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ABSTRACT

The purpose of this research is to determine if the expansion-control model as proposed, adapted, and refined (Munro and Huff 1985; Munro, Huff and Moore 1987) is useful for understanding and predicting changes in EUC management strategy over time. The long-term interest is not so much in understanding the specific problem of managing end-user computing as in understanding the general problem of managing new information technology in organizations. A field study was conducted with eighteen large firms in manufacturing and services to review their experience with EUC management over a nine year period. As predicted, most firms took a hands-off approach to EUC management during the initiation phase and evolved toward a balance between control and slack by 1987. However, changes in firms' EUC management strategy over time were more complex than predicted. In addition, the expansion and control constructs were not as independent as previously thought. The interaction between the two variables appears to be related, at least in part, to time and the stage of diffusion. The research suggests that current models of EUC management (and thus organizational learning about information technology) may be too simplistic. Suggestions for developing more general models of the process are offered.

1. INTRODUCTION

Facilitating the organizational learning and use of information technology has remained a critical issue in information systems (IS) management for over a decade. Over the same period, managing end-user computing (EUC) gained prominence by 1983 but fell to obscurity by 1989. This rise and fall in the importance of end-user computing *as a critical issue in IS management* provides a well documented example of organizational learning about a specific set of information technologies.

Defined here as the autonomous use of computers by knowledge workers outside the information systems function, end-user computing was driven largely by growth in the power and availability of personal computers (PCs) and related end-user software (Benjamin 1982). IBM PC, Apple II, MacIntosh, VisiCalc, Lotus, dBase, IFPS, FOCUS and similar technologies were *new* in the early 1980s. Relatively few managers or end-users had knowledge or experience in dealing with them.

As firms gained experience in managing end-user computing, and as the academic literature and trade magazines filled with articles on the subject, *organizational learning* was taking place. While a great deal of individual learning was also going on, organizational learning is not the same as individual learning. Organizational learning occurs as organizational members act as learning agents for the organization (Argyris and Schon 1978). These members respond to changes in the organization's internal and external environment by detecting and correcting errors in organizational *theory-in-use*. In the case of end-user computing, this theory-in-use is embodied in *management actions* taken with respect to the acquisition and use of personal computers and related end-user software.

As a specific example of organizational learning, consider the information center. An information center is an organizational unit, usually part of the IS department, whose principal function is to facilitate and coordinate end-user computing. Basic services offered by information centers include training, consulting, technical support, and research on new products (Brancheau, Vogel and Wetherbe 1985). Many firms established information centers to manage end-user computing (Johnson 1984) but not all firms followed the standard model proposed by IBM (White and Christy 1987), nor were all firms' information centers equally effective (Brancheau and Wetherbe 1988). Some emphasized *control* over user activities by restricting technology options; others emphasized *support* by providing slack resources for end-users (Munro and Huff 1985). Most authors now maintain that a degree of "balance" is critical for effectively managing end-user computing. Too much slack encourages chaos while too much control stifles creativity and reduces technology diffusion across the

organization. It seems likely that part of learning how to manage any new information technology involves learning how to strike the proper balance between control and slack.

Through organizational learning, the practice of managing end-user computing has evolved over the past decade. During the first half of the 1980s, most information centers were centralized structures located in the IS department and staffed by IS professionals. More recently, many firms have decentralized these "centers" into their business units (Greenberg 1988). Some have abandoned them altogether (Mandell 1988).[1] Most authors now agree that the EUC management strategy appropriate for a given firm must change over time. Thus, while centralized support may be effective during the early stages of end-user computing, decentralized support may be more effective later. Such contingencies are based on the dynamic nature of the organizational learning which underlies these growth models.

Research in end-user computing has also evolved. During the first half of the 1980s, the research was primarily descriptive in nature. Most of the studies dealt with the growth of personal computers and related software. More recently, research models and theories were proposed to explain observed events. Others tested the hypotheses in these models. This evolution is not surprising given the embryonic nature of the phenomenon under study.

Straub (1989) summarized the scientific research cycle by breaking it into two categories: exploratory research or theory building and confirmatory research or theory testing. In exploratory research, the researcher approaches a problem with little or no theory, develops concepts and key variables, and generates hypotheses. In confirmatory research, the researcher tests the hypotheses generated and/or refines the explanatory model as necessary (McGrath 1979). Recently, Robey and Zmud (1989) made a strong case for the importance of theory testing to research in information systems in general and end-user computing in particular.

This research fits into the theory testing category. Its purpose is to determine if the expansion-control model as proposed, adapted, and refined (Munro and Huff 1985; Munro, Huff and Moore 1987) is useful for understanding and predicting the evolution of EUC management strategies over time. The long-term goal is not so much in understanding the specific problem of managing end-user computing as in understanding the general problem of managing new information technology in organizations. As explained earlier, this is a problem of organizational learning. This research takes a step toward that goal.

First, the expansion-control model is discussed in some detail. Then, hypotheses are proposed to test the model and research methods and variables are introduced. Next, results of hypothesis tests are reported. Results are discussed in terms of the research models utility for understanding the management of end-user computing over time. Finally, conclusions are drawn and suggestions are offered for further research.

2. THE EXPANSION-CONTROL MODEL

Rockart and Flannery (1983) were among the first to articulate the need for a proactive strategy for developing and managing end-user computing. Their discussions with IS managers identified a lack of concern about long range EUC activities. They went on to make a number of general recommendations relating to strategy, support, and control. Implicitly, these recommendations took a static view of EUC management. That is no specific directions were provided for changing EUC management strategy over time.

In 1985, Munro and Huff first articulated their dynamic model of EUC strategy development. Their expansion-control model was a step toward providing a theoretical basis for examining management actions relating to end-user computing. The model is based on two dimensions: degree of expansion and degree of control. It highlights four strategies for managing EUC. The model suggests that EUC management actions follow one of two general progressions over time depending on whether a firm first emphasizes expansion tactics (expansion-first) or control tactics (control-first). It also suggests that either approach eventually leads to a state of balance between expansion and control tactics (controlled growth or maturity).

In 1986, Henderson and Treacy also suggested that management strategy needed to change over time to reflect increasing levels of technology assimilation (and learning) within the organization. They felt that a dynamic strategy was required to cope with the dynamic nature of organizational learning. They argued that the importance of key issues such as technology, support, data, and evaluation/justification changed over time. Using the S-shaped learning curve, they identified four distinct perspectives for managing end-user computing with each perspective having a place in the technology assimilation life cycle. Thus, an evolving strategy was required to maintain effectiveness over the long-run.

In 1987, Munro, Huff and Moore refined the expansion-control model by suggesting the use of measurement indices based on management actions taken to either expand or control EUC. By using the indices, an IS manager could more clearly track the firm's theory-in-use as it moved through its growth stages of EUC. The model is based on the forces of expansion and control, which the authors argue are relatively independent. Expansion forces are defined as those which impact the pace at which information technology is introduced and developed in the firm. Expansion activities direct organizational resources toward introducing and supporting new information

technologies. Control forces are defined as those which impact the direction in which information technology is developed. Control activities direct organizational resources toward constraining a user's freedom with respect to new information technology. As depicted in Figure 1, the derived two by two grid highlights four strategies for managing EUC.

