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Michael J. Zhang
Sacred Heart University, zhangm@sacredheart.edu

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Information Systems (IS) Connectivity as a Moderator of the Effects of IS Support for Information Interpretation on Firm Performance: An Empirical Study

Michael J. Zhang
Sacred Heart University

This study examined and tested the roles of information systems (IS) connectivity in influencing the performance impacts of IS support for information sharing and IS support for information interpretation. Using data collected from a survey of large U.S. firms and the Research Insight (Compustat) database, the results showed that when IS connectivity was high, IS support for information sharing was positively related to profitability whereas IS support for information interpretation was negatively associated with profitability. These findings suggest that a high level of IS connectivity is a two-end sword for firms which rely on both IS support for information sharing and IS support for information interpretation for competitive advantage. On one hand, a high level of IS connectivity enabled a firm to reap economic benefits from IS support for information sharing. On the other hand, a high level of IS connectivity hindered the firm's ability to obtain superior performance from IS support for information interpretation.

Introduction

Today, as more and more firms (especially those with large and complex IS infrastructures) develop and deploy a variety of disparate information systems (IS) to support different business activities and processes (March et al., 2000), there has been increasing emphasis on the connectivity or compatibility among different IS (Roth et al., 2002; Sharif et al., 2004). How does IS connectivity affect a firm's ability to use IS to generate and utilize valuable information and knowledge for competitive advantage and superior firm performance? This is the research issue that this study attempted to address. Specifically, the study sought to explore the potential moderating effects of IS connectivity on the performance impacts of IS support for information sharing and IS support for information interpretation. Here, IS connectivity refers to the ease at which different IS within a firm communicate and share information with one another without human intervention (Laudon & Laudon, 2002). While prior research has shown that IS support for information sharing and IS support for information interpretation are vital to a firm's ability to develop and utilize information and knowledge for performance improvements (Vandenbosch & Higgins, 1995; Goodman & Darr, 1998; Andersen & Segars, 2001), the potential influence of IS connectivity on the performance of such IS support has received scant attention in the extant literature. Further, in view of the growing recognition that a firm's internal contexts may affect the effectiveness of IS deployment (Goodman & Darr, 1998), discerning the potential moderating effects of IS connectivity would advance our understanding of the internal conditions under which IS support for information sharing and IS support for information interpretation may generate competitive advantage and superior firm performance.

The rest of the paper proceeds as follows. The next section begins with a discussion of the strategic roles of information sharing and information interpretation, followed by a review of research on IS support for information sharing and IS support for information interpretation. The potential moderating effects of IS connectivity on the performance impacts of these two types of IS support are then examined. Based on this discussion, the research hypotheses are developed for the empirical testing. The third section describes the research methodology and presents the findings. The last section discusses the implications of the research findings, the limitations of the study, and suggestions for future research and practice.

Literature Review and Hypotheses Development

The Strategic Roles of Information Sharing and Information Interpretation

It is well recognized in the literatures of knowledge management and organizational learning that information sharing and information interpretation influence a firm's ability to develop and utilize valuable information and knowledge for competitive advantage (Hambrick & Mason, 1984; Nonaka, 1994; Argote & Ingram, 2000). Through information sharing and exchange, more organizational members gain the valuable information acquired or developed elsewhere in the organization (Huber, 1991), hence avoiding the normal learning curve (Quinn et al., 1996). Consequently, Garvin (1993) concludes that sharing information maximizes the performance impact of information. Information sharing can also foster the generation of new information and knowledge when information from different sources is combined (Huber, 1991; Nonaka, 1994) and the receiver provides feedbacks (e.g., questions, amplifications and modifications) that add further value for the sender (Quinn et al., 1996).

Information interpretation affects how individuals make sense of and use information gathered from either internal or external sources (Weick, 1979; Hambrick & Mason, 1984). Weick (1979), for instance, posits that individuals are more likely to "see something when they believe it" rather than "believe it when they see it." Central to the interpretation process are mental models or cognitive maps that individuals use consciously or unconsciously to guide their search, selection and interpretation of new information (Isenberg, 1984). Composed of beliefs, assumptions, norms, experience, and prior knowledge and judgment, the established mental models of individuals often serve as a "lens" or filter through which new information is given meaning to or attended to (Kim, 1993). Research into managerial decision making suggests that managers are often subject to the influence of their mental models in their search, selection, interpretation and use of information about their environments (Weick, 1979; Isenberg, 1984). Recent empirical studies have shown that managers who fail to constantly test, correct and revise their mental models often inadequately perceive and act on their external environments and, consequently, make suboptimal decisions (Tripsas & Gavetti, 2000; Adner & Helfat, 2003).

