ORGANIZATIONAL FACTORS ASSOCIATED WITH EXPERT SYSTEMS IMPLEMENTATION

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ABSTRACT

This study examines the organizational factors associated with the successful implementation of expert systems (ES), using data from a survey of organizations that have actually implemented ES for their operations. The results show that organizations that practice strategic information systems (IS) planning have management support for IS and have IS diffused across the organization tend to derive more value-added benefits from ES implementation. The results also show that organizations with more decentralized decision-making structure tend to derive more productivity-related benefits from ES implementation. These findings will be useful to managers in assessing the appropriateness of their organizations to ES implementation and further improving the ES implementation practice.

INTRODUCTION

Emerging as one of the most practical applications of artificial intelligence technology, ES have extended to a wide variety of areas. A recent survey of published materials on ES uncovered approximately 2500 developed systems, which could represent a fifth of all systems actually developed (8). Some major companies, such as Digital Equipment, DuPont and IBM, have reportedly generated huge financial returns as well as competitive advantages from using ES (23, 29, 39). While many organizations have tried to implement ES, not every organization has met with implementation success. Several case studies (30, 31) report failure in implementing ES in organizations. Many well-published ES have proved to be pure hyps or system failure (12).

Why are some organizations more successful than others in implementing ES? There may be various reasons for this, from technical and functional quality of the system itself all the way to managerial and organizational issues involved in the implementation. To date, many studies have investigated various factors associated with ES implementation. But most studies that address organizational aspects of ES implementation, with the exception of a few, are based upon experiences of single organizations and their findings are limited in generalizability. A few field surveys (3, 12, 35) involve larger samples and provide more generalizable information, but their findings are still limited to identifying those organizational factors perceived by the respondents as being important to ES implementation. Extending the line of research on organizational aspects of ES implementation, this study examines how certain organizational factors are associated with the successful implementation of ES. Based upon organizational contingency theories (11, 37, 38), we posit that certain organizational attributes facilitate ES implementation, and organizations with such attributes have a better chance for successful ES implementation. We use data from a survey of IS professionals within organizations that have actually implemented ES for their operations. The findings of this study can help explicate the organizational factors that may contribute toward the successful implementation of ES. Such understanding will prove helpful to managers in assessing the appropriateness of their organizations to ES implementation and improving the ES implementation practice.

CONCEPTUAL CONSTRUCTS

Organizational contingency theories (11, 37, 38) propose that an organization’s structure must “fit” its organizational context (usually the task to be accomplished or the core technology used) in order to have a higher performance (13). When an organization’s efforts to implement a new information technology are accompanied by the necessary organizational infrastructure, the organization will have a better chance to successfully implement the new information technology and derive its full benefits. Based upon organizational contingency theories, we posit that ES implementation with proper organizational fit has a better chance for success. That is, there may be certain organizational factors that facilitate ES implementation, and organizations with such factors may have a better chance for success of ES implementation.

There is a wide body of research investigating organizational factors as they relate to IS and innovation implementation. Based upon this line of research, we examine two broad categories of organizational factors: general and IS-related. The general factors include 1) decentralization, 2) risk propensity of top management and 3) the size of the organization. The IS-related factors include 1) strategic IS planning, 2) top management support for IS, and 3) diffusion of IS within the organization. While there is significant empirical research discussing these organizational factors as being associated with IS implementation, relatively little is known except for anecdotal information in a few case studies about these factors in the context of ES implementation. Table 1 lists the six major organizational factors and their sub-items that are included in this study.

Organizational structure is one of the most frequently investigated factors in IS and innovation implementation research. A major dimension regarding organizational structure is centralization or concentration of decision-making activities (9, 14, 15). Centralization is often found to have a negative association with IS and innovation implementation because of decreased autonomy and a bounded perspective (14, 25). In contrast, a decentralized decision-making structure tends to offer fast implementation, foster user ownership and create broad organizational support, as demonstrated in the case of over 600...
ES at DuPont (23). Therefore, we hypothesize that organizations with a decentralized decision-making structure are likely to be more successful in implementing ES than those with a centralized decision-making structure. Regarding decentralization, we examine four items originated by Hage and Aiken (15).