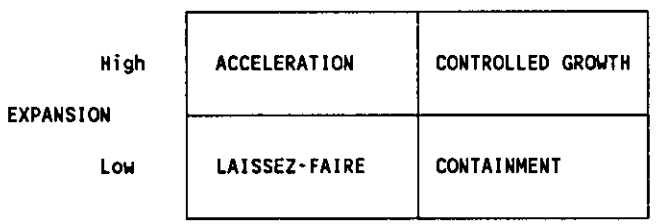

Figure 1. Four Strategies of the Expansion-Control Model

Munro, Huff and Moore classified a firm's opening position with respect to end-user computing as *Laissez-Faire*. At this point there is relatively little interest in end-user computing. Thus the need for expansion or control is low. Firms that decide to develop new technologies slowly move toward a *Containment* strategy. Here, control tactics are implemented at a faster rate than expansion tactics. One objective of this strategy is to define specific growth boundaries for end-user computing. Firms for which control is of a lesser concern than expansion move toward an *Acceleration* strategy. Here, an abundance of organizational resources and support are provided for the development of end-user computing. Finally, as organizations begin to reach a balance between expansion and control tactics, they move toward a *Controlled Growth* strategy. This strategy is considered a mature state.

More recently, Brown and Wynne (1989) suggest an additional implication of the expansion-control model. They suggest that EUC management is most effective when an organization's theory-in-use aligns with its intended strategy and follows one of the two predicted progressions through the cells. To be effective, an organization with a high-growth objective in EUC should follow an acceleration strategy. Conversely, an organization with a low-growth objective should follow a Containment strategy. The implication is that effectiveness results from the alignment of organizational objectives and EUC strategy. The case study reported by Brown and Wynne provided limited but positive support for the effectiveness implications of the model.

3. HYPOTHESES

In reviewing Munro and Huff (1985) and Munro, Huff and Moore (1987), it appears that there are four major components of the expansion-control model. These are discussed next in terms of the hypotheses used to test the model.

3.1 Opening Position

One component of the expansion-control model relates to a firm's opening position with respect to managing end-user computing. The model suggests that most firms do not engage in either expansionary or controlling management activities during the *early* stages of end-user computing. They may ignore the growing phenomenon or simply keep it under a watchful eye. But in either case, they take little or no management action. This position makes practical sense in that management actions are commonly directed at *current problems*. Thus the cliche, "if isn't broken don't fix it!" It also aligns with the absence of end-user computing as a key issue in 1980 (Ball and Harris 1982) and the low volume of EUC-related literature at that time (Lightner and Brancheau 1989). Thus the following hypothesis is offered:[2]

> H1: Plotted on the expansion-control grid, the opening position for most firms is the Laissez-Faire cell.

3.2 Closing Position

Another component of the expansion-control model relates to a firm's closing position with respect to EUC. The model suggests that by the *late* stages of growth, most firms will have settled on a balance between expansion and control activities. Thus, trial-and-error learning will have led each firm to adopt a mix of expansion and control tactics which are roughly in balance. As discussed earlier, the notion of balance has been a mainstream part of the EUC literature for years. Thus, the following hypothesis is offered:

> H2: Plotted on the expansion-control grid, the closing position for most firms is the Controlled-Growth cell.

3.3 Strategy Progression

Another component of the expansion-control model relates to strategy progression over time. The dynamic aspects of the model describe an orderly progression through the various management strategies as represented by the cells of the expansion-control grid. The model suggests that most firms tend to move either clockwise or counterclockwise through the cells in Figure 1. That is, they follow either an Acceleration or Containment strategy. Some support for this was provided by Munro, Huff and Moore (1987). All of the firms in that study began in the Laissez-Faire cell and most were projected to move toward the Controlled Growth cell following one progression or the other. Additional support can be found in research on human learning. Trial-and-error learning is common in certain situations (Hill 1977). Initially one strategy is tried. In complex situations, this trial often results in failure.

Next, the initial strategy is modified based on feedback from the trial. Many trials may be required before an appropriate outcome is achieved. The expansion-control model only assumes one such trial (Acceleration or Containment) before reaching the desired outcome (Controlled Growth). Thus, the following hypothesis is offered:

> H3: Plotted on the expansion-control grid, the progression for most firms involves moving from the Laissez-Faire cell to either the Acceleration cell or Containment cell (but not both) before reaching the Controlled Growth cell.

3.4 Construct Independence

One final component of the model relates to construct independence. This is the notion that the forces of expansion and control are independent of one another. Even though Munro, Huff and Moore actually found a slight negative correlation (r = -0.31) in their second study, they concluded that since it explained less than 10 percent of the variance "the constructs are largely independent of each other" (Munro, Huff and Moore 1987, p. 23). They felt that this made sense in that higher control should correspond with lower expansion. Thus, the following hypothesis is offered:

> H4: Over time, most firms' use of expansionary management actions will not correlate with their use of controlling management actions.

These four hypotheses are central to the expansion-control model. The methods used to test the hypotheses are discussed next.

4. METHODS

A field study was conducted with eighteen large firms in manufacturing and services to track their management actions with respect to end-user computing. Individual and group interviews were conducted in each company during 1987 to review the firm's experience with EUC management over the preceding nine year period (1979-1987). The management actions studied were those undertaken by the organization to either expand or control the use of EUC technologies. Among the companies studied, most (85 percent) had implemented these actions through their information center.

Most of the participating firms were listed in the 1987 *Fortune 1000*. Annual revenues for the firms ranged from 200 million to over 9 billion. Over half (57 percent) were manufacturers or producers of goods, while the balance (43 percent) were providers of services. The manufacturers produced heavy equipment, industrial products, specialty goods, and food. The service firms provided banking operations, insurance underwriting, financial planning, diversified services, retail operations, and energy distribution. No statistically significant differences in research variables were found between the manufacturing and services firms.

4.1 Interviews

Data was collected through structured group interviews involving information center (IC) managers, information center staff, finance/accounting managers, and early adopters of personal computers. Group interviews normally involved four to six professionals from each company and were approximately two hours in length. The first half of each interview involved an open discussion of the introduction and diffusion of personal computers and related software within the firm. Specific EUC management actions taken over the nine year study period were documented in the second half of the interview. This part of the interview was highly structured. Research instruments were projected on a screen to keep the discussion on track and help meeting participants reach consensus.

Meeting format and participation were designed to maximize the accuracy of recall of historical events (Converse and Presser 1986). IS/IC managers were present to provide a technical perspective. Key users were present to keep IS honest and add a business perspective. In most interviews, a synergy developed with some participants recalling key facts and others synthesizing the pieces into a concise history of the firms' EUC management activity.