IS Support for Information Sharing

It is widely established in the IS literature that IS can play an important role in facilitating

information sharing. Research on the electronic communication systems (ECS) shows that a firm can expand its scope (breadth and capacity) of organizational communication from using ECS to increase the speed and spread of information delivery and support asynchronous communication (Adams et al., 1993). Field studies and laboratory experiments on group decisions support systems (GDSS) reported that the systems not only widened organizational communication scope, but also fostered more open and candid generation, sharing and evaluation of ideas by supporting anonymous electronic communication (Dennis et al., 1991). The anonymity feature of GDSS has been found particularly useful in facilitating the transfer of information and knowledge from subordinates to their managers (Huber et al., 1993).

The traditional IS support for information sharing has been enhanced by more recent information technologies. Video conferencing allows for the transmission of information and knowledge in rich media (Fulk & DeSanctis, 1995). Intelligent agent software can be used to develop interest profiles of users to match the potential recipients with the likely holders of the desired information (O'Dell & Grayson, 1998). With the rise of the Internet technology, Web-based intranets have been increasingly used to further reduce the costs and time in preparing and transferring information in ultra-rich content (Bidgoli, 1999) and promote information sharing across global boundaries (Boudreau et al., 1998). Intranets also facilitate contact between individuals that seek information and knowledge and those who posses them by supporting electronic bulletin boards, discussion groups and corporate directories (Andreu & Ciborra, 1997).

There is some evidence to suggest that firms may enjoy performance improvements from using IS to support organizational communication and information sharing. Research on the organizational impacts of computer-aided systems showed that the systems helped firms increase sales, market shares, customer satisfaction and organizational productivity by facilitating sharing and transfer of useful information and expertise in a timely and cost-effective manner (Goodman & Darr, 1998). Case studies of IS support for cross-functional sharing and integration of information have documented such operational benefits as improved productivity, reduced lead times, and increased flexibility (Goldhar & Lei, 1995). Research on the organizational benefits of intranets has also reported lower communication costs and higher labor productivity associated with the use of intranets (O'Dell & Grayson, 1998; Bidgoli, 1999). In a more recent study, Andersen and Segars (2001) have found a positive impact of IS enhancement of internal communications on the financial performance among large companies.

IS Support for Information Interpretation

Research on IS support for human cognitive processes reveals that firms may develop IS to assist managers in developing and evaluating their mental models. Boland et al. (1994) described an actual system (Spider) designed to help users construct their own cognitive maps and evaluate

their assumptions and preferences. Baets (1998) documented another system capable of fostering the development of shared mental models from individual mental models.

By utilizing the artificial neural networks technology, the system enabled a chemical company to construct an overall picture (mental map) of a particular business process based on the mental models of different stakeholder groups. The executive information systems (EIS) literature also suggests that the analytical and modeling capabilities (e.g., What-if analysis and simulation) built in many EIS may assist top managers in surfacing and testing the assumptions in their mental models, hence making them more testable and easier to communicate (Rockart & DeLong, 1988).

Some evidence from field research indicates that organizational performance improvements may accrue from IS support for critical evaluation of the mental models and assumptions of decision makers. Vandenbosch and Higgins (1995) investigated the performance impacts of two types of support provided by executive support systems (ESS): one for mental model maintenance (fitting new information in extant mental models) and one for mental model building (changing mental models to accommodate new information). They found that perceived competitive performance was strongly related to ESS support for mental model building, while ESS support for mental model maintenance had no effect on perceived competitive performance.

