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The Decision-Support Characteristics of ERP Systems

Clyde W. Holsapple
Gatton College of Business and Economics
University of Kentucky

Mark P. Sena
Williams College of Business
Xavier University

Enterprise Resource Planning (ERP) systems have been widely adopted in large organizations. These systems store critical knowledge used to make the decisions that drive an organization's performance. However, ERP systems are known primarily for their transactional rather than their decision-support characteristics. This study examines the extent to which adopters of ERP systems perceive characteristics typically associated with decision-support systems. It also examines the importance that adopters place on such characteristics. The major findings are that ERP adopters perceive substantial levels of decision-support characteristics in their ERP systems and that they consider such characteristics to be important. The study also examines differences in decision-support perceptions among demographic groups. By delineating the current state of ERP systems as they pertain to decision support, the results establish areas that vendors and adopters can focus on to improve the level of decision support provided by their ERP systems.

1. INTRODUCTION

Over the past decade, organizations have spent billions of dollars implementing enterprise resource planning (ERP) systems. These systems have changed the handling of business transactions in many organizations, particularly the larger ones. The impact that these systems have had on organizational decision making is not as clear. In an evaluation of ERP's success to date, Wah (2000) asked the question "Does it really foster better decision making?" This study explores this topic by ex-

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Authors are listed in alphabetical order.

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Requests for reprints should be sent to Mark P. Sena, Accounting and Information Systems, Williams College of Business, Xavier University, Mail Location 5161, Cincinnati, OH 54207–5161. E-mail: sena@xu.edu

amining the extent to which ERP adopters perceive characteristics that are traditionally associated with decision-support systems. Along with these results, this study examines the importance that ERP adopters place on various decision-support characteristics. The study also explores differences in perceptions of characteristics and importance among demographic groups based on job responsibilities, primary ERP vendor, and length of time since the system was implemented.

The results of this study illuminate the current state of ERP practice with respect to decision-support characteristics, furnishing an empirical background for hypothesis identification, theory building, software design, practitioner guidance, and instruction. It contributes to new research initiatives within the decision support system (DSS) and ERP fields. It also offers practical insights that can be used by ERP adopters and vendors in striving to improve the decision-support capabilities of ERP systems.

The remainder of the article is organized as follows: Section 2 reviews previous literature on decision-support characteristics; this leads to the identification of 16 characteristics used in constructing a survey instrument. Section 3 presents an overview of the study's methodology along with a profile of respondent demographics. Section 4 reports on the extent to which decision-support characteristics are perceived by ERP adopters. Section 5 reports on the importance that adopters place on these characteristics; this leads to a discussion of the decision-support areas that vendors and adopters should focus on in future ERP projects. Section 6 explores possible differences in perceptions of the extent and importance of these characteristics among demographic groups. Finally, Section 7 concludes with a discussion of this study's main findings and suggestions for future investigations.

2. LITERATURE REVIEW OF DECISION-SUPPORT CHARACTERISTICS AND ERP

One way to gauge the extent of support that enterprise systems provide for decision making is to examine the characteristics of DSSs and assess whether such characteristics are exhibited by enterprise systems. Analyses of this nature serve to promote a better understanding of enterprise systems' decision-support capabilities and provide a way to compare the characteristics of different enterprise systems. But, what are the main characteristics of decision-support systems? To answer this question, we draw on the DSS literature.

As a starting point, Desanctis and Gallupe (1987) theorized that there are three levels of decision-support capabilities: reduction of communication barriers during decision making (Level 1), reduction of uncertainty or noise during decision making (Level 2), and regulation of processes that occur during decision making (Level 3). Although this classification is intended to distinguish among different types of group decision-support systems, we contend that it can also be applied to other types of DSSs, such as multiparticipant DSSs that support more complex organizational decision makers or DSSs that support individual decision makers. The three levels translate into three classes of decision-support characteristics: (a) those characteristics that support decision maker communications, (b) those that

support decision maker knowledge, and (c) those that support decision maker processes. A list of decision-support characteristics should have entries that pertain to each of these levels.

In a complementary vein, Holsapple and Whinston (1996) theorized that a DSS could be expected to exhibit the following types of characteristics:

a. Includes a body of knowledge that describes some aspects of a decision maker's world that specifies how to accomplish various tasks, indicates what conclusions are valid in various circumstances, and so forth.
b. Has an ability to acquire and maintain descriptive knowledge (i.e., data, information) and possibly other kinds of knowledge (e.g., procedural, reasoning).
c. Has an ability to present knowledge on an ad hoc basis in various customized ways as well as in standardized reports.
d. Has an ability to select any desired subset of stored knowledge for either presentation or deriving new knowledge in the course of problem recognition and/or problem solving.
e. Can interact directly with a decision maker or a decision-making participant in such a way that the user has a flexible choice in requesting sequencing of knowledge management activities.
f. Can coordinate/facilitate interactions among multiple participant decision making.

A specific DSS may have extensive characteristics of one type, but may be less extensive for others (e.g., it may do extensive deriving, but allow only modest customization of presentations). Others have listed similar types of characteristics (Marakas, 1999; Turban & Aronson, 1998).

We refer to the foregoing types of decision-support characteristics as knowledge repository (a, b), presentation (c), operation (d), request (e), and coordination (f) characteristics. A list of decision-support characteristics should have one or more entries for each of these five types. To develop such a list we turn to the generic architecture of multiparticipant DSSs, which subsumes architectures for supporting individual decision makers (Holsapple & Whinston, 1996). This architecture is shown in Figure 1.

A multi-participant decision support system's (MDSS) knowledge system can be viewed in terms of a three-fold classification: system knowledge, domain knowledge, and relational knowledge. System knowledge includes knowledge about the roles, relations, and regulations that define the organizational infrastructure of a multiparticipant decision maker. Domain knowledge pertains to the subject matter about which decisions are made. It can include descriptive, procedural, and reasoning knowledge. Relational knowledge is concerned with characterizing users of the MDSS (as distinct from the roles they fill), relations among roles, and activity regulations. These three classes of knowledge suggest three knowledge repository characteristics: repository for identifying/solving domain problems, repository of relational knowledge to facilitate interactions, and repository of system knowledge to facilitate process regulation. As shown in Table 1, these characteristics belong to Levels 2, 1, and 3 respectively.

