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MANAGING INFORMATION SYSTEMS COMPETENCE FOR COMPETITIVE ADVANTAGE: AN EMPIRICAL ANALYSIS

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Abstract

During the past two decades, both business managers and academic researchers have shown considerable interest in understanding how information systems (IS) lead to competitive advantages in a firm. The present study builds on this interest to examine the nature of IS competence and delineate the process by which IS competence lead to sustainable competitive advantages. Conceptually, IS competence is considered a multidimensional construct, with the quality of the IT infrastructure, IT-business expertise, and the relationship infrastructure. We present a model that elaborates on the interrelationships between IS competence and competitive advantages along with one key contextual antecedent (the intensity of organizational learning), pose a series of hypotheses, and present the results of an empirical test that involved structural equation modeling, using data collected via a national mail survey from chief IT executives from 202 manufacturing firms. While the quality of the IT infrastructure did not have any significant effect on competitive advantages of the firm, the quality of IT-business expertise and the relationship infrastructure were found to be significantly related to competitive advantages. The results of the study indicated that the intensity of organizational learning was significantly related to all three factors: the quality of the IT infrastructure, IT-business expertise, and the relationship infrastructure. IS competence was also found to partially mediate the relationship with regard to the competitive advantages.

Keywords: IS competence, IT infrastructure, IT-business expertise, relationship infrastructure, firm performance, intensity of organizational learning

Introduction

One of the central concerns in information systems (IS) strategy is to understand how organizations create value with information technology (IT) (Bakos and Treacy 1986; Cash and Konysnski 1985; Porter and Miller 1985). In the 1980s, a growing body of literature argued that IT can be used to raise the entry barriers, increase bargaining power with suppliers and customers, offer new products and services, or change the rules of the competition (McFarlan 1984; Porter and Miller 1985). Over the years, however, a number of scholars have noted that sustaining advantages through IT applications might be difficult, because such applications are eventually imitated and appropriated by competitors (Clemons and Row 1991; Mata et al. 1995; Sambamurthy and Zmud 1997). Thus, many strategic IT applications become strategic necessities for the continued existence of the firm.

With the recent popularity of the resource-based view (RBV) of the firm, the focus has shifted to IS competence. A growing body of research now suggests that IT per se may not be the main source of firm-level competitiveness (Mata et al. 1995; Powell and Dent-Micalel 1997). It is, rather, the management of information and technology (Sambamurthy and Zmud 1997) and complementary resources (Clemons and Row 1991) that are likely to determine the competitiveness of the firm.
Using the RBV of the firm, IS scholars indicate that firms are heterogeneous in developing and nurturing IS competences; therefore, they are likely to have different potential in leveraging information systems for their competitiveness (Barney 1991, 1997; Peteraf 1993). For example, Mata et al. (1995) note that for sustaining and capitalizing benefits from IT, a firm should possess managerial IT skills. Ross et al. (1996) posit the importance of IT groups that possess both technical and business problem solving skills. Keen (1991) acknowledges the role of top management commitment in leveraging IT for the competitiveness. Clemons and Row (1991) argue the advantages of complementary resources for long-term advantage. For example, Merrill Lynch’s CMA market advantages in the 1990s were accrued because of the synergy between CMA’s financial product and Merrill Lynch’s money market fund management expertise.

In a recent study, Bharadwaj (2000) finds support to the claim that higher IS competence leads to higher financial performance. Her results have been supported by Santhanam and Hartono (2003). However, these authors did not empirically validate those factors that are associated with IS competences. From an analytical point of view, therefore, it becomes difficult to ascertain the relative roles of the individual factors embedded into IS competences.

Thus, despite the critical role of IS competence in sustaining competitive advantages of the firm, we still lack an understanding of the relative value of different factors associated with IS competence. The study presented here fills this gap and looks at the effect of three factors: IT infrastructure, IT-business expertise, and relationship infrastructure on competitive advantages of the firm (e.g., Ross et al. 1996). The study also examines the effect of one antecedent: learning intensity of the organization. We, thus, begin to untangle the relative effect of different factors associated with IS competence on competitive advantages of the firm.

**Conceptual Framework**

The conceptual framework used for this study is shown in Figure 1.

![Figure 1. Conceptual Model](image_url)
Our antecedent variable is intensity of organizational learning. We believe that the quality of IT infrastructure, IT-business expertise, and the relationship infrastructure affect the competitive advantages of the firm. We also believe that the intensity of organizational learning will affect both the IS competence and the competitive advantages of the firm.

On the basis of the RBV of the firm, we argue that the ability of a firm to develop, nurture, and exploit IT for competitive advantage defines the quality of its IS competence, and that competitive advantages can accrue as a result of specialization, flexibility, or low-cost in information processing (Bharadwaj 2000; Ross et al. 1996). The intensity of organizational learning is critical as it enhances the absorptive capacity of the firm to quickly locate and acquire new knowledge from external sources that are relevant to its capabilities (Cohen and Levinthal 1990).