Moderating Effects of IS Connectivity

Many firms of today employ a variety of IS developed and implemented with different hardware, operating systems, programming languages, and data and processing definitions in their daily operations (March et al., 2000). Since different types of software and hardware are typically adopted according to different system and data standards, the different IS developed and used by a firm may not be connected with one another (Davenport, 1998). The connectivity of IS or the lack of it may affect the ability of IS to support information sharing. Laudon and Laudon (2002) discuss several communication problems arising from using many incompatible IS. For instance, a company may use multiple e-mail systems that cannot communicate with one another, and the company's mainframe computers cannot share information meaningfully with its microcomputers. Consequently, the lack of IS connectivity limits a firm's capacity to share and integrate information gathered from different IS (Davenport, 1998). In the IS literature, a number of techniques (e.g., standardization of communication protocols, data integration through common data models, and Internet) and systems (e.g., enterprise resource planning system) have been advanced to increase the connectivity of IS and hence the effectiveness of IS support for information sharing (Goodhue et al., 1992; Al-Mashari, 2002; Hulme, 2003).

There is growing anecdotal evidence to suggest that operational benefits accrue from better information flow as a result of increased IS connectivity (Colkin, 2002; Dutta & Kendall, 2002; Hulme, 2003; Shaw et al., 2004). Colkin (2002) showed how FleetBoston Financial Corp. (now part of Bank of America) benefited from installing a Web-based marketing and sales software designed to facilitate communication among different databases and systems from separate business units. Sales representatives in one division, for example, could access databases from other divisions for more customer

information to help close a sale. Dutta and Kendall (2002) reported that an international joint venture led by ExxonMobil saved as much as five cents per barrel from using a new system ("integrated control and information management system") that provided seamless information link among different oil and gas production facilities. Accordingly, firms with a high level of IS connectivity are expected to reap greater benefits from IS support of information sharing than firms with a low level of IS connectivity.

Hypothesis 1: The interaction between IS support for information sharing and IS connectivity is positively related to firm performance.

Whereas a high level of IS connectivity enhances IS support of information sharing, a low level of IS connectivity appears to be more conducive to IS support of information interpretation. As mentioned above, increasing the connectivity of different IS typically requires system and data standardization, which may induce simplicity and rigidity. In her analysis of the tradeoff between standardization and heterogeneity in the context of organizational learning, Argote (1999) argues that standardization, while conducive to knowledge transfer, is less useful for new knowledge creation, which is often based on incorporation of diverse perspectives and experiences. IS research into the problems of standardizing data definitions and structures shows that data standardization may impose certain constraints on information interpretation (Goodhue et al., 1992; Davenport, 1998; Al-Mashari, 2002). One study revealed that forcing the whole company to conform to a single data design reduces its managers' flexibility in using IS at the local level (Goodhue et al., 1992). Research on ERP systems suggests that ERP-enabled standardization, while improving the integration of dispersed organizational systems, reduces organizational flexibility to accommodate emerging changes in business processes and systems (Pawlowski et al., 1999). Millet and Mawhinney (1992) also observed that data inflexibility (data retrieval and presentations in pre-specified formats) imposed by some EIS limited managers' ability to evaluate critical information. In light of these potential problems of IS connectivity, it is reasonable to expect the performance impact of IS support of information interpretation to diminish with a high level of IS connectivity.

Hypothesis 2: The interaction between IS support for information interpretation and IS connectivity is negatively related to firm performance.

Methodology

Sample and Data Collection

The data for this study were obtained from two sources. The data tapping the independent and moderating variables were gathered via a mail survey in 1998, and the data about the performance and control variables were obtained from the Research Insight (formerly known as Compustat) database. The target respondents of the survey were senior IS executives in large U.S. firms. The sample frame for the study consisted of 879 firms that had contact information of their senior IS executives in the Directory of Top Computer Executives as well as financial data in the Research Insight database.

Before being mailed to the target respondents, the survey instrument was pre-tested and refined for content validity and item clarity with senior IS executives from five Fortune companies headquartered in a mid-western state. Of the 778 firms that received the questionnaires, a total of 164 responses were received, out of which 11 responses were unusable. The effective response rate was thus 20% (153 responses), which is comparable to those reported in similar studies using senior IS executives in large firms (Byrd & Turner, 2001; Kearns & Lederer, 2003). To test for potential nonresponse bias, the respondent firms were compared to their non-respondent counterparts with respect to sales and number of employees. T-test results showed no significant differences in both characteristics between the two groups. Another nonresponse bias check was conducted by comparing early with late respondents (Armstrong & Overton, 1977). T-tests of the mean differences for the three explanatory variables failed to reveal any significant differences. Together, these checks provided some evidence for the absence of non-response bias in the data set.