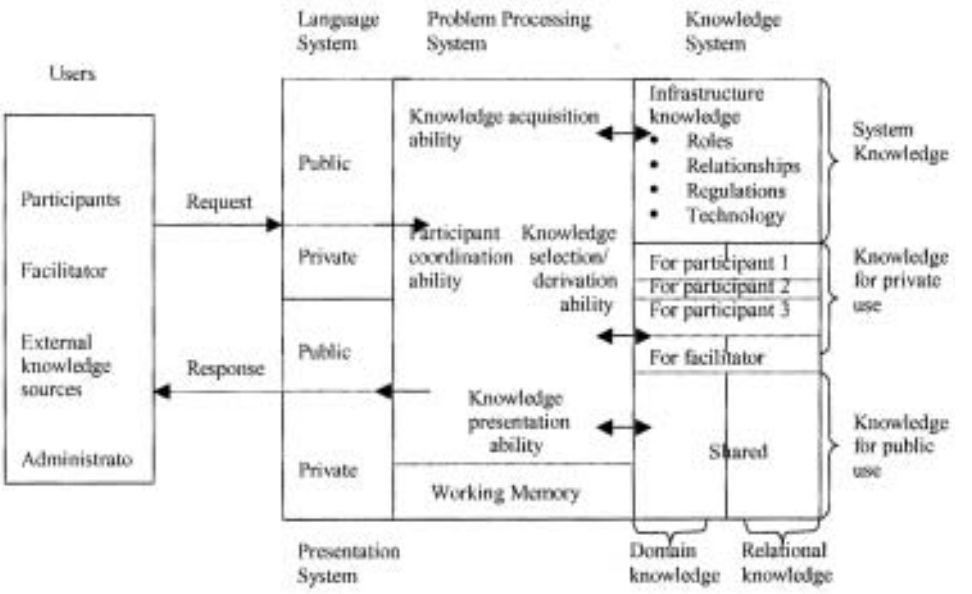

FIGURE 1 Generic multiparticipant decision-support architecture.

The architecture also accommodates both public and private repositories. The former is open to all users for shared access. The latter is under the access control of a specific individual. The public–private distinction yields two more knowledge repository characteristics shown in Table 1. These can belong to any of the characteristic levels, depending on which of the knowledge classes is included.

The architecture's language system is comprised of requests to recall knowledge, acquire knowledge, derive knowledge, clarify prior responses, accept knowledge, route messages, and provide help about using the system. Each can be public or private. In a DSS that allows private messages, selected users are able to make requests in ways that are unknown or off limits to others. Further complicating the possibilities, a DSS can allow some degree of result customization, enabling a user to issue a command or query in a style that suits his or her tastes. The combinations of possible request types, public versus private, and fixed versus customized, yields too many detailed request combinations ($7 \times 2 \times 2$) to practically handle in this exploratory study.

As shown in Table 1, the two request characteristics that we focus on are the availability of mechanisms for issuing customized requests (Level 1) and allowing users flexibility in determining the timing of their requests for domain knowledge (Level 2). Similarly, there are many detailed presentation questions that could be listed based on alternative presentation types: public versus private, fixed versus customized, and so forth. As Table 1 shows, we concentrate on the availability of mechanisms to permit customized presentations that suit users' preferences (Level 1).

Table 1: Decision-Support Characteristics

Type of Characteristic	*Abbreviated Description*	*Characteristic's Survey Item*	*Characteristic Level **
Knowledge repository	Repository to identify/solve problems	Includes a repository of knowledge used to identify and/or solve problems encountered in decision making	2
	Repository to facilitate interactions	Includes a repository of knowledge about decision participants used to facilitate interactions among decision participants	1
	Repository to define, document, regulate actions	Includes a repository of knowledge used to define, document, or regulate the actions of decision participants	3
	Private knowledge repositories	Allows private knowledge repositories, under the access control of individuals	1, 2, 3
	Public, shared repositories	Allows public repositories of organizational knowledge with shared access	1, 2, 3
Request	Customized requests styles	Accepts requests in styles that suit the tastes or needs of decision participants	1
	Flexibility in timing of requests	Gives users flexibility in determining the timing of requests — from spur-of-the-moment to scheduled requests	2
Operation	Knowledge for unanticipated needs	Selects and delivers knowledge to meet unanticipated needs	2
	Derives via calculation, analysis, reasoning	Derives new knowledge via automated calculation, analysis, or reasoning	2
Presentation	Customized result styles	Presents results in formats customized to suit the tastes or needs of decision participants	1
Coordination	Facilitate communication within organization	Provides mechanisms to facilitate communication among decision participants within the organization	1
	Facilitate communication across organizational boundaries	Provides mechanisms to facilitate communication among decision participants across the organization's boundaries	1
	Structure, regulate tasks—individual	Provides mechanisms to structure and regulate tasks performed by an individual decision maker	3
	Structure, regulate tasks—joint	Provides mechanisms to structure and regulate tasks performed by multiple participants jointly making a decision	3
	Structure, regulate tasks—interrelated	Provides mechanisms to structure and regulate the making of interrelated decisions	3
	Structure, regulate tasks—transorganizational	Provides mechanisms to structure and regulate tasks performed in decision making that crosses organizational boundaries	3

* 1 = characteristics to support decision-maker communications; 2 = characteristics to support decision-maker knowledge; 3 = characteristics to support decision-maker processes.

Aside from interacting with a user, the problem processor of an MDSS has two other major abilities: select and/or derive knowledge and perform coordination tasks for participants. The first of these yields the two operation characteristics shown in Table 1. Aside from routine retrievals for standardized reporting, a hallmark of DSSs is the capability to select and deliver knowledge to users to meet their

unforeseen knowledge needs. Another hallmark is the use of solvers or reasoning mechanisms to meet new knowledge needs by deriving what could not be readily selected from a repository. Both operation characteristics belong to Level 2, as they are prime means for coming up with the knowledge needed to reduce uncertainty and noise.

Examples of problem processor coordination abilities include channel control, decision process guidance, information distribution, communication synchronizing, role assignment, incentive management, and learning. These stem largely from the forms of coordination identified by Shaw and Fox (1993), including: adjusting activities to avoid conflicts among participants, synchronizing participant actions, defining a series of steps that participants must follow, providing negotiation mechanisms, providing opportunities for participants to contribute ideas, adjusting participant utilities to control actions, and analyzing constraints of participants.

At a higher level, it appears that coordination abilities involve issues of communicating and regulating. Accordingly, the coordination characteristics in Table 1 involve Level 1 and Level 3 entries. With respect to communication, there may be mechanisms to facilitate knowledge flows among decision makers within an organization's boundaries, and possibly distinct mechanisms to facilitate those flows among participants across organizational boundaries (as in virtual corporations or network organizations). As for regulating tasks that occur within a decision process, possible distinct mechanisms include the structuring of tasks of an individual during the production of a decision, structuring the pattern of tasks performed by multiple participants jointly working to produce a decision, structuring the tasks of participants engaged in making a set or series of interrelated decisions, and regulating the pattern of tasks involved when decision-making participants represent multiple organizations.