\begin{table}
\centering
\caption{Organizational Factors Included in the Study}
\begin{tabular}{ll}
\hline
Organizational Factors & Alpha \\
\hline
Decentralization (DC): & 0.7933 \\
Encouragement of participation of subordinates in decision making & \\
Taking action before a superior approves a decision & \\
Encouragement of a subordinate who wants to make his or her decisions & \\
Participation of subordinates in decisions on the adoption of new policies & \\
Risk propensity (RS): & 0.8238 \\
Top management’s willingness to accept changes in organizational structure, workforce composition, skills, etc. that may result from a decision & \\
Top management’s willingness to absorb information technology with which the organization is unfamiliar & \\
Top management’s willingness to commit large investments to new information technology & \\
Organization size (SZ): & 0.9164 \\
Sales/revenue/budget in terms of dollar amount & \\
Number of employees & \\
Size relative to the relevant industry & \\
Strategic IS planning (PL): & 0.8921 \\
Constant involvement of IS management in business planning & \\
Consideration of competitive strategy in IS planning & \\
Active involvement of top management in IS planning & \\
Continuous assessment of information technology in IS planning & \\
Management support for IS (SP): & 0.8806 \\
Top management’s encouragement of IS use & \\
Top management’s consideration of IS as important to the organization & \\
Top management’s effective communication of its support for IS & \\
Diffusion of IS (DF): & 0.8288 \\
Diffusion of IS within the organization & \\
Penetration of IS into the organization in terms of importance and impact & \\
Sharing databases for various applications & \\
\hline
\end{tabular}
\end{table}

Studies in the IS area also suggest that the level of risk an organization is willing to take influences IS projects (14, 21). An organization’s position regarding this risk is reflected in top management’s innovative uses of IS and the decisions regarding the changes in methods and procedures. ES implementation may be viewed as risky, since the technology has the potential to change the methods, procedures and skills needed for a job. Sviokla (33) and Trappi (34) suggest that ES may have an unfavorable impact on the social aspects of the workplace and thereby increase risk. Therefore, we hypothesize that organizations with high risk-taking propensity are likely to be more successful in implementing ES than those with low risk-taking propensity. Drawing from Clemons, Keen and Kimbrough (5), we examine three items of top management’s risk propensity.

Organization size is another factor that has been well studied in IS implementation research (6, 19). While organization size is widely recognized as an important factor affecting IS success (9), the results on this factor are ambivalent. That is, arguments are made for both large sizes (great slack, economies of scale) and small sizes (great flexibility) fostering IS and innovation implementation (14, 36). Because of the heavy time and resource commitment required for ES implementation, large organizations that in general have more resources, may be in a better position to implement ES than small organizations that in general have less resources.

Therefore, we hypothesize that large organizations are likely to be more successful in implementing ES than small organizations. Adopting from Ein-Dor and Segev (9), we examine three dimensions of organization size.

The use of IS as a competitive advantage has received quite a bit of attention (1). Links between IS and business plans are particularly important for IS activities to enhance competitive strategy (22). Strategic IS planning establishes a link between the organizational strategy and IS strategy to establish the course for IS in organizational performance (14). A study of several organizations that successfully implemented ES emphasizes the overall link between ES projects and the business strategy of an organization as being one of the most important factors for success (24). Therefore, we hypothesize that organizations with a high degree of strategic IS planning are likely to be more successful in implementing ES than those with a low degree of strategic IS planning. Deriving from Benson and Parker (2), we examine four items of strategic IS planning.

Top management support is consistently recognized as an important factor in IS implementation (18, 26) and a good predictor of successful introduction of new or different IS (14). The importance of top management support is signified in several cases of ES implementation, e.g., XCON at Digital Equipment (20), Management Advisor at Krypton Chemical (28), and Life Underwriter at Lincoln National (24). The results of a survey of knowledge engineers also show that management
support is an important factor to ES success (3). Therefore, we hypothesize that organizations with a high degree of top management support for IS are likely to be more successful in implementing ES than those with a lower degree of top management support. Based upon Raymond (27), we examine three items of top management support for IS.