4.2 Variables

The variables measured and their operationalizations are summarized in Figure 2. Most of these variables were suggested in the Munro and Huff (1985) and Munro, Huff and Moore (1987) articles introducing and refining the expansion-control model. Following their lead, measured variables were aggregated to form composite scales for expansion and control. (See Appendix for details.)

Reliability coefficients were derived for the two composite scales. These coefficients indicate the degree of internal consistency within each scale (Kerlinger 1986). Any set of measures has a total variance due to several causes. Cronbach alpha estimates reliability based on item intercorrelations. Nunnally (1967) suggests the 0.80 level for confirmatory research and the 0.70 level for exploratory research (whenever prior validated instruments are not available). To examine each scale in detail, alpha coefficients were calculated with each variable deleted in order to determine the effectiveness of the reduced scale. The expansion scale performed quite well with a reliability coefficient of 0.932. Although lower than preferred, the

control scale was reasonably effective with a coefficient of 0.704. None of the individual items in either scale warranted deletion since the alpha with each item deleted was smaller than the alpha with the item included.

OPERATIONAL MEASURE	QUANTIFIERS
Expansion Variables	
Information Center Established	none, informal, formal
Mission Statement Published	none, informal, formal
Formal Training Provided	none, passive, active, strategic
Consulting/Troubleshooting Support	number of FTE staff
Product Research	none, formal, informal
Hot Line/Help Desk	none, one, both
Newsletter Published	none, irregular, regular
PC Acquisition Support	none, light, heavy
Equipment Walk-in Center	no, yes
Equipment Loan	no, yes
Software Loan	no, yes
Reference Library	no, yes
Software Resource Directory	no, yes
User Groups	no, yes
Open Houses	no, yes
Equipment/Software Subsidies	none, light, heavy
Equipment Maintenance Subsidies	none, light, heavy
Custom User Manuals	none, light, heavy
End-User Software Customization	none, light, heavy
PC Communication Network	none, partial, full
Dedicated Mainframe/Minicomputer	none, partial, full
Decentralized Staff Location	none, centralized, distributed
End-Users on IC Staff	none, some, most
Target Efforts Toward Key Users	never, always, sometimes
Departmental Experts	none, informal, formal
Supportive IS Management Involvement	none, light, heavy
Mainframe Access from PCs	none, read-only, full
Control Variables	
Restraining Management Involvement by IS	none, heavy, light
Formal Steering Committee	no, yes
IS/IC Veto Power Over Acquisition	none, partial none
Formal Cost/Benefit Required	none, lax, standard, stringent
Equipment/Software Standards	none, weak, moderate, strong
Personnel Service Chargeback	none, partial, full
Equipment/Software Chargeback	none, partial, full
User Developed Applications Reviewed	never, sometimes, always
User Developed Applications Certified	never, sometimes, always

Figure 2. Expansion-Control Research Variables

4.3 Partitioning the Grid

One issue to be resolved was the partitioning of the expansion-control grid into four quadrants. Munro, Huff and Moore (1987) had simply used the median values for the expansion and control indices to partition the grid into four cells. Since their study included data for a single year of EUC management activity, their method guaranteed that approximately equal numbers of firms would fall into each of the four cells. Ideally, the grid would be partitioned into high and low sectors based on the experience of a large number of firms over an extended period of time. Lacking such data, this study partitioned the grid at the grand medians for the expansion index and the control index. Thus, the grid was partitioned based on the experience of nineteen companies over the nine year study period (based on 171 data points). As demonstrated below, this method appeared to capture the intent of the expansion-control model.

5. RESULTS

Before reporting on formal hypothesis tests, aggregate data (across all companies) are presented for selected expansion and control variables. Examining this data provides a glimpse of the degree of diffusion of EUC management actions over time.

5.1 Expansion Tactics

Figure 3(a) presents the normalized scores of three expansion variables over the period 1979 to 1987: deployment of information centers, level of formal training activities, and number of consulting and troubleshooting staff.

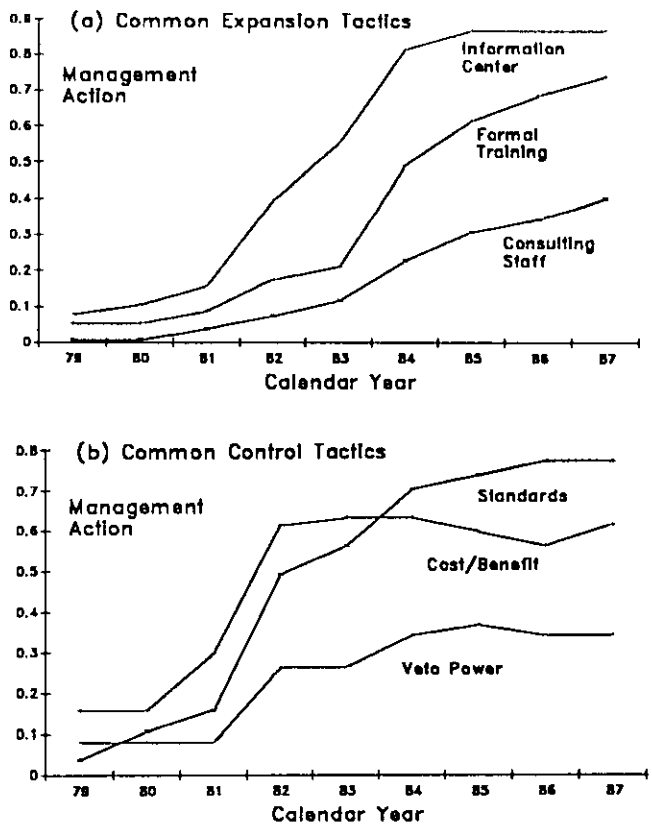

Figure 3. Expansion and Control Tactics Over Time

As depicted in the figure, information centers were used by most of the firms studied. Given that an IC's mission is to help users help themselves, it is not surprising that the IC indicator led all of the other expansion indicators. Among the firms studied, the data suggest the take-off point for IC establishment occurred in 1982 with 1982 to 1984 the period of highest growth. This corresponds with a period of rapid technological development led by the

introduction of the IBM PC in 1982. All but three of the firms (85 percent) had formally established an information center by 1985. The remaining three were highly decentralized organizations. Two were the smallest organizations participating in the study in terms of office staff. They may have been too small to justify a formal information center. Interestingly, even these companies had informal "centers" staffed by business-persons turned PC gurus.

The use and formality of training programs also increased steadily from 1979 to 1987. Organizations gained a great deal of experience in end-user training during those years. By 1987, the most common training approach among the firms studied was offering regularly scheduled corporate classroom/lab sessions at multiple skill levels. Although a few firms had shifted training responsibility to human resources, most offered end-user training through their information center. Depending on the firm's stage of development, different training methods were prominent. Confirming earlier research (Raho, Belohlav and Fiedler 1987), the typical firm's training activities evolved from a passive approach relying on outside training, to an active but often informal in-house program, to a formal and regularly scheduled program of training.

