500 firms; (b) they had an active end-user computing environment; and (c) they had an annual budget for computing resources in excess of 1 percent of sales. Out of the seventy-four organizations chosen at random from a list of Fortune 500 manufacturing, service, and public sector firms, forty agreed to participate in the study. The sample represented a wide variety of firms with average sales of $6.6 billion, and an average number of employees of approximately 45,000. Most of the firms were from the private sector, including airlines, food manufacturers, distributors, banks, electronics companies, and insurance firms.

End users were selected by corporate contact individuals. They had to meet several criteria, including: (a) developing applications for their own use within the past twelve months; and (b) working in a functional area such as finance or marketing, rather than the IS area. Contacts were instructed to select respondents for the study randomly rather than choose successful end users. Follow-up telephone calls to corporate contacts were made within two weeks of delivering the instruments to encourage the distribution and ultimate return of the questionnaires. Random follow-up telephone calls were also made to several of the end users to ensure that they had no problems understanding or interpreting the measurement instrument.

Respondents were required to complete a questionnaire that gathered information regarding corporate demographics, end-user information satisfaction, application utilization, and the eight specific independent variables. Most of the responses were Likert and semantic differential scales. This provided sample variation for the analysis.

Heeding the warnings of Tait and Vessey [52] and Rivard and Huff [46], no single-item scales were employed in order to ensure an adequate level of reliability and validity for the measures. Composite scales were created for each of the independent and dependent variables.

3.2. Characteristics of the Respondents

The distribution of the 506 users in this study is not representative of the entire end-user population as categorized by Rockart and Flannery [48]. All of the users surveyed fell into Rockart and Flannery's Command-Level End-User and End-User Programmer categories. The functional areas represented by the users are presented in Table 3. Over 80 percent of the respondents have worked in their present jobs less than four years, with 40 percent working less than two years (see Table 4). Almost 50 percent of the participants do not supervise anyone else, while another 40 percent supervise fewer than nine people. Another interesting point is that half of the respondents worked in relatively small departments with fewer than twenty people, while only 6 percent of the subjects worked in very large departments that comprised 200 or more individuals.

As expected, the users surveyed had a high degree of experience in several of the basic computing categories, such as a "knowledge of application development tools," but few had any general programming experience. They were knowledgeable about Lotus 1-2-3 but not about DB2 or COBOL. This corresponds with the experience levels of respondents in two other studies [45, 48]. Fifty percent of the respondents had less than three years of development experience. The primary method of training for these respondents was self-training and this type of training received the highest evaluation (see Table 5).

Over 50 percent of the end-user developers in the study developed fewer than five applications annually, while 20 percent of the respondents developed at least one application per month. The end users had a high level of enthusiasm for developing future applications. Approximately 85 percent of the subjects rated their level of enthusiasm for developing new applications as "very high" or "strong." These were the highest two categories for propensity or desire to develop applications in the future, measured on a six-point Likert scale. The most mentioned areas where the respondents were planning to develop new applications were for: (1) aiding the user in increasing productivity; (2) aiding the user in reporting to supervisors; (3) making decisions; and (4) planning.

Users were asked to describe the computing equipment they used to develop application systems. As expected, 31.4 percent reported that they used microcomputers exclusively, while 11.8 percent used mainframes only. Only 1 percent used minicomputers exclusively. A total of 85 percent of the respondents reported some use of microcomputers in the development of end-user applications.

The majority of end users had been in their present position less than five years. Table 6 describes the types of applications the respondents reported developing during the previous twelve months. Over 90 percent of the 506 users in this study generated

Table 3 Functional Location of User/Developers

Functional Area	Number of Responses	% of Population	Comparison with Rockart/Flannery Findings (1983) %
Corporate Strategy - Planning & Forecasting	57	11.6	11.4
Marketing Research	26	4.8	5.7
Marketing Planning	42	8.5	6.4
Finance - Accounting	38	7.6	7.2
Finance - Planning/Analysis/Investment	98	19.7	5.0
Purchasing/Scheduling/Distribution	23	4.3	6.4
Human Resources/Personnel	37	7.3	6.4
Actuarial	46	9.4	3.6
Production/Operations Research	22	4.2	3.6
Engineering	31	5.7	8.6
I/S Developer/Supporter	33	6.2	14.3
Customer Service	46	9.4	4.3
Other - Legal	7	1.3	2.1
TOTALS	506	100.0	