Measures

Independent variables. Based on the review of research on IS support for information sharing, four items were developed to measure this construct. IS support for information interpretation was measured with five items adopted from Vandenbosch and Higgins (1996). For each of the nine items, the respondents were asked to indicate the extent to which their IS had provided a particular type of support during the previous three years on a five-point, Likert scale with anchors ranging from "Very great extent" (=5) to "No extent" (=1). To assess the convergent and discriminant validities of the two scales, a principal components factor analysis with varimax rotation was performed on the nine items. The factor analysis (Table 1) revealed two factors explaining 72% of the total

Table 1. Factor Analysis of IS Support

Item Description	IS Support for Information Sharing	IS Support for Information Interpretation
Provide timely access to internal information in decision making situations	.748	
Provide access to more internal information in decision making situations	.709	
Increase communication linkages among employees	.792	
Increase sharing of information throughout the company	.777	
Challenge employees' perspectives		.882
Re-orient employees' thinking		.895
Question employees' preconceptions		.913
Foster employees' creativity		.863
Expand employees' scopes of thinking		.879
Eigen Value	1.86	4.60
% of common variance explained	27.33	44.51
Cronbach Alpha	.77	.94

variance and the two factors corresponded with IS support for information sharing and IS support for information interpretation, respectively.

IS connectivity. IS connectivity was measured with four items tapping four qualities of system connectivity: applications portability, information portability, interoperability, and migration (Laudon & Laudon, 1996). The respondents were asked to indicate the extent to which their IS exhibited each of the above qualities on a five-point Likert scale with anchors ranging from "Very great extent" (=5) to "No extent" (=1). A principal components factor analysis of these four items yielded a single factor explaining 55% of the total variance (see Table 2).

Performance measures. Two popular measures of profitability (return on sales and return on assets) were employed to measure firm performance. Both profitability ratios have been frequently used in previous assessments of the strategic impacts of IS (Tam, 1998; Li & Ye, 1999). To smooth annual fluctuations and reduce short-term effects to some degree, a three-year average (covering 1997-1999) was used for both variables.

Control variables. Since the firms participating in this research came from a variety of industries, it was necessary to control, to some degree, the different industry conditions under which the firms operated. To control for the industry effects, SIC codes were first used to classify the firms into four groups: 1) manufacturing, 2) transportation and public utilities, 3) wholesale and retail trade, and 4) service. Three dummy variables were then created, each with values of 0 or 1, for the second, third and fourth groups of firms. The fourth control variable was firm size, measured as the number of full-time employees. The fifth control variable was technological resources, which may influence the firm's ability to develop IS for sustainable competitive advantage (Kettinger et al., 1994). In keeping with Kettinger et al. (1994), technological resources were measured as investment intensity (invested capital to sales). The sixth control variable was organizational slack, which measures the firm's ability to generate cash flow for reinvestment (Chakravarthy, 1986). Organizational slack needs to be taken into account because of its potential influence on the firm's ability to invest in and develop IS (Kettinger et al., 1994). The

Table 2. Factor Analysis of IS Connectivity

Item Description	Loadings
The same software can be operated on different hardware platforms.	.785
Computer files can be shared among different hardware platforms.	.819
Computer files can be shared among different information systems.	.660
Software can be moved from one generation of hardware to another more powerful generation.	.686
Eigen Value	2.19
% of common variance explained	54.83
Cronbach Alpha	.72

current ratio (current assets to current liabilities) was employed to measure organizational slack (Bourgeois, 1981).

Analysis

Two sets of hierarchical regression analyses were run to test the hypotheses. In the first step of the regression analyses, the six control variables were entered into the model. To separate the main effects of the independent and moderating variables from their interactive effects, the two IS support variables and the moderating variable were added as a set in the second step. To test the moderating effects of IS connectivity, the two interaction terms were added as a set to the equation in the third step. To avoid potential multicollinearity among the independent and moderating variables, the three variables were mean-centered before being added to the model.

Results

Table 3 displays the results of the regression analyses. Models 3 and 6 show that the interaction term between IS support for information sharing and IS connectivity was positively related to both ROS (b = .16, p < .05) and ROA (b = .22, p < .05). Thus, hypothesis 1 was supported. The same models also indicate that the interaction term between IS support of information interpretation and IS connectivity was negatively associated with both ROS (b = -.15, p < .05) and ROA (b = -.17, p < .05), hence providing support for hypothesis 2.