Figure 3(a) also depicts levels of consulting and troubleshooting staff over time (each FTE staff is represented by an increment of 0.1 on the chart scale). Among the companies studied, the number of staff rose slowly during the period 1980 to 1983 with the largest increases during the period 1984 to 1985. These staffing levels appeared to lag both the formation of information centers *and* the adoption of personal computers and spreadsheet software (see Brancheau and Wetherbe 1990). Group interviews suggested that support staff levels were driven by user *demand* rather than by a proactive plan by IS departments to expand end-user computing.

5.2 Control Tactics

Figure 3(b) presents the normalized scores of three control variables: equipment and software standards, formal cost-benefit analyses, and IS veto power over end-user acquisition.

Not surprisingly, most of the firms studied had implemented some degree of equipment standards and by 1982 these were often strong. Equipment standards exceeded formal cost/benefit as the most common control tactic after 1983 with 1982 to 1984 the period of highest growth. Group interviews suggested that equipment standards were necessary for a variety of reasons. They made it possible for information centers to provide high quality service and they preserved a degree of compatibility to permit future systems growth. Standards were also cited as reducing the cost of integrating data across application and technology platforms.

Due to pre-existing business practices, formalized cost/benefit analyses were the first EUC control tactic employed by most of the firms studied. Many firms reacted to the rapid growth in demand for PCs by requiring specific and stringent cost/benefit justification. This control orientation was strongest during the period 1981 to 1982. Eventually (1985 to 1987), most firms relaxed their cost/benefit requirements back to *standard* levels considering the asset value of the equipment and software under consideration.

Also depicted in Figure 3(b), the growth of IS/IC veto power followed a trend similar to cost/benefit analyses. Use of this control tactic rose quickly in the middle years of the study period (1982 to 1984) but never gained universal acceptance. By 1986, some IS departments had begun to relax their power over end-user acquisition of equipment and software.

5.3 Management Action Over Time

It is also useful to examine aggregate expansion and control tactics from 1979 to 1987 as a means of analyzing the increasing levels of effort directed toward managing end-user computing. For this purpose, management action is defined as the normalized sum of all expansion and control tactics for each year in the study period. These aggregate data are depicted in Figure 4.

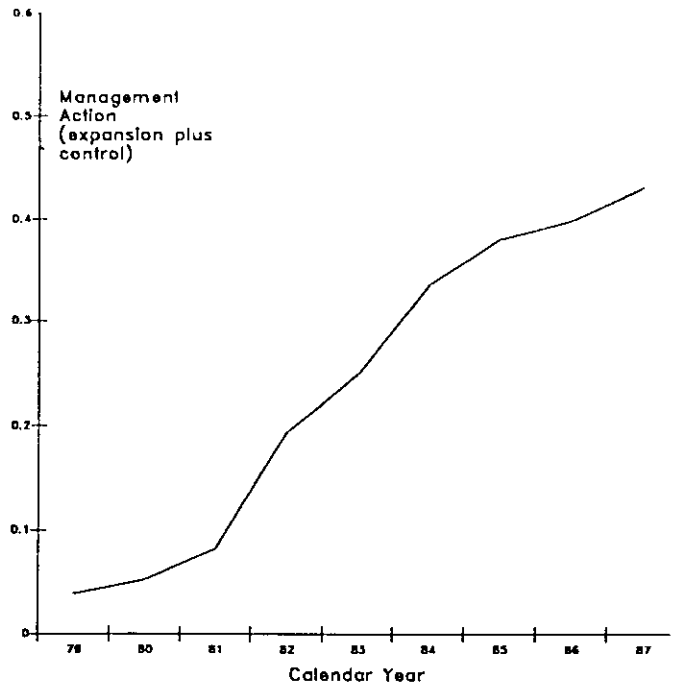

Figure 4. EUC Management Action Over Time

As highlighted in the figure, the management action curve approximates the familiar S-shaped learning curve. Little or no management action was taken in most companies prior to 1981 but by 1982 the curve reached a take-off point with large increases in management action reported

EUC Management Strategies Over Time

Company Code	H1: Opening Position	H2: Closing Position	H3: Strategy Progression 1979-1981		H4: Construct Independence
A(CA1)	3	4	344444444	*pioneer*	.682
B(CA2)	1	4	112222444	Containment	.373
C(CC)	1	4	111224444	Containment	.841*
D(DH)	1	4	111244444	Containment	.704
E(ECO)	1	4	122444444	Containment	.486
F(ELI)	1	4	111334444	Acceleration	.944**
G(ID1)	1	4	113444444	Acceleration	.915**
H(IJ1)	1	4	111222444	Containment	.685
I(JO1)	1	4	111124444	Containment	.957**
J(MBM)	1	2	111111122	*immature*	.972**
K(MGS)	2	4	222224444	*pioneer*	.925**
L(MIN)	1	2	111111112	*immature*	.795*
M(MST)	1	4	111144444	*balanced*	.897**
N(MTS)	1	3	111111333	*immature*	.740
O(NNL)	1	4	111114444	*balanced*	.950**
P(NO1)	1	4	111444444	*balanced*	.854*
Q(ONA)	1	4	113444444	Acceleration	.941**
R(PIL)	1	4	111112444	Containment	.892**
S(SPC)	1	4	111444444	*balanced*	.966*
count(+)	*17/19*	*16/19*	*10/19*		*6/19*
p-value	*.001***	*.004***	*.648*		*.167*
h-test	*yes*	*yes*	*no*		*no*

Notes:
'#' indicates (1) Laissez-Faire, (2) Containment, (3) Acceleration, (4) Controlled Growth

'*' indicates significance level for sign test: *(.05), **(.01)

Figure 5. Expansion-Control Tests by Company

through 1984. These rapid increases were followed by a period of smaller increases in management action from 1985 to 1987. This suggests a multi-phased cycle of EUC management activity up to 1987. Thus, these data appear to provide indirect support for an evolutionary view of EUC management. This is discussed in more detail later.

5.4 Hypothesis Tests

As described earlier, four hypotheses were derived from the research model. With respect to the derived expansion-control grid, these hypotheses related to a firm's opening position, its closing position, its progression through the cells in the grid, and the independence of the expansion and control constructs. Since the management actions predicted by the research model are organization-level phenomena, hypotheses were tested across all firms in the sample. Sign tests were used to determine the probability that the number of firms meeting the criteria for each hypothesis were due to chance. The results of these tests are reported in Figure 5 and discussed below.

5.4.1 Opening Position

Hypothesis H1 predicted that most firms would initially take a "hands-off" position with respect to end-user computing. As reported in Figure 5, seventeen out of nineteen firms in the study occupied the Laissez-Faire cell in 1979 (p = .001). Further analysis indicated that 81 percent of all firms' time between 1979 and 1981 was spent in the Laissez-Faire cell (see Figure 6(a)). Thus there is strong support for the opening position hypothesis. As discussed earlier, this is not surprising given the general lack of attention to end-user computing prior to 1982.