Table 4 Development Experience of Respondents (in years)

Years in Present Position	Number of Responses	Proportion of the Population	Cumulative Percentage of the Population
< 1 year	69	13.8 %	13.8 %
1 to < 2 years	98	20.4 %	34.2 %
2 to < 3 years	68	13.4 %	47.6 %
3 to < 4 years	56	10.6 %	58.2 %
4 to < 5 years	59	11.3 %	69.5 %
5 to < 6 years	39	7.6 %	77.1 %
6 to < 7 years	17	3.5 %	80.6 %
7 to < 8 years	14	2.8 %	83.4 %
8 to < 9 years	6	1.2 %	84.7 %
9 to < 10 years	20	4.1 %	88.7 %
10 years or more	50	11.3 %	100.0 %

Table 5 Sources of CBIS Training

Questionnaire Item	1 None	2 Fair	3 Average	4 Good	5 Excellent	Mean
Self trained	1.5%	2.5%	20.5%	46.7%	28.7%	3.98
College trained	33.2%	16.4%	23.7%	21.9%	4.9%	3.13
Firm trained	13.0%	14.5%	26.6%	35.9%	8.8%	2.49
Vendor trained	61.1%	10.6%	11.6%	14.1%	2.5%	1.87

reports. Seventy percent manipulated data and two-thirds performed more sophisticated data analysis. Overall, access to databases and database tools appeared to be critical in the development of successful EUC applications.

Several previous studies have stressed the need to establish and enforce formal written EUC policy statements [43, 48, 57]. The users in our study responded to a series of questions that were designed to measure their awareness of certain EUC corporatewide issues. In general, the respondents were either unaware of the EUC policies, or viewed them as not helpful. The policies governing the procurement of hardware and software were either not known or viewed as cumbersome by 70 percent

Table 6 Types of End-User Applications Developed

Application	Number of Responses	Proportion of the Population[1]
Reports	463	91.6 %
Data Manipulation	354	70.5 %
Data Analysis	337	66.5 %
Graphics	232	45.5 %
Queries	227	44.9 %
Statistics	209	41.3 %
Modeling	184	36.4 %
Project Management	107	21.1 %
Other	46	9.0 %

[1] Proportions do not add up to 1.0 as multiple applications were reported by most respondents.

Table 7 Awareness of End-User Computing Policies

Policy	(Score = 5) Very Helpful	(Score = 1) Not Known/ Helpful	Mean	Median	Mode	Std. Dev.
Software Purchases	44.5 %	21.0 %	3.10	3.00	4.00	1.40
Access to Corporate Date	41.7 %	18.4 %	3.07	3.00	3.00	1.36
Data Backup Procedures	40.3 %	16.0 %	3.11	3.00	3.00	1.31
Hardware Purchases	31.0 %	32.9 %	2.66	3.00	1.00	1.43
Equipment Compatibility	30.1 %	26.6 %	2.72	3.00	3.00	1.34
Peripherals Purchases	27.7 %	34.8 %	2.54	3.00	1.00	1.38
Establishing Audit Trails	23.7 %	38.1 %	2.41	2.00	1.00	1.38
Documentation Standards	23.0 %	35.7 %	2.42	2.00	1.00	1.33
Obtaining Vendor Support	18.6 %	48.3 %	2.13	2.00	1.00	1.31
Application Quality Reviews	17.7 %	46.6 %	2.13	2.00	1.00	1.29
Technical Walkthroughs	17.7 %	41.1 %	2.21	2.00	1.00	1.29
Closing Vendor Contracts	5.2 %	72.9 %	1.49	1.00	1.00	0.92

of the respondents. Policies governing vendor support, application quality reviews, and technical walkthroughs were either not known or not viewed as helpful by over 40 percent of the respondents (see Table 7).

4. Data Analysis

THE DATA WERE ANALYZED USING Partial Least Squares (PLS), a multivariate path analysis statistical technique developed by Wold [59]. PLS is known as a second-generation causal modeling technique. In contrast, most researchers have used factor analysis and regression equations to investigate potential relationships. The traditional approach is not without its problems, the first of which is that regression analysis restricts the researcher with a strict set of assumptions. For example, independent variables cannot be correlated with each other. Second, the measurement model, analogous to factor analysis, is tested independently of the structural model, created by regression. Thus, a maximally efficient fit between the data and structural model is not likely to occur.