The existing state of IS diffusion within the organization can also affect the implementation of new IS (14, 32). IS diffusion refers to the extent to which IS are disseminated or scattered throughout the organization. An organization’s decision to implement a new information technology should be accompanied by the necessary infrastructure to derive its full benefits. Innovation literature strongly proposes that the implementation of any technological innovation should be based upon a firm’s technological strengths (7). The existing state of IS diffusion appears to be an important factor in IS implementation, since more ES are integrated with other IS (10, 16), often making other IS more useful and easier to use (4, 17).

Therefore, we hypothesize that organizations with a high degree of IS diffusion are likely to be more successful in implementing ES than those with a low degree of IS diffusion. Based upon Sullivan (34), we examine three items of IS diffusion.

In this study, we measure the success of ES implementation in terms of the benefits derived from the implementation. Perceived benefits are one of the most widely used measures of success in IS studies (39). Several studies (e.g., 3, 30, 35) report that ES can provide such benefits as improved decision making, greater consistency and continuity in decision making, faster response time, operational cost savings, and more readily available information. Drawing from these studies, we examine the benefits of ES implementation in three major areas: value-added, productivity-related, and managerial areas. The value-added area includes such benefits as improved decisions and reporting (in terms of consistency, accuracy and timeliness), improved customer service, and improved competitiveness and market share. The area related to productivity includes such benefits as improved productivity (in terms of cost and time saving), more creative work, and less routine tasks. The managerial area includes such benefits as improved managerial control and improved education and training.

RESEARCH METHODS

We used data from a survey of IS professionals within organizations that have actually implemented ES for their operations. There are several reasons for aiming at IS professionals for this study. First, IS professionals are presumed to have some knowledge of ES technology itself as well as of the state of ES implementation in their organizations. Second, they can provide rather objective information regarding the consequences of ES implementation in a neural position between ES practitioners or advocates (e.g., knowledge engineers) and end users in other functional areas. Third, they are believed to provide the most reliable information about IS practices in their organizations, as one of our aims is to examine any association of IS-related organizational factors with the successful implementation of ES. For these reasons, IS professionals, who also play an important role in the process of ES implementation, are deemed to be appropriate respondents for this study.

The survey instrument was pre-tested by several IS professionals in order to test its validity. Their responses and comments were subsequently used to modify the instrument. Then the questionnaire was mailed to 600 IS professionals across organizations in the United States. The mailing list was made up of different names from the member directories of the Association of Information Technology Professionals and the Association for Systems Management, of which most members are IS practitioners. We attempted to distribute questionnaires across distinct geographical regions where regional chapters of the associations are established. Potential respondents in each region were selected randomly with the number being proportional to the number of chapter liaisons and representatives of the region. In this way, we could significantly enhance the chance of each response from a distinctive organization.

We first asked IS professionals of the status of their organization regarding ES implementation. Then we asked only those reporting the actual implementation of ES to classify the extent to which they agree on the benefits that their organization derived from ES implementation. If more than one ES were in use in the organization, they were asked to respond regarding the one ES with which they are most familiar. The extent of their agreement on ES benefits was measured using a five-point Likert-type scale (i.e., 1 = no benefit at all, 5 = great benefit). We also asked them to classify the extent to which they agree on the general and IS-related organizational factors of their organization. The extent of their agreement on these organizational factors was measured using a five-point Likert-type scale (i.e., 1 = strongly disagree, 5 = strongly agree). We also collected some demographic data on the respondents and their organizations.

Responses were received from 143 IS professionals, representing a response rate of 24%. Fifteen responses did not indicate the status of ES implementation in their organizations. Of the remaining 128 responses, only 25 reported that their organization has ever been involved in ES projects. Of the 25 implementers, 16 reported current use, four reported current development, and five reported disuse of ES. Seventeen of the 25 implementers reported involvement with only one ES, while eight reported involvement with more than one ES. These results suggest that ES have not been widely implemented in organizations, contrary to the hypotheses and speculations made earlier regarding the technology. Many organizations appear to have merely “talked the talk” of ES implementation, not being motivated enough to implement the technology themselves.

We used data from 21 respondents whose organizations have actually implemented ES for their operations but with various implementation consequences. We acknowledge the limitations of the small sample size. But it should be noted that the small sample size is due largely to the low rate of ES implementation among the respondents. Table 2 shows the profile of the sample. The respondents included IS professionals in the IS area as well as other functional areas, with various ranks. The majority of the respondents were either executives or managers, and this seniority could enhance the credibility of the data. The organizations represented in the sample were skewed toward the service sector but relatively evenly distributed with respect to organization size. These characteristics of the sample should be kept in mind when interpreting the results.