5.4.2 Closing Position

Hypothesis H2 predicted that most firms would eventually take a "balanced" position with respect to managing end-user computing. As reported in Figure 5, sixteen out of nineteen firms occupied the Controlled Growth cell by 1987 (p = .004). Further analysis indicated that 84 percent of all firms' time between 1985 and 1987 was spent in the

Controlled Growth cell (see Figure 6(b)). Thus there is also strong support for the closing position hypothesis, i.e., firms move toward a degree of balance in their use expansion and control tactics.

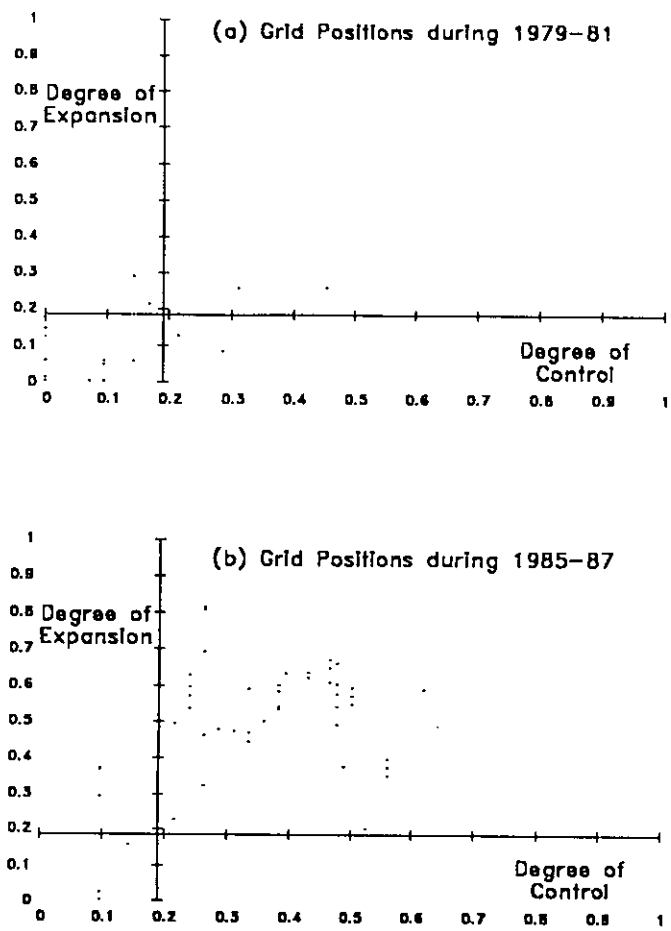

Figure 6. Opening and Closing Grid Positions

5.4.3 Strategy Progression

Hypothesis H3 predicted that most firms would take either an expansive or controlling position in their management of end-user computing before settling on a balanced approach. As reported in Figure 5, only ten out of nineteen firms moved through the Acceleration or Containment cells during the study period (p = .648). However, it could be argued that the two firms which had already moved out of a Laissez-Faire strategy by 1979 (labeled *pioneer* in Figure 5) should be counted as satisfying the hypothesis test. It could also be argued that the three firms which had not yet reached maturity (labeled *immature* in Figure 5) should also be counted. As discussed later, however, two of the firms are unlikely to ever reach Controlled Growth. However, to produce a significant finding, the analysis would need to include all five of these firms. Thus, the strategy progression hypothesis is not supported. This is discussed in more detail later.

5.4.4 Construct Independence

Hypothesis H4 predicted that most firms would use expansionary management tactics independently of controlling tactics, i.e., that expansion and control would not correlate. As reported in Figure 5, only six out of nineteen firms in the study had nonsignificant correlations between expansion and control during the period 1979 to 1987 (p = .167). It is noteworthy that this near significant result is in the direction *opposite* to that hypothesized. Nearly all of the correlations reported in Figure 5 are high to moderately high. Many were not significant due to the coarseness of the sample data (one data point per year, n = 9). Thus, the construct independence hypothesis is not supported.

Correlation coefficients were also computed overall and for each of the nine years in the study period (see Figure 7). These data further indicate a moderate to strong correlation between the two constructs. The overall correlation of 0.701 accounts for almost 50 percent of the observed variation. Examining each year individually shows a strong and significant correlation in the first four years, with lower and nonsignificant correlations thereafter. The low correlation found by Munro, Huff and Moore (1987) was for data collected during the later years of the study period. Thus, it is possible that the relationship between expansion and control tactics is evolutionary in nature.

Pearson Correlation Coefficients for Expansion and Control Indices:

by Calendar Year

1979	1980	1981	1982	1983	1984	1985	1986	1987
.67**	.79**	.58*	.66*	.44	.44	.37	.43	.41

for All Years 1979-1987

.701**

Note: '*' indicates significance level for correlation: *(.05), **(.01)

Figure 7. Construct Independence Over Time

Further contradicting Munro, Huff and Moore, no negative correlations were found between the two indices. Rather, positive relationships were found for every year indicating simultaneous implementation of both control and expansion tactics. While each of the tactics could be used independently in *theory*, they were implemented together in *practice*, especially during the early stages of technology assimilation. A possible explanation is that IC managers recognized quite early that a degree of balance between expansion and control was necessary for effectively managing end-user computing. This is not surprising considering the IC's extensive coverage in trade and research journals during the period 1983 to 1987. Most reports on the IC concept portrayed the information center as employing a mix of expansionary and controlling tactics (for example Hammond 1982; Sonsin 1983; *Computerworld* 1984).