Each step of the PLS iterative procedure involves the minimization of some residual variation with respect to a subset of the parameters. In contrast to the more popular LISREL, the objective of PLS is the explanation of variance and prediction in the model, as opposed to LISREL's aim of minimizing residual covariance. This makes PLS more predictive in the traditional regression sense. Also, LISREL operates under some rather strict assumptions, such as the need for proof of multivariate normality and rather large sample sizes. Primarily, though, PLS allows the researcher to investigate research problems where abstract constructs do not have powerful theoretical models (formative indicators) [35, 59]. Lohmoller [35] proposed that theory be applied in order to specify whether modeled relationships are reflective or formative.

To test the proposed model of EUC effectiveness and retest it for statistical validation purposes, the data set was split [15, 21]. To accomplish this, firms were assigned a number from one to forty, and a random number generator determined the group to which a firm was categorized [9]. Although we did not expect to find systematic differences between the two groups, the Hotelling T-square multivariate statistic was used to compare the mean vectors of the two groups across the fifty variables, making adjustments for possible intercorrelations [21, 42]. At the 0.001 level of statistical significance, only one variable was significant. The results of the Hotelling T-square statistic (based on the F distribution) led us to conclude that the two samples were reasonably comparable. Missing data were estimated by using means from the instruments where the items were completed. Ninety-one questionnaires with excessive missing data items were discarded.

Concerned about organizational effect among the samples and the consequences of bias, we tested each sample for independence by firm. Multivariate analysis of variance (MANOVA) was recommended [9, 42] in order to determine whether there are overall significance differences among the groups. Using Roy's Maximum Root Criterion, we could not reject the null hypothesis that the mean vectors of the groups are equal for either sample. Therefore, we concluded that there were no signficant organizational effects present.

4.1. The Measurement Model

We then tested the psychometric properties of the measurement model. Fundamental to theory building is the development of new constructs and reliable measures to estimate them. First, we present the correlation matrix of the survey data in Table 8. Strong correlations are observed initially between several sets of variables: Motivation to Develop and Application Utilization ($r = 0.59$); Perceived Quality of Tools and User Attitudes ($r = 0.54$); Perceived Quality of Tools and Perceived Organizational Support ($r = 0.46$); and Perceived Organizational Support and User Attitudes ($r = 0.51$). None of the squared correlations was close enough to 0.80 to suggest a problem with multicollinearity between the constructs.

In Table 9 we report the PLS estimates of the factor loadings, the reliability of each measure, the composite reliability of each construct, and the percentage of variance extracted from each construct. As a guide to interpreting the reliabilities, Nunnally [42] suggests that the composite reliability of a construct should be in the range of 0.6 to 0.8. Fornell and Larcker [17] recommend that the average variance extracted for PLS models be above the 0.5 mark.

Table 8 Correlation Matrix of the Original Sample

Variable	1	2	3	4	5	6	7	8	9
1. Backlog	1.00								
2. Experience	.14	1.00							
3. Policies	.03	.35	1.00						
4. Support	.25	.27	.21	1.00					
5. Tools	.19	.25	.16	.46	1.00				
6. Attitudes	.24	.26	.26	.51	.54	1.00			
7. Motivation	.10	.18	.25	.25	.18	.22	1.00		
8. Satisfaction	.09	.17	.17	.15	.10	.32	.22	1.00	
9. Utilization	.03	.16	.11	.14	.10	.19	.59	.18	1.00

Note: All correlations > .095 are statistically significant at alpha = 0.01

4.1.1. Testing Convergent Validity

Three tests for convergent validity were suggested by Fornell and Larcker [17], including item reliability, composite reliability, and "average variance extracted." The measurement of item reliability involves the basic premise that the variance shared with a construct is greater than variance due to error. The objective in measuring convergent validity is that multiple items measuring a single construct should converge on that construct.