Using the sample of 21 responses, we first calculated the means and standard deviations of all variables to see the extent of agreement on individual variables. Then, we performed an assessment of reliability to verify integrity of the measuring instrument using Cronbach’s alpha as an indicator. Table 1 shows the results of the reliability test on six major organizational variables. In reliability test, the internal reliability coefficients for the six variables were high enough to be accepted for an exploratory study, suggesting that all the sub-items should be retained. For each response, the sub-items comprising each variable were averaged to produce the response’s score for that variable. Finally, we computed correlation coefficients between

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the variables of ES benefits and the organizational factors to see any associations between them.

RESULTS AND DISCUSSION

Table 3 shows the means and standard deviations of the variables of ES benefits. In general, the respondents perceived that their organizations derived moderate or small benefits from ES implementation, while there were some variances across the benefit areas considered. The benefit of improved decisions and reporting was the greatest, followed by the benefit of improved productivity. Regarding the extent to which the benefits were derived, our results are rather consistent with the findings from a survey of knowledge engineers across organizations (3). The benefits that organizations derive from ES implementation appear to be still limited, contrary to the many benefits and successes previously reported in the press and literature.

<table>
<thead>
<tr>
<th>Respondents:</th>
<th>IS area</th>
<th>Other area</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive</td>
<td>24%</td>
<td>19%</td>
<td>43%</td>
</tr>
<tr>
<td>Manager</td>
<td>24%</td>
<td>5%</td>
<td>29%</td>
</tr>
<tr>
<td>Analyst/engineer/programmer</td>
<td>19%</td>
<td>5%</td>
<td>24%</td>
</tr>
<tr>
<td>Unknown</td>
<td>5%</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>71%</td>
<td>29%</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organizations:</th>
<th>Industry</th>
<th>Number of employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>19%</td>
<td>&lt;=10 10%</td>
</tr>
<tr>
<td>Service</td>
<td>67%</td>
<td>&lt;=100 14%</td>
</tr>
<tr>
<td>Unknown</td>
<td>14%</td>
<td>&lt;=1,000 29%</td>
</tr>
<tr>
<td>Sales/revenue/budget ($)</td>
<td>10%</td>
<td>&lt;=10,000 33%</td>
</tr>
<tr>
<td>&gt;=$1 billion</td>
<td>24%</td>
<td>&gt;10,000 14%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Mean Ratings of ES Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benefits</strong></td>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td>Value-added benefits (VB):</td>
<td></td>
</tr>
<tr>
<td>Improved decisions and reporting</td>
<td>3.56</td>
</tr>
<tr>
<td>Improved customer service</td>
<td>2.67</td>
</tr>
<tr>
<td>Improved competitiveness/market share</td>
<td>2.67</td>
</tr>
<tr>
<td>Productivity benefits (PB):</td>
<td></td>
</tr>
<tr>
<td>Improved productivity</td>
<td>3.00</td>
</tr>
<tr>
<td>More creative works</td>
<td>2.67</td>
</tr>
<tr>
<td>Less routine tasks</td>
<td>2.67</td>
</tr>
<tr>
<td>Managerial benefits (MB):</td>
<td></td>
</tr>
<tr>
<td>Improved managerial control</td>
<td>3.00</td>
</tr>
<tr>
<td>Improved education and training</td>
<td>2.33</td>
</tr>
</tbody>
</table>

Table 4 shows the results of correlation test between the organizational factors and the major variables of ES implementation benefits. Given the exploratory nature of this study and the small size of the sample, the results should be interpreted with caution. The results corroborate some of our hypotheses as follows.

First, value-added benefits (VB) of ES implementation correlate positively and significantly with all three IS-related organizational factors (PL, SP and DF). This result suggests that organizations with a high degree of strategic IS planning, top management support for IS, and IS diffusion are likely to derive more value-added benefits from ES implementation. But no significant correlation is observed between value-added benefits of ES implementation and any of the general organizational factors. Second, productivity benefits (PB) of ES implementation correlate positively and significantly only with decentralization (DC). This result suggests that organizations with a decentralized decision-making structure tend to derive more productivity benefits from ES implementation. Third, no significant correlation is observed between managerial benefits (MB) and any of the general and IS-related organizational factors.