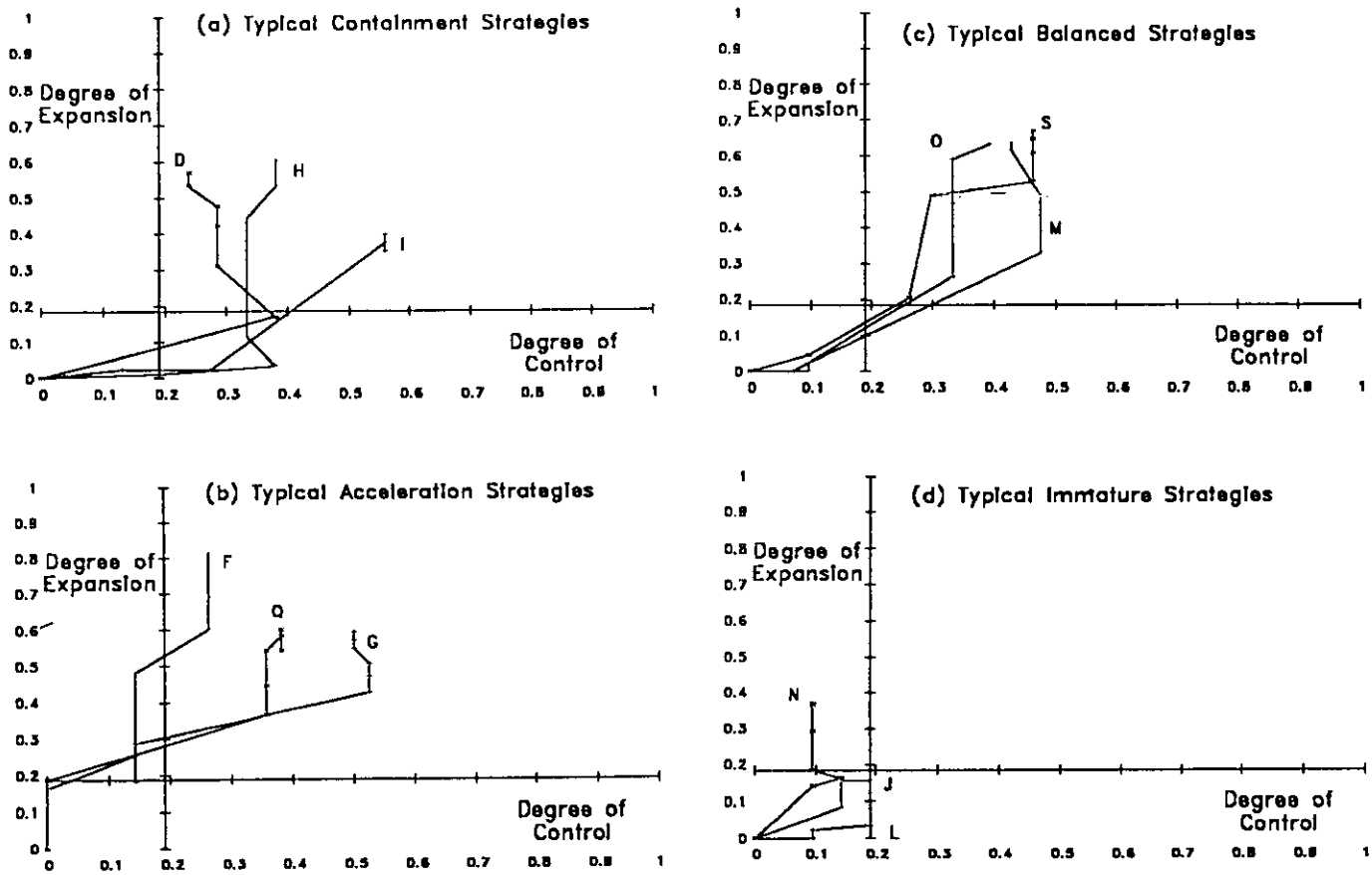

Figure 8. Typical EUC Management Strategies

6. DISCUSSION

The hypothesis tests reported above provide partial support for the expansion-control model. They strongly support the notion that most firms started with a hands-off approach to end-user computing (Laissez-Faire) and moved toward a mature balance of expansion and control tactics (Controlled Growth). However, the hypothesis tests also failed to support two key elements of the research model. The failure of the construct independence hypothesis has been discussed above. The failure of the strategy progression hypothesis is examined in more detail next.

6.1 A Closer Look at EUC Strategy Progression

Among the firms studied, the progression of EUC management strategies was not as simple as theorized. Given the nine year study period from 1979 to 1987, several different progressions were observed. These are illustrated in Figure 8.

6.1.1 Containment Strategy

Figure 8(a) illustrates some typical Containment strategies employed by participating firms. These firms fit the Containment pattern predicted by the expansion-control model. They each moved from a Laissez-Faire strategy to a Controlled Growth strategy via a Containment strategy lasting one or more years. These firms included a retailer (D), a food producer (H), and a specialty goods manufacturer (I). Other firms (not shown) included another food producer, a commodities dealer, and a hospitality services provider.

More firms followed the Containment strategy (seven of nineteen; 34 percent) than any other pattern observed in the research sample. In general, these firms were very large. All were listed in *Fortune 1000*. Each provided traditional mainframe-based IS services for their headquarters location. Comments from group meetings suggested that despite their focus on mainframe development, senior IS executives in these firms felt *accountable* for end-user computing. In general, IS management's attitude toward PCs was skeptical. IS veto power over PC acquisition was universal. One firm even employed a "delaying strategy" for PC acquisition, "they were not sure if PC acquisition would pay-off in the long-run." A user in another firm reported that "a certain hoopla was required to buy a PC." These firms were also late in adopting the information center concept with most adopting in the period 1984 to 1985. They also tended to enforce narrow (single-vendor)

technology standards. One firm standardized on Burroughs/Convergent PCs, betting on future compatibility with its Burroughs mainframe computers. Most of the other firms standardized on the IBM PC series.

6.1.2 Acceleration Strategy

Figure 8(b) illustrates the Acceleration strategies employed by participating firms. These firms also fit a pattern predicted by the expansion-control model. They each moved from a Laissez-Faire strategy to a Controlled Growth strategy via an Acceleration strategy lasting one or more years. The firms included a financial services provider (G), a heavy equipment manufacturer (O), and a pharmaceutical producer (F). These were the only three firms whose EUC strategies fell into the Acceleration cell.

Quantitative and qualitative data suggested the most striking difference between firms employing a Containment strategy and those employing an Acceleration strategy was the *timing* of the establishment of their information centers. The three firms in this group formalized their information centers quite early (in 1977, 1979, and 1983). Even the firm implementing its IC in 1983 provided "informal support from the day the company's first PC was unpacked from its box." IS managers in these firms made an early commitment to help end users help themselves. Surprisingly, after 1983 the management of end-user computing in these companies was very similar to firms categorized in the Containment cell. That is, the IS department was considered to be somewhat restrictive and controlling. For example, users reported that "just last year, Audit had to write an eight page justification for buying a PC" and "some of us still find it difficult to get support from the information center."

6.1.3 Balanced Strategy

Figure 8(c) illustrates some of the strategies referred to as *balanced* in Figure 5. These firms did not fit the patterns predicted by the expansion-control model. They each moved from a Laissez-Faire strategy directly to a Controlled Growth strategy. The firms included two insurance companies (O & S), a publisher (M), and a bank (not shown).

The distinguishing characteristic of these firms was the rapid staffing of their information centers. These firms started their information centers roughly mid-way in time between the groups discussed above (in 1982, 1983, and 1984), but in each firm, the information center was provided adequate resources and staffing. Each IC was launched with a formal mission statement and decisive commitment from IS management. The quick start-up of their IC enabled these firms to skip the intermediate stage and move directly from Laissez-Faire to Controlled Growth.

6.1.4 Immature Strategy

Figure 8(d) illustrates the strategies referred to as *immature* in Figure 5. These firms also failed to fit a predicted pattern. While each firm began with a Laissez-Faire strategy, by 1987 none employed a Controlled Growth strategy. The firms included a mid-sized bank (J), a mid-sized industrial products manufacturer (N), and a billion dollar holding company (L).

The distinguishing feature of this group was the firms' moderate to small size in terms of office staff. The holding company was highly decentralized maintaining a corporate staff of only twenty-five people. The bank was also heavily decentralized with a central staff of two hundred. These firms did not have internal IS departments and had no information center. Users tended to characterize management's attitude as "benign neglect." While these two firms had recently moved toward a containment strategy, it is doubtful that either firm will ever move into the Controlled Growth strategy as defined here. The third firm was the mid-sized industrial products manufacturer. Its information center was staffed by one person and had focused on mainframe end-user computing until 1985. At that time, an additional person was added to the IC staff to focus on PC-based support. Given this firm's size (1,000 people on headquarters staff) and their plans for EUC management, they may move into a Controlled Growth strategy some time in the future.