Based on the decision-support characteristics developed in Table 1, a concise survey instrument was devised and then pilot-tested by ERP practitioners and scholars, resulting in minor alterations to instructions and item wording. The survey instrument appears in the Appendix. This instrument is comprised of a comprehensive set of decision-support characteristics that can be used to examine the degree of decision-support capabilities of various computer systems. Although this study focuses on the capabilities of ERP systems, the instrument could be employed to examine custom-built systems or other packaged applications such as customer relationship management systems or supply chain management systems.

The extent to which ERP systems furnish the decision-support characteristics identified in Table 1 is largely unknown. Although ERP has not been the subject of a large number of academic studies, it has recently begun to garner considerable interest from academic researchers. Many of the early ERP studies focus on implementation issues and methodologies, key factors for successful adoption, and potential problems that may arise during ERP implementations. Davenport (1998) provided an overview of the ERP market, identifying the reasons for its proliferation, the potential benefits that organizations can achieve, and the problems and expense that accompany ERP adoption. Bingi, Sharma, and Godla (1999) examined several critical issues that organizations face when implementing ERP systems. Scheer and Habermann (2000) examined the use of business models that may en-

hance the success of ERP implementations. Markus, Tannis, and Fenema (2000) analyzed strategies employed in multisite ERP implementations. Soh, Kien, and Tay-Yap (2000) offered an Asian perspective of ERP, suggesting several possible cultural misfits that organizations may encounter when implementing in this region. In terms of empirical research, two consulting studies (Cooke & Peterson, 1998; Deloitte Consulting, 1998) provide insights into the reasons why organizations adopt ERP systems, the benefits they achieve, and the obstacles they face in implementing and using ERP systems. None of this literature specifically addresses the impact of ERP on organizational decision support.

Judging from the descriptions of such systems, there appear to be some decision-support capabilities. Whether these characteristics are widely used, and thus perceived by enterprise system adopters, remains unclear. ERP systems, such as SAP R/3, are designed to streamline back-end business processes (Roberts-Witt, 1999). Although the systems integrate knowledge and provide reporting tools for users to examine and analyze functional data, decision support is not their primary purpose. This is evidenced by the recent development of "business intelligence" products offered by SAP and other ERP vendors to provide decision-support capabilities that, presumably, are not fully developed in the core ERP products.

Although the ERP emphasis had traditionally been on transaction handling, it has been suggested that an enterprise system can also serve to support individual and multiparticipant decision makers (Holsapple & Sena, 1999). If this is the case, then one or more of the characteristics noted in Table 1 should be observed. Moreover, beyond supporting decision makers within an organization, transorganizational decision making may be aided. By providing a common set of tools and data structures, it is plausible that an ERP effort could involve participants from multiple organizations. One of the advantages of adopting a standardized system is the ability to communicate and collaborate with suppliers, business partners, geographic divisions, and other parties.

3. METHODOLOGY AND DEMOGRAPHICS

Potential survey respondents for this study were identified from an ERP web site (ERP World, 2000) that summarized specific implementations and from vendor web sites (e.g., SAP.com) that list selected customers. These sites typically identified organizations that implemented ERP systems but did not identify names or contact information for managers. The American Big Business Directory, a CD-ROM and web-based database, was employed to identify mailing addresses and contact information. This resource identifies selected executives in large American organizations.

The survey was delivered primarily via traditional mail. Excluding those returned to the sender as undeliverable, surveys were mailed to 553 organizations. The 53 responses received yielded a response rate of about 10%. To assess the replicability of our findings, we split our sample into random halves to determine whether mean values are approximately equal across the two subsets. An independent *t* test for equality of means reveals no significant differences in mean val-

ues for any of the 32 items in the two split groups. This method is based on recommendations by Pedhazur (1982) for assessing sample validity.

Respondents to the survey are high-level managers from information systems (IS) or from functional business units involved in the ERP implementation. Respondent job titles include chief information officer (CIO), IS director, chief financial officer (CFO), human resources manager, and others. Respondents have been with their current organizations for a median of 8 years and have a median of 5 years of experience with enterprise systems.

ERP surveys suggest that organizations may need at least several months before they begin to realize expected benefits from their ERP implementations (Cooke & Peterson, 1998; Deloitte Consulting, 1998). In this study, 28% of organizations have "gone live" with the majority of their modules more than 3 years ago, 51% had implemented them 1 to 3 years ago, and 17% had implemented them 6 months to 1 year ago.

Respondents were sought for each of the following ERP vendors: SAP, Peoplesoft, Oracle Applications, and J. D. Edwards. SAP is the current market leader in this industry with approximately one third of the market share. The other vendors' market shares range from 4% to 14%. The primary business activity of respondent organizations is spread widely across various industries, none accounting for greater than 25% of responses. The most common industries were high technology, automotive, and consumer products. Respondent demographics are summarized in Table 2.

Table 2: Respondent Demographics

Business activity of respondent organizations	
High technology	23%
Automotive	9%
Consumer products	8%
Retail	8%
Other/not specified	52%
Respondent functional area	
Information systems	51%
Business function	32%
Other/not specified	17%
Years of experience/employment	
Median years with organization	8.0
Median years using enterprise systems	5.0
Primary enterprise system vendor	
SAP	38%
Peoplesoft	24%
Oracle Applications	15%
J. D. Edwards	11%
Other/not specified	12%
Years since enterprise resource planning implemented ("live")	
6 months to 1 year	17%
1 to 3 years	51%
More than 3 years	28%
Not specified	4%

4. EXISTENCE OF DECISION-SUPPORT CHARACTERISTICS IN ERP SYSTEMS

As shown in Table 3, adopters of ERP systems do perceive appreciable levels of decision-support characteristics in their systems. Most of the items are perceived at an extent near the midpoint (moderate) of the survey scale. Highest rated, with a mean of 4.27 (on a 7-point scale) is the item about furnishing a knowledge repository for problem solving. This is consistent with one of the major selling points of ERP—its centralized, integrated database that contains information that may previously have been fragmented or distributed around the organization (Davenport, 1998).