The strong IS infrastructure and practice of an organization can facilitate ES implementation and help derive value-added benefits from the implementation. Gaining a competitive advantage is one of the most important motivations for implementing ES, as perceived by knowledge engineers (3). When ES plans are closely linked with those of the business strategy as a whole, ES implementation appears to bring more value-added benefits, which in turn become a strategic advantage over a period of time. Also, top management's strong support for IS can result in provision of adequate resources such

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as people, time and funding for ES implementation, and hence, more value-added benefits from the implementation. The existing state of IS diffusion within the organization also appears to play an important role in implementing ES and deriving value-added benefits, as it provides a technological base from which ES are launched. Organizations with little experience with conventional IS may not be able to implement easily more sophisticated IS. In contrast, organizations with IS which are well diffused across the organization seem prone to implement ES.

<table>
<thead>
<tr>
<th>Organizational Characteristics</th>
<th>Value-added Benefits (VB)</th>
<th>Productivity Benefits (PB)</th>
<th>Managerial Benefits (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decentralization (DC)</td>
<td>-0.01</td>
<td>0.91**</td>
<td>0.19</td>
</tr>
<tr>
<td>Risk Propensity (RS)</td>
<td>0.23</td>
<td>0.40</td>
<td>0.44</td>
</tr>
<tr>
<td>Organization Size (SZ)</td>
<td>0.05</td>
<td>0.36</td>
<td>0.46</td>
</tr>
<tr>
<td>Strategic IS Planning (PL)</td>
<td>0.69**</td>
<td>-0.25</td>
<td>-0.09</td>
</tr>
<tr>
<td>Management Support for IS (SP)</td>
<td>0.69**</td>
<td>0.23</td>
<td>-0.09</td>
</tr>
<tr>
<td>IS Diffusion (DF)</td>
<td>0.74**</td>
<td>0.17</td>
<td>0.39</td>
</tr>
</tbody>
</table>

**p<0.001

A decentralized decision-making structure can facilitate ES implementation and help derive productivity benefits from the implementation, as it can offer fast implementation, foster user ownership and create broad organizational support. In such a decentralized decision-making structure, decisions on ES implementation can be made locally and immediately. Furthermore, since continuous involvement of users is essential in ES projects, the decentralized, participative decision-making structure appears to be more appropriate to implementing ES that have a strong user orientation.

CONCLUSION

Using data from a survey of IS professionals in organizations that have implemented ES, this study has attempted to examine the organizational factors that may be associated with the success of ES implementation. The results suggest that some organizational factors can facilitate ES implementation and help derive some benefits from ES implementation. Specifically, organizations with a high degree of strategic IS planning, top management support for IS, and IS diffusion are likely to derive more value-added benefits from ES implementation. Also, organizations with a decentralized decision-making structure are likely to derive more productivity benefits from ES implementation. These results are well worth trying to understand, as they could provide guidance concerning organizational conditions and practices that are most appropriate to implementing ES and deriving the benefits from the implementation. For example, such a guide can be used by IS managers in assessing the appropriateness of their organizations to ES implementation and improving the ES implementation practice. Taken together, the findings of this study can contribute to increasing our understanding of ES implementation in organizations and associated organizational factors.

There are several limitations to this study. First, we have considered only a restricted set of organizational factors. These organizational factors are certainly not comprehensive, although some of them are found as being associated with the success of ES implementation. Second, there might be multiple responses from some organizations in the sample and hence some bias effects on the results. But our attempt to distribute questionnaires across distinct geographical regions (i.e., states and cities) is believed to have reduced the potential bias significantly. Third, the results, which are based upon the perceptions of a sample of IS professionals are subject to the problems related to perceptual studies. If we had targeted managers and end-users in functional areas, the results might have been different but the response rate might have been much lower. Given the importance of IS professionals’ perceptions and attitudes in the decision process of IS implementation, however, this study can provide some meaningful insights into the organizational conditions and practices that may be most associated with the success of ES implementation. These limitations are certain not exhaustive but rather important ones. Obviously, these limitations suggest several possibilities for future research.

REFERENCES