Generally, the convergent validity for our measures appears to be quite strong. Table 9 indicates that all of the loadings are greater than 0.5, with the exception of BACKLOG3 in the holdback sample. However, this loading of 0.44 is sufficiently close to 0.5 that we felt relatively confident that convergent validity had not been violated, although we have some concern. To measure the composite reliability, we used Cronbach's alpha to assess the overall reliability of a scale. As a guide to interpreting reliability, Nunnally [42] reported that the composite reliability of a construct should be in the range of 0.6 to 0.8, where Fornell and Larcker [17] suggested that the average variance of the PLS model should be above 0.5. From Table 9, we can conclude that all of the constructs in both samples possess reliability coefficients of 0.8 and greater.

Average variance extracted exceeded 0.5 in all but one case in the original sample, Application Utilization (0.49). We felt the variance extracted was acceptable, since 0.49 is sufficiently close to 0.5 (Fornell and Larcker). The holdback sample had three variables that did not exceed 0.5 average variance extracted: *Perceived Helpfulness of EUC Policies* (0.49); *Motivation to Develop New End-User Applications* (0.46); and *Application Utilization* (0.49). We were somewhat concerned with the *Motivation* variable, since it tended to be somewhat lower than the guideline of 0.5. Overall, we felt that on the basis of the three convergent validity tests conducted, our measures passed the test of convergent validity.

4.1.2. Testing Discriminant Validity

Finally, discriminant validity, the degree to which a construct differs from other constructs, was assessed for the measurement model. A variable should correlate more

Table 9 Psychometric Properties of the Measurement Model

Construct/ Measures	Standardized Factor Loadings[a]		Reliabilities[b]		Portion of Variance Extracted[c]	
	Original Sample	Holdback Sample	Original Sample	Holdback Sample	Original Sample	Holdback Sample
PERCEIVED BACKLOG			.87	.82	.63	.53
Backlog1	.68	.93				
Backlog2	.65	.56				
Backlog3	.88	.44				
Backlog4	.91	.85				
PREVIOUS COMPUTER EXPERIENCE & TRAINING			.89	.86	.58	.50
ExpTrn1	.71	.55				
ExpTrn2	.73	.51				
ExpTrn3	.72	.50				
ExpTrn4	.77	.81				
ExpTrn5	.79	.92				
ExpTrn6	.81	.84				
PERCEIVED HELPFULNESS OF EUC POLICIES			.90	.88	.52	.49
Policy1	.61	.65				
Policy2	.73	.73				
Policy3	.74	.75				
Policy4	.71	.54				
Policy5	.75	.55				
Policy6	.69	.65				
Policy7	.72	.76				
Policy8	.76	.82				
ORGANIZATIONAL SUPPORT OF END-USER DEVELOPMENT			.84	.84	.52	.51
Support1	.61	.61				
Support2	.76	.75				
Support3	.57	.59				
Support4	.81	.81				
Support5	.79	.78				
ERCEIVED QUALITY OF END-USER DEVELOPMENT TOOLS			.86	.83	.60	.55
Tools1	.82	.80				
Tools2	.80	.78				
Tools3	.62	.85				
Tools4	.82	.71				
USER ATTITUDES TOWARD END-USER DEVELOPMENT			.87	.87	.62	.62
Attitud1	.82	.80				
Attitud2	.83	.78				
Attitud3	.74	.85				
Attitud4	.74	.71				
MOTIVATION TO DEVELOP NEW END-USER APPLICATIONS			.86	.81	.51	.46
Motivat1	.71	.52				
Motivat2	.75	.54				
Motivat3	.63	.56				
Motivat4	.72	.79				
Motivat5	.76	.73				
Motivat6	.67	.65				
END-USER INFORMATION SATISFACTION			.90	.91	.54	.58
Satis1	.77	.67				
Satis2	.76	.81				
Satis3	.78	.80				
Satis4	.63	.68				
Satis5	.73	.76				
Satis6	.74	.76				
Satis7	.71	.81				
APPLICATION UTILIZATION			.85	.85	.49	.49
Util1	.57	.51				
Util2	.75	.74				
Util3	.72	.78				
Util4	.58	.55				
Util5	.78	.76				
Util6	.75	.77				

[a] All factor loadings significant at $p < .001$ level; jackknife t-values were used to assess significance where 5% of the cases were removed to calculate each jackknife sample.

[b] This value is the composite reliability or internal reliability of the construct, see Nunnally [39] or Fornell, Tellis, & Zinkhan [16].