Although integration, a key feature of ERP systems, can foster communication within an organization, little has been written about ERP's ability to improve communication. However, respondents see mechanisms that facilitate such communication as the second most extensive of an ERP's decision-support characteristics (M = 4.19). Mechanisms that facilitate communication across organization boundaries (M = 4.02) are also viewed as moderately extensive. Third highest (M = 4.14) is the

Table 3: Perceived Extent of Decision-Support Characteristics Provided by Enterprise Resource Planning Systems

Characteristic	*Extent*[a]	*SD*
Includes a repository of knowledge used to identify and/or solve problems encountered in decision making	4.27	1.99
Provides mechanisms to facilitate communication among decision participants within the organization	4.19	1.73
Allows public repositories of organizational knowledge with shared access	4.14	1.91
Provides mechanisms to structure and regulate tasks performed by an individual decision maker	4.13	1.66
Gives users flexibility in determining the timing of requests—from spur-of-the-moment to scheduled requests	4.04	1.45
Provides mechanisms to facilitate communication among decision participants across the organization's boundaries	4.02	1.81
Provides mechanisms to structure and regulate tasks performed by multiple participants jointly making a decision	3.88	1.81
Provides mechanisms to structure and regulate the making of interrelated decisions	3.77	1.90
Provides mechanisms to structure and regulate tasks performed in decision making that crosses organizational boundaries	3.73	1.92
Presents results in formats customized to suit the tastes or needs of decision participants	3.62	2.08
Derives new knowledge via automated calculation, analysis, or reasoning	3.54	2.14
Includes a repository of knowledge about decision participants used to facilitate interactions among decision participants	3.48	1.90
Includes a repository of knowledge used to define, document, or regulate the actions of decision participants	3.38	1.72
Selects and delivers knowledge to meet unanticipated needs	3.33	1.74
Accepts requests in styles that suit the tastes or needs of decision participants	3.27	1.81
Allows private knowledge repositories under the access control of individuals	3.14	1.85
Mean of characteristics	3.74	1.84

[a]Measured using a Likert-type scale ranging from 1 (*very extensive*) to 7 (*not at all*), with a midpoint labeled *moderate degree*.

ability of ERP systems to provide shared, common access to these repositories of knowledge. On the other hand, the ability to utilize private, controlled repositories ($M = 3.14$) is seen as being the least extensive decision-support characteristic.

Mechanisms for structuring and regulating decision tasks rank near the middle of the list as being moderately evident in ERP systems. This appears to reflect the regimen that an ERP system imposes on an organization, even though it stops well short of dictating how decisions are made. Respondents tend to perceive more extensive support for simple arrangements than for complex relations. Mechanisms for coordinating the tasks of an individual decision maker ($M = 4.13$) are viewed as more extensive than those for a decision task performed jointly by multiple participants ($M = 3.88$), those for interrelated decision tasks ($M = 3.77$), and those for decision making that crosses organizational boundaries ($M = 3.73$).

With the exception of flexibility in the timing of requests, with a mean of 4.03, all other characteristics related to problem processing, customizing requests, or presentations contain mean values below the midpoint of the survey scale. Customized request styles and the ability to meet unanticipated knowledge needs ranked near the bottom of the characteristics list with mean values of 3.33 and 3.27, respectively. These results, along with the other values indicated in Table 3, provide some support for opinions that ERP systems are not considered to be particularly user-friendly or flexible.

Overall, the results summarized in Table 3 indicate that ERP systems are perceived as exhibiting decision-support characteristics to a moderate extent. Although none of the characteristics is seen as nonexistent, none is seen as very extensive or especially prominent. This suggests that there is considerable opportunity for enhancing future ERP offerings to furnish more extensive decision-support characteristics, with the greatest room for extension lying with those characteristics near the bottom of Table 3. However, this opportunity has value and should be pursued only if it is important for ERP systems to exhibit these characteristics.

5. IMPORTANCE OF DECISION-SUPPORT CHARACTERISTICS IN ERP SYSTEMS

Although it is interesting to note the extent to which ERP adopters perceive various decision-support characteristics, this information is more useful when viewed in the context of how important it is that these characteristics be present in an ERP system. Some characteristics could be very prominent but judged to be of little importance; conversely, a characteristic that is not so prominent could be deemed very important. The results depicted in Table 4 show that decision-support characteristics are considered quite important by respondents. With the exception of one item, every decision-support characteristic received a mean importance above the midpoint (4) of the survey scale.

The characteristics in Table 4 are ordered from the greatest to least discrepancy between importance and perceived extent. The three items (and four of the top five) with the largest disparity relate to the system's flexibility, suggesting that there is a substantial need for ERP vendors and adopters to enhance their sys-

Table 4: Perceived Importance Versus Extent of Decision-Support Characteristics

Characteristic	*Extent*[a]	*Importance*[b]
Selects and delivers knowledge to meet unanticipated needs	3.33	5.08
Presents results in formats customized to suit the tastes or needs of decision participants	3.62	5.02
Derives new knowledge via automated calculation, analysis, or reasoning	3.54	4.67
Provides mechanisms to facilitate communication among decision participants across the organization's boundaries	4.02	5.13
Accepts requests in styles that suit the tastes or needs of decision participants	3.27	4.32
Provides mechanisms to structure and regulate the making of interrelated decisions	3.77	4.75
Provides mechanisms to structure and regulate tasks performed in decision making that crosses organizational boundaries	3.73	4.71
Includes a repository of knowledge used to define, document, or regulate the actions of decision participants	3.38	4.35
Includes a repository of knowledge about decision participants used to facilitate interactions among decision participants	3.48	4.44
Includes a repository of knowledge used to identify and/or solve problems encountered in decision making	4.27	5.19
Provides mechanisms to facilitate communication among decision participants within the organization	4.19	5.06
Gives users flexibility in determining the timing of requests—from spur-of-the-moment to scheduled requests	4.04	4.90
Provides mechanisms to structure and regulate tasks performed by multiple participants jointly making a decision	3.88	4.69
Allows public repositories of organizational knowledge with shared access	4.14	4.88
Provides mechanisms to structure and regulate tasks performed by an individual decision maker	4.13	4.62
Allows private knowledge repositories under the access control of individuals	3.14	3.58
Mean of characteristics	3.74	4.71

[a]Measured using a Likert-type scale ranging from 1 (*very extensive*) to 7 (*not at all*) with a midpoint labeled *moderate degree*.

[b]Measured using a Likert-type scale ranging from 1 (*very important*) to 7 (*not at all important*) with a midpoint labeled *moderately important*.

tems' abilities to satisfy unanticipated knowledge needs, enable customized requests and presentations, and go beyond retrieval by also deriving new knowledge in various ways.