Discussion

The purpose of this research was to investigate the influence of IS connectivity on the performance contributions of IS support for information sharing and IS support for information interpretation. The results show that IS connectivity affected the performance impacts of IS support for information sharing and IS support for information interpretation in different ways.

On one hand, a high level of IS connectivity enabled a firm to reap economic benefits from IS support for information sharing. On the other hand, a high level of IS connectivity hindered the firm's ability to obtain superior performance from IS support for information interpretation. These findings echoed a growing body of research which views a high degree of system connectivity and data integration as a double-edged sword (Goodhue et al., 1992; Davenport, 1998; Al-Mashari, 2002). In the context of organizational learning, this tradeoff mirrors the tension between exploitation and exploration (March, 1991). Whereas enhancing a firm's ability to exploit its information resources for competitive advantage, IS connectivity may be detrimental to the exploration of new insights and ideas.

The findings from this study are informative for scholars and managers concerned with the management of IS connectivity or compatibility. The past decade has witnessed a proliferation of emphasis on integrating different IS to improve organization-wide sharing and exchange of information (Roth et al., 2002; Sharif et al., 2004). Some researchers even view the ability to connect different IS as part of a firm's IS

infrastructure that can yield competitive advantage (Byrd & Turner, 2001). While confirming some positive influence of IS connectivity, the study reveals that the organizational impacts of- IS connectivity may not be always positive. Given that both positive and negative effects of IS connectivity may exist, firms and their managers now face the challenge of how to maximize the positive impacts of IS connectivity while minimizing its negative impacts. For IS researchers, the findings suggest is that we still lack a complete picture of the competitive consequences of IS connectivity. Future investigation into the disparate organizational impacts of IS connectivity could benefit from the contingency approach and the logic of opposition (Robey & Boudreau, 1999).

Table 3. Regression Results[a]

	ROS			ROA		
Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Industry dummy 1	-.09	-.10	-.10	-.10	-.11	-.11
Industry dummy 2	-.13^{+}	-.14^{+}	-.14^{+}	-.23**	-.25**	-.24**
Industry dummy 3	.20*	.19*	.21*	-.27**	-.29**	-.26**
Firm size	.10	.10	.12	.18*	.18*	.20*
Current ratio	-.03	-.01	.01	.04	.05	.07
Investment intensity	.44***	.43***	.42***	.02	.02	.01
IS support for information sharing		.07	.09		.04	.07
IS support for information interpretation		-.04	-.04		-.12	-.12
IS connectivity		-.09	-.10		-.08	-.09
IS support for information sharing X IS connectivity			.16*			.22*
IS support for information interpretation X IS connectivity			-.15*			-.17*
R^2	.33	.34	.37	.11	.13	.18
ΔR^2		.01	.03		.02	.05
F	12.13***	8.28***	7.59***	3.13**	2.45*	2.77**
ΔF		.72	3.28*		1.08	3.77*

[a] N = 153. Standardized regression coefficients are shown.
$^{+}$ p < .10, *p < .05, **p < .01, ***p < .001

The current research also contributes to a growing body of research into organizational factors that may affect the performance impacts of IS deployment (e.g., providing IS support for certain key organizational capabilities). Previous studies have identified a number of contextual factors (e.g., organizational culture and structure, and employee skills and knowledge) as potential determinants of IS deployment effectiveness (Constant et al., 1996; Powell & Dent-Micallef, 1997; Goodman & Darr, 1998; Zhang, 2005). This study adds to the literature by showing IS connectivity can also play a critical role in affecting the outcomes of IS deployment. Further, by highlighting some undesirable performance effects of having a high level of IS connectivity, the study draws our attention to the need to investigate both positive and negative influences of various organizational conditions under which IS are deployed.

The findings in this research need to be interpreted within its limitations. The study relied on perceptual data collected from single informants in measuring IS support and IS connectivity. Data collected in such a manner may be subject to the respondents' cognitive biases and distortions. On the other hand, the use of objective measures for the performance and control variables avoided similar biases and inaccuracies in collecting the data for those variables and reduced the "common variance bias." As another limitation, the response rate (20%) for the survey used in this research, while comparable to those of similar studies, was relatively low and thus limited the generalizability of the study results. Obtaining high response rates for sensitive information concerning the strategic use of IS continues to be a challenge for researchers.

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Contact email address: zhangm@sacredheart.edu