[c] This value is the squared sum of factor loadings/number of factors.

strongly with other variables of the same construct than with variables of other constructs. Fornell, Tellis, and Zinkhan [18] specified, as a criterion for discriminant validity, that the squared correlations between variables in any two constructs be statistically lower than the variance shared by variables within a construct. We examined the squared correlations between and within constructs. Of the 1,225 individual tests, only five (0.4 percent) appeared to violate the guidelines for discriminant validity. The quality and quantity of violations were so minimal that we felt the research measures had discriminated adequately between constructs.

4.2. The Original Structural Model

Given appropriate psychometric properties, we proceeded to examine the structural model in order to assess the model's explanatory power and the significance of its paths. Hypotheses testing consisted of examining the size, sign, and significance of path coefficients in the structural model. Jackknifing, a distribution-free approach to significance testing, was recommended by Fornell and Barclay in order to produce parameter estimates, standard errors, and *t*-values [16]. Figure 2 depicts the explanatory power of the original structural model.

Because PLS is a predictive causal modeling tool, the variance explained in the endogenous constructs provides important information about the power of a model. All of the constructs showed strong explanatory power, especially *System Utilization* (45 percent) and *Attitudes toward EUC* (37 percent). *Perceived Quality of End-User Development Tools* and *End-User Information Satisfaction* each represented about 23 percent of the variance explained in the original model. Overall, the construct *R*-squares are very encouraging given the early stage of empirical research in end-user application development.

The *t*-values, derived from the jackknifing test, were used to evaluate the statistical significance of each path coefficient. All of the paths were statistically significant at the alpha = 0.005 level; therefore, all of the hypothesized relationships were supported by the data. Certain paths were more significant than others, however. For example, the path coefficients among the constructs representing *Perceived Organizational Support* with (1) *Attitudes toward EUC* (coef. = 0.43); (2) *Perceived Quality of End-User Tools* (coef. = 0.44); and (3) *End-User Information Satisfaction* (coef. = 0.21) were highly significant. Also, the paths from *Perceived Quality of EUC Tools* to *End-User Information Satisfaction* (coef. = 0.20) and *Previous Computer Experience/Training* with *Attitudes toward EUC* (20 percent) were also found to be significant. Some of the strongest path coefficients, however, were found to exist between the moderator and dependent variables: *Motivation to Develop* with *Application Utilization* (coef. = 0.52) and *Attitudes toward EUC* with *End-User Information Satisfaction* (coef. = 0.31).

On the other hand, extremely low path coefficients existed between *Perceived Application Backlog* and the two variables *End-User Information Satisfaction* (coef. = 0.04) and *Motivation to Develop Applications* (coef. = 0.06). The relationships between *Perceived Helpfulness of End-User Policies* with *Attitudes toward EUC* (coef. = 0.02) and between *Perceived Quality of End-User Tools* with *Application Utilization* (coef. = 0.01) were also found to be very low.

4.3. The Revised Structural Model

After examining both the measurement model and path coefficients of the structural