6.2 An Evolutionary View of EUC Management

As mentioned earlier, the management action data appear to support a stage theory of EUC management, but current stage theories support a *single* progression for management action over time. Thus important differences are revealed in this study. The typical stage theory suggests a progression from initiation to maturity with an emphasis on *expansion before control.*

The data reported here clearly support a progression from initiation to maturity. But lumping expansion and control activities together hides important qualitative information about the intent of management action over time. Examining the firms' use of expansion and control tactics separately provides additional insight. Figure 9(a) traces the use of expansion and control activities over time, while Figure 9(b) traces the mean difference between the two variables. These figures illustrate the changing emphasis from hands-off, to control, to expansion, to balance over time among the firms studied. These data can be interpreted as supporting a four phase cycle of management actions and suggest that 1979-1980 was a period with minimal emphasis on managing end-user computing. Following this, 1981-1982 was a period of increasing emphasis on controls. In contrast, 1983-1985 was a period of rapidly increasing emphasis on expansion activities. Finally, 1986-1987 was a period of stability with both expansion and control activities leveling off.

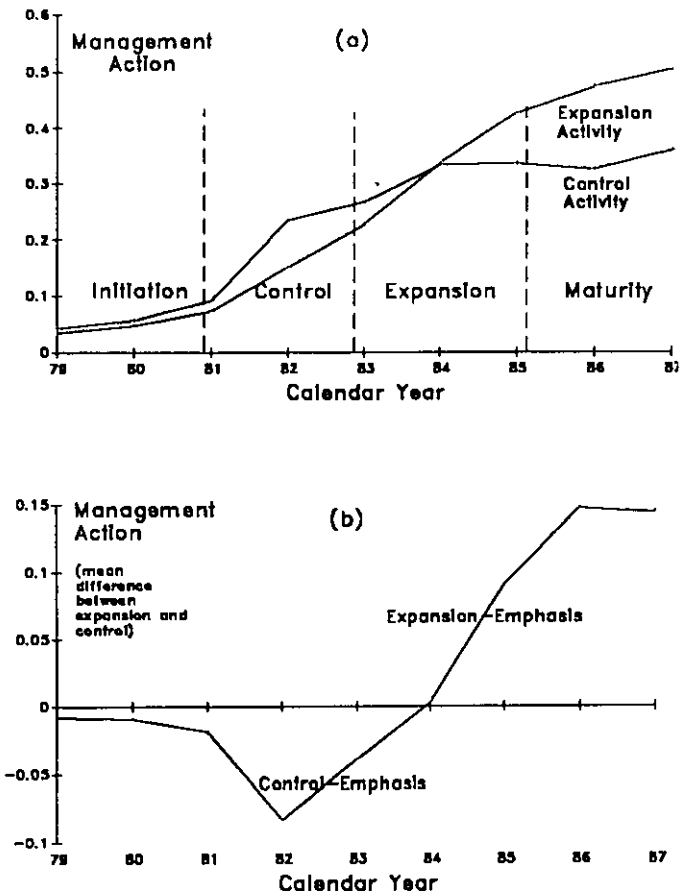

Figure 9. Changing Emphasis on Expansion and Control

If viewed in aggregate, the firms studied generally followed a pattern of initiation, control, expansion, and maturity. Thus they tended to follow a control-first strategy. Group interviews suggested that this was a *reaction* to the rising demand for personal computers and related software among knowledge workers outside the information systems function. For most firms, expansion came later, after sufficient controls were in place and after technology issues began to stabilize. These data also underscore the importance of technological imperatives led by the introduction of the IBM PC in 1982. Indeed, many of the still current technology platforms were introduced during the expansion phase of managing end-user computing.

However, it has already been shown that individual firms varied in their approach to managing end-user computing. Five different approaches were identified in Figure 5. These included expansion-first, control-first, balanced, pioneer, and immature. These data support the notions of backwards progression and skipped stages. It could be argued that some of these categories could be collapsed. Even still, it appears that prevailing theory may be too simplistic.

Treating end-user computing as a specific observation of organizational learning offers the advantage of viewing it as a trial-and-error learning process. Given this interpretation, additional strategy progressions can be explained. In this view, management action occurs as a corrective action based on observed results of previous actions (or inactions). Changes in management action over time thus reflect learning based on the outcomes of past experiences. An example of trial-and-error learning at the organization level is provided by Griner (1972) in his theory on evolution and revolution in organizational management. More theoretically grounded examples of this type of learning are provided by Bandura (1977) in his theory of social learning. These and other models of complex learning situations provide promising bases for improving understanding of organizational learning about information technology.

6.3 Implications for Research

Models for explaining the management of end-user computing are valuable because they can improve understanding of the management of new information technologies just emerging in the market. Given the rapid commercialization of new information technologies, what is needed are more general models of the technology implementation process and a schema for classifying new technologies so they can be related back to the general model.

In terms of needed research, additional longitudinal data are badly needed and new organizational learning situations need to be identified and studied. Prime candidates for study include the implementation of computer assisted software engineering (CASE), group decision support systems (GDSS), and integrated services digital networks (ISDN). These three technology applications represent a range of learning situations involving individuals, groups, and entire organizations. In addition, effectiveness data is needed to evaluate which approaches to organizational learning work best in which situations.

6.4 Limitations

A number of limitations need to be acknowledged. First, the number of companies studied was quite small (n = 19). In addition, the participation rate of 50 percent leaves open the possibility of participation bias. Given the small and not necessarily representative sample, the generalizability of the results cannot be assured. Furthermore, recall of certain historical events may have been a problem. While the group interview format minimized this problem, it did not eliminate it. Overall, the findings should be interpreted with caution.

7. CONCLUSIONS

The expansion-control model suggests strategic and tactical choices for managers addressing the difficult task of managing the introduction of emerging technologies. It provides an important step toward understanding manage-

ment of the technology assimilation process. The longitudinal nature of the data reported here permitted new analyses, particularly with respect to changes in management actions over time.

Three major conclusions can be drawn. First, while nearly all firms started in the Laissez-Faire cell and finished in the Controlled Growth cell, several did not follow the predicted progression through the expansion-control grid. Thus, the data provide only partial support for the dynamic aspects of the expansion-control model. More firms followed a Containment strategy than any of the other strategies observed. This may have represented IS management's overreaction to the user-led nature of the EUC phenomenon. Second, perhaps the expansion and control constructs are not as independent as previously thought. The interaction between the two variables appears to be related, at least in part, to time and stage of assimilation. Finally, current models of EUC management (and thus organizational learning about information technology) may be too simplistic. They tend to predict only one or a small number of orderly progressions of management action over time. As suggested above, more general models of the process may be appropriate. Learning models such as Bandura's social learning theory may provide a basis for further work in this area. Such models can be adapted, tested, and refined as new information technologies diffuse through organizations.