Table 4 also identifies the relative importance of characteristics related to transorganizational decision support. Mechanisms to facilitate communication with decision participants across organizational boundaries is rated as the second most important characteristic. This result is particularly notable given the emerging trend of using an ERP system as a basis for connecting with stakeholders outside of the organization (e.g., suppliers, customers, stockholders). Coordinating decision tasks with others is also considered an important and underdeveloped characteristic of ERP systems. Considerable discrepancies exist between the importance and perceived extent of mechanisms to structure and regulate tasks for interrelated and transorganizational decision making.

Items with more modest differences between importance and extent include mechanisms to aid in the coordination of an individual's decision tasks and support for public and private knowledge repositories. In the case of private repositories, the characteristic is considered relatively unimportant (M = 3.58), whereas public repositories and individual coordination mechanisms are given higher importance (M = 4.88 and 4.62) but are perceived as being provided to a moderate extent (M = 4.13 and 4.14).

The results of the final column of Table 4 clearly show that ERP adopters consider DSS characteristics to be important for ERP systems, even though the ERP emphasis to date has been on transaction handling and record keeping. Because decision-support characteristics are "only" moderately evident in today's enterprise systems, there appears to be opportunity and need for enhancing their presence in future ERP offerings. However, this may be more pronounced for some ERP adopters than for others. Thus, we explore perceptions of decision-support characteristics within various demographic groups. The comparisons that follow, although not conclusive or definitive, can be used to identify possible directions for future studies related to this topic.

6. PERCEPTIONS OF CHARACTERISTICS AMONG DEMOGRAPHIC GROUPS

6.1. Length of Time From Implementation Date

Deloitte Consulting (1998) conducted an empirical study of 62 organizations that examined the link between time and organizational performance following an ERP implementation. The study identifies three distinct stages that organizations encounter. After going live, organizations experience a dip in performance as they "stabilize." Following this period, organizations tend to "synthesize," realizing additional effectiveness "from the better decision-making capabilities afforded by ERP." Finally, firms that are able to enter Stage 3 "synergize" around their ERP systems and are able to transform their system's usage into business strategies. Other studies (Cooke & Peterson, 1998; META Group, 1999) also recognized the relation between time and return on investment or realization of benefits.

In line with the time frames suggested by the Deloitte study, respondent implementations fell into three groups: 6 months to 1 year, 1 year to 3 years, and more than 3 years. Table 5 shows means of perceived extent and importance of decision-support characteristics within each of these time frames. Respondents with the most recent implementations did not perceive any of the 16 characteristics as existing at moderate or higher level (i.e., $M > 4$). In particular, the two mean values for characteristics related to facilitating communication were significantly lower (at $p \leq .05$) than those for organizations with older implementations. However, respondents with newer implementations viewed all characteristics as being at least moderately important, with two having mean importance of at least 5: selection/delivery of knowledge for unanticipated needs and provision of a knowledge repository to identify/solve problems.

Table 5: Perceptions of Decision-Support Characteristics by Time Since Implementation

	6 Months–1 Year		*1 Year–3 Years*		*More than 3 Years*	
Characteristic	*Extent*[a]	*Importance*[b]	*Extent*[a]	*Importance*[b]	*Extent*[a]	*Importance*[b]
Repository to identify/solve problems	3.56	5.00	4.31	5.37	4.21	5.00
Repository to facilitate interactions	2.89	4.33	3.46	4.44	3.50	4.57
Repository to define, document, regulate actions	3.11	4.56	3.33	4.22	3.38	4.43
Private knowledge repositories	2.89	4.00	3.31	3.19	3.46	4.08
Public, shared repositories	3.56	4.67	4.77	4.96	4.00	5.00
Customized request styles	2.89	4.44	3.46	4.50	3.31	4.08
Flexibility in timing of requests	3.75	4.88	3.69	4.96	4.50	4.86
Selects/delivers for unanticipated needs	2.78	5.22	3.38	5.04	3.71	5.07
Derives via calculation, analysis, reasoning	3.11	4.89	3.54	4.63	3.79	4.43
Customized result styles	3.33	4.67	4.38	5.22	3.64	4.93
Facilitate communication within organization	3.00[c]	4.56	4.31	5.22	4.21	4.93
Facilitate communication across organizational boundaries	2.89[c]	4.33	4.00	5.30	4.00	5.14
Structure, regulate tasks—individual	3.33	4.67	3.92	4.67	4.00	4.43
Structure, regulate tasks—joint	3.33	4.56	3.58	4.70	3.77	4.71
Structure, regulate tasks—interrelated	3.33	4.44	3.62	4.89	3.86	4.64
Structure, regulate tasks—transorganizational	3.44	4.33	3.38	4.70	3.86	4.86
Mean of characteristics	3.20	4.60	3.78	4.75	3.83	4.70

[a]Measured using a Likert-type scale ranging from 1 (*very extensive*) to 7 (*not at all*) with a midpoint labeled *moderate degree*.

[b]Measured using a Likert-type scale ranging from 1 (*very important*) to 7 (*not at all important*) with a midpoint labeled *moderately important*.

[c]Differences between this group and other two groups are statistically significant at $p \leq .05$.

Respondents whose implementations were effected 1 to 3 years previously perceived five characteristics as existing at a moderate or higher level: provision of a public knowledge repository, usability of this repository for problem solving/finding, accommodation of customized styles for result presentations, and provisions of mechanisms to support communication both within and across organizational boundaries. These respondents view all but one of the decision-support characteristics (i.e., allowing private knowledge repositories) as being at least moderately important, with five having mean importance above 5: provision of a knowledge repository for finding/solving problems, of mechanisms to facilitate communication within and across organizational boundaries, of customized result presentations, and facilities to select/deliver knowledge to meet unanticipated needs.

Largely in agreement, respondents with the greatest elapsed time since "going live" rate all decision-support characteristics as at least moderately important. This group perceives six of the characteristics as existing at least to a moderate extent: provision of means for flexible request timing, of a knowledge repository that is both public and useful for identifying/solving problems, of mechanisms that facilitate communication both within and across organizational boundaries, and of mechanisms to structure/regulate an individual decision maker's tasks.