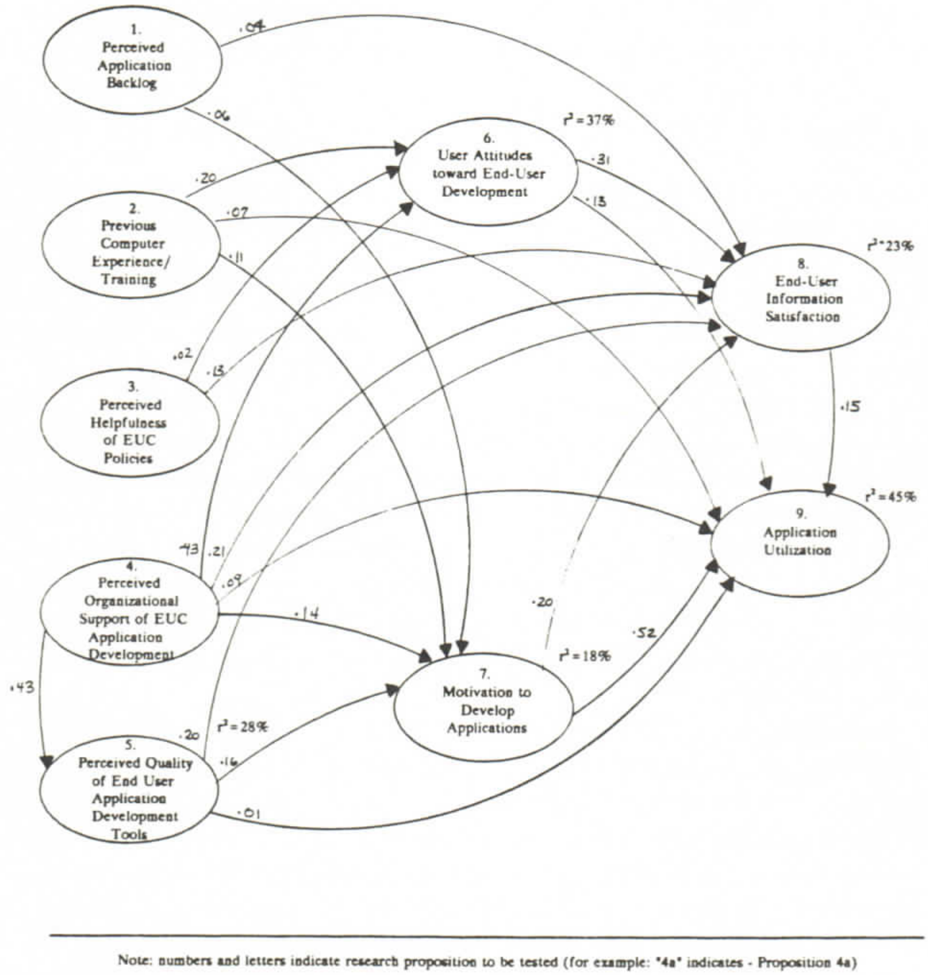


Figure 2. Path Coefficients–Original Model

model, we decided that the model could be improved. Although a causal model should not necessarily be revised strictly on the basis of data findings, certain results could not be interpreted reliably [3]. Two constructs and associated paths were dropped from the original model, *Perceived Application Backlog* and *Perceived Helpfulness of EUC Policies*. The data collected for these two constructs did not contribute new information to our understanding of EUC application effectiveness; rather, they artificially elevated the variance explained in the two moderating constructs, and especially with *End-User Information Satisfaction*, which had a path from each of the independent variables. In addition, an argument can be made for dropping those paths associated with strongly explanatory constructs that did not add to the research findings (e.g., path coefficients less than 0.05) [3, 35]. Therefore, four paths were dropped from the original model, three leading into *Application Utilization* from *Previous Computer Experience/Training, Perceived Organizational Support*, and *Perceived Quality of*

EUC Tools, and the path from *Attitudes toward EUC* to *Application Utilization* was also eliminated. Figure 3 illustrates the revised model, the path coefficients, and construct variance explained. Very little change is indicated in variance explained (r^2) from the original to the revised model, with the exception of the *Perceived Quality of EUC Tools* construct. Decreases in variance explained are expected for each of the endogenous constructs in revised models where paths are dropped. The revised model continues to demonstrate strong predictive and reliable explanatory power.

5. Discussion

THE PRELIMINARY EMPIRICAL EVIDENCE we have reported provides general support for most of the key relationships contained in the model. Both the original PLS model and the revised model had good overall fits to the data. In PLS there is no separate goodness of fit computation; instead, goodness of fit is incorporated into the PLS analysis [59]. The following discussion will draw conclusions based upon our findings.