8. REFERENCES

Argyris, C., and Schon, D. A. *Organizational Learning: A Theory of Action Perspective*. Reading, Massachusetts: Addison-Wesley, 1978.

Ball, L., and Harris, R. "SMIS Members: A Membership Analysis." *MIS Quarterly*, Volume 6, Number 1, March 1982, pp. 19-38.

Bandura, A. *Social Learning Theory*. Englewood Cliffs, New Jersey: Prentice-Hall, 1977.

Benjamin, R. "Information Technology in the 1990's: A Long Range Planning Scenario." *MIS Quarterly*, Volume 6, Number 2, June 1982, pp. 11-31.

Brancheau, J.; Vogel, D.; and Wetherbe, J. "An Investigation of the Information Center from the User's Perspective." *Data Base*, Volume 17, Number 1, Fall 1985, pp. 4-17.

Brancheau, J., and Wetherbe, J. "Higher and Lower Rated Information Centers: Exploring the Differences." *Journal of Information Management*, Volume 9, Number 1, Spring 1988, pp. 53-69.

Brancheau, J., and Wetherbe, J. "Testing Innovation Diffusion Theory in the Context of End-User Computing: The Adoption of Spreadsheet Software." Forthcoming in *Information Systems Research*, 1990.

Brown, C., and Wynne, B. "Effective Management of End-User Computing: Prior Models and a Case Example." *Proceedings of the Working Conference on Desktop Information Technology* (IFIP 8.2), Cornell University, June 1989.

Computerworld. "Info Centers Gaining." Framingham, Massachusetts: CW Communications, February 27, 1984, p.6.

Converse, J., and Presser, S. *Survey Questions: Handcrafting the Questionnaire*. Beverly Hills, California: Sage, 1986.

Greenberg, E. R. "How Far, How Fast?" *Information Center*, August, 1988, pp. 20-24.

Griner, L. E. "Evolution and Revolution as Organizations Grow." *Harvard Business Review*, Volume 50, Number 4, July-August 1972, pp. 37-46.

Hammond, L. "Management Considerations for an Information Centre." *IBM Systems Journal*, Volume 21, Number 2, April 1982, pp. 131-161.

Henderson, J., and Treacy, M. "Managing End-User Computing for Competitive Advantage." *Sloan Management Review*. Volume 27, Number 2, Winter 1986, pp. 3-24.

Hill, W. F. *Learning: A Survey of Psychological Interpretations*, Third Edition. New York: Harper & Row, 1977.

Johnson, R. "The Infocenter Experience." *Datamation*, January 1985.

Kerlinger, F. *Foundations of Behavioral Research*. New York: Holt, Rinehart, and Winston, 1986.

Lightner, T., and Brancheau, J. "Research on the Management of End-User Computing: A Guide to the Literature." Faculty Working Paper 89-36, University of Colorado, Boulder, September 1989.

Mandell, P. "When the Info Center Outlived its Usefulness, Quaker Toe it Down." *PC Week*, January 19, 1988, p. 38.

McGrath, J. *Toward a Theory of Method for Research in Organizations*. Santa Monica: Goodyear Publishing, 1979.

Munro, M., and Huff, S. "Information Technology Assessment and Adoption: Understanding the Information Centre Role." *Proceedings of ACM Conference on End-User Computing*, Minneapolis, Minnesota, 1985, pp. 29-37.

Munro, M.; Huff, S.; and Moore, G. "Expansion and Control of End-User Computing." *Journal of Management Information Systems*, Volume 4, Number 3, Winter 1987-88, pp. 5-27.

Nunnally, J. *Psychometric Theory*. New York: McGraw-Hill, 1967.

Raho, L. E.; Belohlav, J. A.; and Fiedler, K. D. "Assimilating New Technology into the Organization: An Assessment of McFarlan and McKenney's Model." *MIS Quarterly*, March 1987, pp. 47-56.

Robey, D., and Zmud, R. W. "Research on End-User Computing: Theoretical Perspectives from Organizational Theory." *Proceedings of the Working Conference on Desktop Information Technology* (IFIP 8.2), Cornell University, June 1989.

Rockart, J., and Flannery, L. "The Management of End-User Computing." *Communications of the ACM*, Volume 26, Number 10, October 1983, pp. 776-784.

Sonsin, W. "Implementing an Information Center." *Information Executive*, Volume 1, Number 1, 1983, pp 18-30.

Straub, D. "Validating Instruments in MIS Research." *MIS Quarterly*, Volume 13, Number 2, June 1989, pp. 147-169.

White, C. E., and Christy, D. P. "The Information Center Concept: A Normative Model and a Study of Six Installations." *MIS Quarterly*, Volume 11, Number 4, December 1987, pp. 451-458.

9. ENDNOTES

1. A closer analysis reveals "abandonment" in most firms simply meant a redistribution of the functions initially provided by the information center.

2. For clarity, all hypotheses are stated in non-null form.

APPENDIX

Composite Expansion Index

EXPANSION = sum $(X_i)/22$; i = 1 to 22; where:

X_1 = Information Center
X_2 = Mission Statement Published
X_3 = Formal Training
X_4 = Consulting/Troubleshooting Support
X_5 = Product Research
X_6 = Hot Line/Help Desk
X_7 = Newsletter Published
X_8 = PC Acquisition Support
X_9 = Walk-in Center for Equipment Access
X_{10} = (Equipment Loan + Software Loan)/2
X_{11} = Reference Library
X_{12} = Software Resource Directory
X_{13} = User Groups
X_{14} = Open Houses
X_{15} = (Acquisition Subsidies + Maintenance Subsidies)/2
X_{16} = (Custom User Manuals + Custom Software)/2
X_{17} = (PC Network + Dedicated Mainframe-Minicomputer)/2
X_{18} = (Decentralized Staff Location + End-Users on IC Staff)/2
X_{19} = Target Efforts Toward Key Users
X_{20} = Departmental Experts
X_{21} = Supportive Management Involvement by IS
X_{22} = Mainframe Access from PCs

Composite Control Index

CONTROL = sum$(Y_i)/7$; i = 1 to 7; where:

Y_1 = Restraining Management Involvement by IS
Y_2 = Formal Steering Committee
Y_3 = IS/IC Veto Power Over Acquisition
Y_4 = Formal Cost/Benefit Required
Y_5 = Equipment/Software Standards
Y_6 = (Personnel Chargeback + Equipment Chargeback)/2
Y_7 = (Accepted Practices Guide + Application Review + Certification)/3

Expansion-Control Cell Derivation

Based on sample medians:

if (EXPAND > = .186 and CONTROL > = .190) CELL = 4. (Controlled Growth)
if (EXPAND > = .186 and CONTROL < .190) CELL = 3. (Acceleration)
if (EXPAND < .186 and CONTROL > = .190) CELL = 2. (Containment)
if (EXPAND < .186 and CONTROL < .190) CELL = 1. (Laissez-Faire)

Note: All expansion-control variables normalized to (0,1) range.