It is interesting that, overall, the level of importance given to decision-support characteristics does not vary substantially based on the length of time from the implementation date. Regardless of which stage they are in, respondents share the view that the presence of these characteristics is solidly above the level of moderate importance (means of 4.6 vs. 4.7 vs. 4.7). However, for some individual characteristics, there are disagreements among the stages' respondents about importance level. For instance, early- and late-stage respondents assert that private knowledge repositories are of moderate importance (M = 4.00 and 4.08) whereas middle-stage respondents clearly disagree (M = 3.19). Newer adopters did not view communication across organizations to be as important (M = 4.33) as those with older implementations (M = 5.30 and 5.14). For older implementations, the greatest needs for improvement appear to be ability to meet unanticipated needs and support for transorganizational communication. This same trend holds for the characteristic of mechanisms to facilitate communication within an organization, although it is milder in degree.

As expected, based on the Deloitte study, the perceived extent of decision-support characteristics does seem to be impacted by time. In particular, respondents with newer implementations (those less than 1 year old) tend to recognize less extensive characteristics than those with older implementations. However, the trend is much less pronounced after the first year. Overall, the extent of characteristics recognized by late-stage respondents is only slightly greater than for those in the middle stage.

Examining individual characteristics across the stages reveals some interesting insights. For instance, the characteristic of providing flexibility in timing requests is perceived much more strongly by late-stage adopters than it is by those in the early or middle stage. In contrast, provision of customized result styles is a characteristic that middle-stage respondents perceive as more extensive than either of their early or late-stage counterparts. Early-stage respondents perceive little in the way of mechanisms for structuring/regulating individual decision tasks relative to the middle- and late-stage respondents. This particular pattern of perceptions is most striking for the two communication characteristics of DSSs—within and across organizational boundaries. For newer implementations, substantial gaps between importance and perceived extent exist for the ability to support unanticipated knowledge needs (M = 5.22 vs. 2.78) and deriving new knowledge via calculation, analysis, or reasoning (M = 4.89 vs. 3.11). Such a pattern suggests that early-stage adopters may be well advised to deliberately seek and exploit relatively overlooked characteristics; doing so may yield greater or faster benefits from ERP implementations.

6.2. Vendors

Various reports have reviewed the relative advantages of various ERP vendors. Hecht (1997) reported on Gartner Group's rating of ERP vendor performance in terms of two contrasting dimensions: technical architecture versus functionality and manufacturing functionality versus accounting functionality. More detailed comparisons of ERP vendors are available from Meta Group (1999). Although many anecdotes can be gleaned from consultants and ERP system users, no study provides evidence to suggest that major differences do or do not exist in decision-support characteristics of software offered by the major vendors.

As shown in Table 6, the overall means of perceptions for both existence and importance of decision-support characteristics are practically identical for adopters of SAP and Oracle enterprise software. On average, Peoplesoft ERP adopters detect the highest extent of decision-support characteristics, while attaching the least importance to them (although still above the moderate importance level). Perhaps being more accustomed to a higher extent of decision support leads these respondents to take the characteristics for granted; or it may be that the audience to which Peoplesoft markets differs in its decision-support expectations from those of other major vendors. The opposite situation occurs for J. D. Edwards software. On average, they perceive the least extensive decision-support characteristics, but place the greatest importance of these characteristics ($M = 5.23$). Perhaps by attributing more importance to these characteristics, respondents are more demanding in their assessment of the degree to which they exist; or this result may be indicative of a distinct market segment served by the vendor.

Although the relatively small sample sizes in this study do not enable conclusive judgments about vendor differences, variations for individual characteristics are apparent in Table 6, suggesting areas that deserve further investigation. For example, substantial differences in importance and extent for SAP, the leading ERP vendor, exist for the characteristics that involve meeting unanticipated needs ($M = 5.05$ vs. 2.95) and providing for customized request styles ($M = 4.95$ vs. 3.32). Oracle Application respondents also perceive large gaps in these items. Peoplesoft adopters place less importance on each of the communication and coordination characteristics than any other class of respondents. J. D. Edwards adopters, on the other hand, place greater importance on these decision-support characteristics than other respondents. Large disparities exist between importance and perceived extent in several areas (e.g., J. D. Edwards respondents' views of the derivation characteristic: 2.5 vs. 5.5). More extensive research is necessary to confirm, dispute, or further investigate such differences. These results may help adopters to make better ERP software selections and help vendors in marketing and development efforts.

6.3. Job Function

The Deloitte Consulting (1998) study measured differences in perceptions based on whether participants were users, implementers, or executives in companies using

Table 6: Perceptions of Decision-Support Characteristics by Vendor

	SAP		*Peoplesoft*		*Oracle Applications*		*J.D. Edwards*	
Characteristic	*Extent*[a]	*Importance*[b]	*Extent*[a]	*Importance*[b]	*Extent*[a]	*Importance*[b]	*Extent*[a]	*Importance*[b]
Repository to identify/solve problems	4.37	5.26	4.31	4.77	4.00	5.38	3.50	5.00
Repository to facilitate interactions	3.42	4.42	3.46	4.62	3.63	3.75	2.50	4.50
Repository to define, document, regulate actions	3.42	4.42	3.33	4.00	3.29	4.14	3.00	4.67
Private knowledge repositories	3.06	3.76	3.31	2.92	2.50	3.13	2.50	3.50
Public, shared repositories	3.83	4.72	4.77	4.15	3.88	5.88	3.33	5.50
Customized request styles	3.00	4.18	3.46	4.46	2.88	4.50	3.50	4.50
Flexibility in timing of requests	3.79	5.00	3.69	4.54	4.25	5.25	4.83	5.00
Selects/delivers for unanticipated needs	2.95	5.05	3.38	4.54	3.29	5.00	3.83	5.67
Derives via calculation, analysis, reasoning	3.58	4.53	3.54	4.08	3.38	4.88	2.50	5.50
Customized result styles	3.32	4.95	4.38	5.00	3.00	4.88	3.00	5.33
Facilitate communication within organization	4.26	4.89	4.31	4.54	4.13	5.25	4.00	6.17
Facilitate communication across organizational boundaries	4.00	5.00	4.00	4.69	4.63	5.50	3.50	6.17
Structure, regulate tasks—individual	4.11	4.74	3.92	4.15	4.25	4.50	3.67	5.17
Structure, regulate tasks—joint	3.84	4.79	3.58	4.15	4.25	4.50	3.67	5.50
Structure, regulate tasks—interrelated	3.79	4.95	3.62	4.23	3.75	4.50	3.33	5.67
Structure, regulate tasks—transorganizational	3.84	4.79	3.38	4.15	3.75	4.63	3.17	5.83
Mean of characteristics	3.66	4.72	3.78	4.31	3.68	4.73	3.36	5.23

[a]Measured using a Likert-type scale ranging from 1 (*very extensive*) to 7 (*not at all*) with a midpoint labeled *moderate degree*.
[b]Measured using a Likert-type scale ranging from 1 (*very important*) to 7 (*not at all important*) with a midpoint labeled *moderately important*.