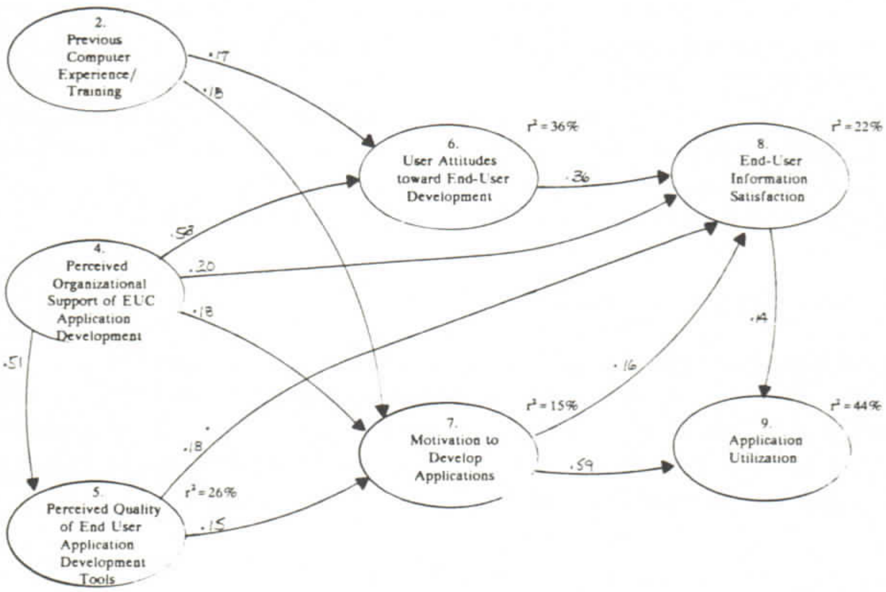
5.1. Model Confirmation

On the whole, the measurement model was quite acceptable given the newly evolving set of constructs. The psychometric properties of the model that were tested included the internal consistency (reliability) of each measure, convergent and discriminant validities of the construct in question, and the proportion of variance each construct explained. A holdback model, randomly selected at the outset of the analysis, strongly validated the original model results in all respects.

The PLS structural model results are parsimonious, supporting most of the theoretical linkages; however, some show only moderate strengths of association. The t-values of each path coefficient in the original and revised models were tested using the jackknifing technique. All of the propositions in the revised model were statistically supported at the 0.005 level. The amount of shrinkage in either the portion of variance explained or the R-squared values in each construct with the original model as compared to the revised model was not significant.

5.2. Motivation to Develop

End users' *Motivation to Develop Applications* was found to be the most significant construct showing the strongest positive path coefficient (coef. = 0.59), with Application Utilization. This construct was very reliable while extracting about 50 percent of the variance in the measurement model. In some instances, end users reported developing only one large application in the previous twelve-month period, while others developed fifteen or more. In either case, we found *Motivation to Develop* to be a future-oriented perception that affects an end user's propensity to use existing end-user-developed applications. Because the motivation construct is relatively new to information systems research, we feel that some additional rigorous design and testing of motivation instruments will be needed before strong implications can be



Variance Explained

	Quality of EUC Tools	Attitudes toward EUC	Motivation to Develop	End-User Information Satisfaction	Application Utilization
ORIGINAL MODEL	28%	37%	18%	23%	45%
REVISED MODEL	26%	36%	15%	22%	44%

Figure 3. Path Coefficients—Revised Model

made from this finding.

5.3. Perceived Organizational Support of End-User Application Development

The importance of the support factor in effectively managing the end-user computing environment cannot be overstated. *Organizational Support* seems to show up in almost every study in end-user computing. Our results indicate that the most significant association does not exist directly with *End-User Information Satisfaction* as originally suggested by the existing literature. As hypothesized, the support construct is strongly and directly associated with the two intervening variables, *User Attitudes toward EUC*, and *Motivation to Develop Applications*, although clearly support is more directly related to the attitudes construct. In addition, a very strong relationship was noted to exist between *User Attitudes* and *End-User Information Satisfaction*. The indirect effects of *Perceived Organizational Support* appear stronger (coef. = 0.53; coef. = 0.36) than the direct effect on *End-User Information Satisfaction* (coef. = 0.20). Support groups often expect to observe direct changes in behavior as a result of their efforts. We predict from these results *delayed* changes in the propensity to use existing end-user-developed applications because attitudes and user motivation to develop are the first variables to be affected.

5.4. Perceived Quality of End-User Application Development Tools

There was a strong, positive association between the *Perceived Quality of End-User Tools* and *End-User Information Satisfaction* (coef. = 0.18) as hypothesized. The indirect effects with *Application Utilization* (coef. = 0.15; coef. = 0.59) were important enough to lead to further examination. The user's perception of tool quality was the variable measured in this study, rather than an externally rated approach to determining the quality level. With this in mind, it seems improbable for EUC managers to upgrade the level of effectiveness simply by throwing financial resources at expensive hardware and software. In other words, the perceived quality of EUC tools may not strongly change an end user's motivation to develop applications. Rather, one can expect to influence and perhaps to improve motivation, which will eventually impact effectiveness as measured by satisfaction levels and application utilization.