ERP. Respondents in our study are categorized according to their job titles into two groups: IS managers (e.g., CIO, IS Director) and managers of other business functions (e.g., CFO, Human Resources Manager).

As depicted in Table 7, striking differences exist between the perceptions of these two groups. For each of the 16 decision-support characteristics, respondents from functional areas outside of IS place a greater level of importance on decision-support characteristics than do those from the IS area, often by a wide margin. Seven of these differences are statistically significant (at $p \leq .05$). Overall, the IS respondents see the characteristics as more than moderately important (average of means = 4.56), but the non-IS respondents assess the importance of all but two of the characteristics as being greater than 5 (average of means = 5.32). Perhaps the functional managers are more attuned to the needs for supporting decision making within their own functional domains.

Regarding the existence of decision-support characteristics, there is little difference in overall perceptions of the two groups; the averages of the means across the characteristics are approximately equal (3.80 vs. 3.88). Each group rates seven of the characteristics as at least moderately extensive (above 4). In terms of individual characteristics, IS respondents tend to perceive more extensiveness in the characteristics concerning task coordination, public repositories, and repositories for identifica-

Table 7: Perceptions of Decision-Support Characteristics by Job Title: Information Systems (IS) Versus Non-Information Systems (Non-IS)

	IS		*Non-IS*	
Characteristic	*Extent*[a]	*Importance*[b]	*Extent*[a]	*Importance*[b]
Repository to identify/solve problems	4.46	5.15	4.18	5.71
Repository to facilitate interactions	3.57	4.08[c]	3.64	5.18
Repository to define, document, regulate actions	3.32	4.00	3.53	5.06
Private knowledge repositories	3.19	3.50[c]	3.50	4.75
Public, shared repositories	4.30	5.03	4.19	5.19
Customized requests styles	3.15	4.26	3.69	4.50
Flexibility in timing of requests	4.08	4.52[c]	4.17	5.53
Selects/delivers for unanticipated needs	3.40	5.00	3.59	5.47
Derives via calculation, analysis, reasoning	3.58	4.81	4.00	5.24
Customized result styles	3.38	4.73	3.94	5.41
Facilitate communication within organization	4.15	4.92	4.23	5.76
Facilitate communication across organizational boundaries	4.12	5.08	4.12	5.82
Structure, regulate tasks—individual	4.23	4.31[c]	4.12	5.18
Structure, regulate tasks—joint	4.00	4.50[c]	3.94	5.29
Structure, regulate tasks—interrelated	3.88	4.50[c]	3.38	5.65
Structure, regulate tasks—transorganizational	3.96	4.58[c]	3.88	5.41
Mean of Characteristics	3.80	4.56	3.88	5.32

[a]Measured using a Likert-type scale ranging from 1 (*very extensive*) to 7 (*not at all*) with a midpoint labeled *moderate degree*.

[b]Measured using a Likert-type scale ranging from 1 (*very important*) to 7 (*not at all*) with a midpoint labeled *moderate degree*.

[c]Indicates that differences between groups are statistically significant (at $p \leq .05$).

tion/solution of problems than do non-IS respondents. The latter tend to recognize comparable or greater extent in the other characteristics than do the IS respondents.

Interestingly, the disparities between perceptions of importance and extent are nearly twice as large for respondents outside IS. In particular, these respondents report substantial levels of importance for facilitating communication—both across organizations (M = 5.82) and within an organization (M = 5.76). They also place much greater importance on coordination. Structuring and regulation of tasks related to interrelated decision making is given a mean importance level of 5.65, whereas its perceived extent earns a mean of only 3.38. These results in Table 7 may have implications for ERP postimplementation reviews and enhancement projects, as well as for vendors' marketing strategies.

7. CONCLUSIONS

Given the increased dependence that organizations have on ERP systems, it is important for researchers to examine the impacts that these systems have upon their adopters. Among the most important of these is the impact that ERP systems have on organizational decision making. This study is an initial exploration of this issue in terms of the existence and importance of decision-support characteristics. The results offer practical insights into the current state of ERP related to decision-support characteristics.

This research establishes that ERP adopters currently perceive a moderate level (M = 3.73 on a 7-point scale) of decision-support characteristics. It also finds that adopters believe that it is substantially important (M = 4.71) for ERP systems to provide decision-support characteristics. At a more detailed level, this study identifies the extent to which adopters perceive the presence of 16 decision-support characteristics. These results identify particular characteristics that are viewed as being moderately extensive (e.g., providing a repository of knowledge for identifying/solving problems with M = 4.27) and those viewed as being less extensive (e.g., providing private knowledge repositories with M = 3.14). Similarly, we report the level of importance that adopters place on these individual characteristics showing, for example, the high level of importance (M = 5.06) that adopters place on mechanisms that support communication within an organization. Jointly, the extent and importance of these characteristics identifies areas in which adopters and vendors may be able to make substantial improvements in the levels of satisfaction among decision-support users. For example, by establishing the relatively high importance (M = 5.08) and low perception (M = 3.33) of the characteristic related to meeting unanticipated knowledge needs, adopters and vendors can focus on this area in future projects and software offerings.

We also identify differences in the perceptions surrounding these characteristics among different demographic groups. These results confirm that organizations that implemented ERP systems more than 1 year ago tend to perceive a greater extent of decision-support characteristics (M = 3.78 for organizations that "went live" 1 to 3 years ago and 3.83 for those that went live more than 3 years ago) than those with newer implementations (M = 3.20 for organizations live 6 months to 1 year).

The level of importance, however, does not vary widely among these groups. We also gauge differences in vendors on these points. These results identify modest differences, both in perceptions of importance and extent, among adopters of different vendors. For example, Peoplesoft adopters perceive a slightly greater extent of decision-support characteristics than do SAP adopters (M = 3.78 vs. 3.66). SAP adopters, conversely, view such characteristics as being more important (M = 4.72 vs. 4.31). Finally, we examined differences in perceptions between IS professionals (e.g., CIOs, IS directors) and those from other functional areas (e.g., CFOs, HR managers). This investigation suggests that non-IS managers view decision-support characteristics as being appreciably more important (M = 5.32 vs. 4.56) than do IS managers. It also establishes that these two groups view the extent of such characteristics at an approximately equal level (M = 3.88 vs. 3.80).

Although this study makes substantial contributions toward an understanding of the decision-support capabilities of ERP systems, many questions remain unanswered. Although this study establishes preliminary differences in perceptions of decision-support characteristics among different groups, larger sample sizes for these groups would allow more conclusive comparisons to be made. Further research could combine the findings in this study with other ERP literature to explore related topics. For example, future research could explore the decision-support perceptions of Asian ERP implementations by examining these findings along with those of Soh et al.'s (2000) study of possible cultural misfits. Another study could examine the findings from this study in conjunction with Li's (1999) study that identifies the importance of collecting and analyzing external information in ERP systems. Finally, additional decision-support facets of ERP could be examined by using the empirical findings of Cooke and Peterson (1998) and Deloitte Consulting (1998) as a foundation for research on the objectives, benefits, limitations, and success of ERP systems in terms of decision support.

This exploratory study establishes decision-support markers in the territory of enterprise systems. These markers furnish benchmarks and guidance for ERP adopters, vendors, educators, and researchers. Further investigation is needed to better understand the relation between important ERP characteristics and related variables such as the achievement of decision-support benefits and the overall success of ERP implementations. Other studies could also focus on establishing factors that contribute to an organization's success in using ERP for decision support. These lines of research can lead to the establishment of best decision-support practices for an ERP platform, identifying ways to leverage ERP investment into better decision-support capabilities.

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APPENDIX: SURVEY INSTRUMENT

Instruction

The objective of this study is to examine the relation between enterprise resourcee planning (ERP) and decision support. A decision-support system is a computer-based system that assists human decision makers in one or more of the following ways: recognizing decision opportunities, developing decision alternatives, choosing among alternatives, or executing the decision. In several places in the survey, you are asked to distinguish between four different types of decision support. Descriptions of these four types of decision support appear next.

1) Support for individual decision making: This is a situation where the system uses and provides knowledge resources (e.g., information, procedures, rules) to support activities conducted by an individual making a decision.

2) Support for joint decision making: This is a situation where the system supports multiple persons jointly contributing to a decision. It does one or more of the following: provides knowledge resources, gives mechanisms to facilitate communication among participants, or furnishes mechanisms to coordinate their activities.

3) Support for interrelated decision making: This is a situation where the system facilitates knowledge flows between one decision and another, structures or regulates decision activities, and analyzes the impact of interrelated decisions.

4) Support for interorganizational decision making: This is a situation where the system uses and furnishes knowledge, facilitates knowledge flows between organizations, and coordinates interactions of decision participants.

The survey asks several questions about enterprise system characteristics. Please answer these questions as they pertain to your organization's overall experience with your ERP system(s) (e.g., SAP, Peoplesoft, Baan, Oracle Applications, J.D. Edwards).

Once again, all answers provided are completely confidential. The study is being conducted strictly for research purposes. Your information will not be provided to vendors, consultants, or other third parties. A summary of results will be provided to you upon request. If you would like to receive these results, please provide an e-mail address in the space below. We will use this address only to provide you with the results. Thank you very much for your support.

For the following items, please mark one box in each row.

In your organization, how important is it that an enterprise system exhibits the following characteristics:	*Not at All Important* 1	2	3	*Moderately Important* 4	5	6	*Extremely Important* 7
Includes a repository of knowledge used to identify and/or solve problems encountered in decision making	☐	☐	☐	☐	☐	☐	☐
Includes a repository of knowledge about decision participants used to facilitate interactions among decision participants	☐	☐	☐	☐	☐	☐	☐
Includes a repository of knowledge used to define, document, or regulate the actions of decision participants	☐	☐	☐	☐	☐	☐	☐
Allows private knowledge repositories under the access control of individuals	☐	☐	☐	☐	☐	☐	☐
Allows public repositories of organizational knowledge with shared access	☐	☐	☐	☐	☐	☐	☐
Accepts requests in styles that suit the tastes or needs of decision participants	☐	☐	☐	☐	☐	☐	☐
Gives users flexibility in determining the timing of requests—from spur-of-the-moment to scheduled requests.	☐	☐	☐	☐	☐	☐	☐
Selects and delivers knowledge to meet unanticipated needs	☐	☐	☐	☐	☐	☐	☐
Derives new knowledge via automated calculation, analysis, or reasoning	☐	☐	☐	☐	☐	☐	☐
Presents results in formats customized to suit the tastes or needs of decision participants	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to facilitate communication among decision participants within the organization	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to facilitate communication among decision participants across the organization's boundaries	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to structure and regulate tasks performed by an individual decision maker	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to structure and regulate tasks performed by multiple participants jointly making a decision	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to structure and regulate the making of interrelated decisions	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to structure and regulate tasks performed in decision making that crosses organizational boundaries	☐	☐	☐	☐	☐	☐	☐

For the following items, please mark one box in each row.

To what degree does your enterprise system exhibit the following characteristics:	*Not at All* 1	2	3	*Moderate Degree* 4	5	6	*Very Extensive* 7
Includes a repository of knowledge used to identify and/or solve problems encountered in decision making	☐	☐	☐	☐	☐	☐	☐
Includes a repository of knowledge about decision participants used to facilitate interactions among decision participants	☐	☐	☐	☐	☐	☐	☐
Includes a repository of knowledge used to define, document, or regulate the actions of decision participants	☐	☐	☐	☐	☐	☐	☐
Allows private knowledge repositorie, under the access control of individuals	☐	☐	☐	☐	☐	☐	☐
Allows public repositories of organizational knowledge with shared access	☐	☐	☐	☐	☐	☐	☐
Accepts requests in styles that suit the tastes or needs of decision participants	☐	☐	☐	☐	☐	☐	☐
Gives users flexibility in determining the timing of requests—from spur-of-the-moment to scheduled requests	☐	☐	☐	☐	☐	☐	☐
Selects and delivers knowledge to meet unanticipated needs	☐	☐	☐	☐	☐	☐	☐
Derives new knowledge via automated calculation, analysis, or reasoning	☐	☐	☐	☐	☐	☐	☐
Presents results in formats customized to suit the tastes or needs of decision participants	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to facilitate communication among decision participants within the organization	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to facilitate communication among decision participants across the organization's boundaries	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to structure and regulate tasks performed by an individual decision maker	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to structure and regulate tasks performed by multiple participants jointly making a decision	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to structure and regulate the making of interrelated decisions	☐	☐	☐	☐	☐	☐	☐
Provides mechanisms to structure and regulate tasks performed in decision making that crosses organizational boundaries	☐	☐	☐	☐	☐	☐	☐