5.5. User Attitudes toward End-User Development

A strong association was discovered between this construct and *End-User Information Satisfaction* (coef. = 0.36). The *Attitudes* construct reported 36 percent of the variance explained. The predictability resulting from the high r^2 value confirms previous research of this construct in the MIS literature. It is clear from the results that user attitudes are primarily intervening in their effects [22, 37, 47, 61]. More important than the direct effects was the significant strengthening of the relationship between *Organizational Support* and *Quality of EUC Tools* constructs and effectiveness due to the indirect relationship with User Attitudes.

5.6. Association between Satisfaction and Utilization

A moderate relationship (coef. = 0.14) was found to exist between the two surrogate measures of effectiveness, satisfaction and utilization. This association has been debated in the literature for over a decade. With regard to the end-user computing environment, it appears that increased *End-User Information Satisfaction* only slightly impacts *Application Utilization*. More importantly, the related variables (*End-User Information Satisfaction* and *Motivation to Develop*) robustly explain over 36 percent of the structural model variance in the *Utilization* construct. It appears that end users' motivation played an important part in that explanation. The same cannot be said about the *End-User Information Satisfaction* construct, where only 22 percent of the structural model variation is explained by the related variables. Given the reported reliability and validity of the Ives, Olson, and Baroudi instrument, we were surprised the variance explained was not significantly higher. Although not a poor explanation of variance, perhaps the Ives, Olson, and Baroudi [31] user information satisfaction instrument should not be modified for use in the end-user computing environment. Certainly, more valid measures of end-user information satisfaction such as the one created by Doll and Torkzedeh [13] could be developed and tested. Given the breadth of end-user computing in most organizations, theoretically grounded instruments measuring end-user information satisfaction should be a priority.

5.7. Limitations of the Study

Three limitations should be noted. First, although the proposed model was derived from existing theory and current literature, we did not attempt an exhaustive test of all model configurations. In its present form, the exogenous/endogenous variable mix yields thirty-four potential one-way paths. We tested only those relationships that were specifically proposed in the literature. Second, the weakness of some of the paths in the original model, specifically with respect to the *Perceived Application Backlog* and *Perceived Helpfulness of EUC Policies* constructs and associated path, may be a function of a lack of reliable and valid measures. Consensus on form and content of measures must, of necessity, become foremost in the minds of IS researchers. Third, any generalization of the research findings should be carefully interpreted. In particular, the cross-sectional nature of the sample limits the ability to identify causal specifications, because of the varying nature of the firms and functional units where the instrument was administered.

6. Conclusions

THE PRIMARY OBJECTIVE OF THIS EXPLORATORY RESEARCH was to create a causal model to investigate the potential relationships between many of the identified variables that have been purported to impact end-user application effectiveness. The results of this research go beyond recent models examining end-user application effectiveness [8, 20, 28, 46]. For example, users' *Motivation to Develop New Applications* was proposed in this study, tested, and found to have an extremely significant association with *Application Utilization*. Even with the limitations stated earlier, we avoided using single-scale measures of important dependent variables, a problem with many empirical studies in our field [52].

We feel that our findings provide an important step forward in understanding many of the relationships within the area of end-user computing. Further, we investigated the nature of certain variables, such as utilization and end-user information satisfaction, which adds to the general implementation stream of research. We also believe the model that was tested and validated here holds important implications for practicing managers. Specifically, *Perceived Organizational Support* is indirectly related to improved *End-User Information Satisfaction* and *Application and Utilization*. Likewise, the *Perceived Quality of End-User Tools* was found to have a much stronger impact on user perceptions, such as attitudes and satisfaction, than on utilization. Given the limited organizational resources devoted to managing end-user computing and a set of unbounded, and maybe unrealistic, expectations about end-user behavior, certain findings and conclusions suggested in this research should aid those decision makers who are struggling with the problems of managing EUC environments.

Testing new or existing effectiveness models, such as the one we examined here, is a critical activity for researchers who take first steps toward discovery and suggesting better management practices. From this model, we hope that these and other measures of end-user computing effectiveness will continue to be tested and validated. Such measures would allow researchers to investigate the relationships proposed here and allow for the development of new, theoretically based models. Future researchers, in our opinion, should conduct collaborative longitudinal studies with standardized instruments in order to provide the much needed methodological strength to substantiate future research recommendations in this area of end-user computing. We believe this study has taken an important first step in this direction.

NOTE

1. Those firms who reported their EUC budgets were used in this study.

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