Several researchers have used perceptual impressions for measuring business value, productivity, or profitability (Powell and Dent-Micaleff 1997; Tallon et al. 2000). The research has shown that perceptual measures on firm performance correlate strongly with traditional objective measures (Venkatraman and Ramanujam 1987). In this study, we work with perceptual measures.

Hypotheses

**IS Competence and Competitive Advantages of the Firm**

Traditionally IT infrastructures were laid down in an ad hoc manner to meet the information demands of each business units. Presently, however, suppliers, customers, and other major partners directly contribute to the development of the IT infrastructure (Weill and Broadbent 1998). Keen (1991) posits that a quality IT infrastructure enables a firm to respond to the environmental changes swiftly, as it can easily be modified to meet future business needs. In sum, an IT infrastructure allows a firm to identify and develop key applications quickly, share information across different functions, implement common systems across different business functions, and exploit opportunities for synergy across different business units (Bharadwaj 2000; Rockart et al. 1996).

Using the RBV of the organization, we argue that a high quality IT infrastructure will directly contribute to the firm’s long-term competitiveness.

**Hypothesis 1.** Higher quality IT infrastructure will have a positive effect on the competitive advantages of the firm.

Over the last decade, researchers have realized that physical assets and tangible resources do not provide long-term advantages to the firm, because competitors are likely gain access to them in due course. Long-term advantages in the market, therefore, often depend on the expertise of the people in the organization. Sambamurthy and Zmud (1997) argue that IT-business expertise allows a firm the ability to integrate IS strategy and business strategy, develop reliable and cost effective systems for the business, and anticipate business needs sooner than competitors. Keen believes that the competitive advantages of a firm are largely attributed to the business judgment and technical skills of IT groups and top management. Clark et al. (1997) note that IT groups’ business expertise, in combination with IT skills, directly determine the firm’s ability to rapidly develop and deploy critical information systems for the long-term competitive advantages of the firm.

**Hypothesis 2.** Higher quality IT-business expertise will have a positive effect on the competitive advantages of the firm.

The relationship infrastructure consists of sharing risk and responsibility of IT applications between IT and business unit management (Ross et al. 1996). One of the beliefs that resides in the relationship infrastructure is the role of trust that is developed between IT groups and business units (Nahapiet and Ghosal 1997). In support of Nahapiet and Ghosal’s argument on trust, we posit that once an organization succeeds in forming trust between IT groups and business units, their interaction enables knowledge flow and knowledge diffusion throughout the organization, which is likely to bring a greater appreciation for each units’ work, expertise, and roles in the organization.

The need for coordination and collaboration between IT group and business management is vital. As Rockart et al. (1996) have pointed out, only business units are in a position to effectively utilize IT in their strategy and everyday work. Therefore, in order to make effective use of IT, IS responsibilities and roles should be shared between line management and IS management (Reich and Benbasat 1990; Sambamurthy and Zmud 1997).
Hypothesis 3. Higher quality relationship infrastructure will have a positive effect on the competitive advantages of the firm.

Intensity of Organizational Learning and IS Competence

Broadbent et al. (1999) have noted the iterative relationship between the strategic contexts of the firm and the competitive advantages of the firm on IT investment. According to this view, IS investments decisions are being influenced by factors within a firm’s internal and external environments. One such contextual factor is the intensity of organizational learning. Learning involves accumulation, sharing, and application of knowledge (Huber 1991, p. 90). The intensity of organizational learning is reflected through the means that a firm uses in searching, acquiring, assimilating, and deploying relevant knowledge (Cohen and Levinthal 1990). Thus, intensity of organizational learning becomes critical for affecting IS competence.

In sum, developing IS competence takes time and requires learning and experience. For example, Neo (1988) finds that the firms that were successful in IT implementations had already implemented similar systems in the past and had accumulated experience. Similarly, Cash et al. (1992) argue that an IT infrastructure evolves over time through periodic learning on the firm’s information requirements. The research has also shown that development of IS skills, embedded into specific business practices, takes time (Bassellier et al. 2001; Mata et al. 1995). Sambamurty and Zumd (1997) argue that technical and business skills evolve over time and are accumulated as a result of experience and practice. In regard to the relationship infrastructure, Bharadwaj (2000) argues that creating cordial relationships between IS groups and line management takes several years. Often, IS projects that were delivered quickly to meet business needs required continuous interaction and communication between IS groups and other functional groups. These interactions are likely to be affected through the intensity of organizational learning.

Hypothesis 4. Higher level intensity of organizational learning will have a positive effect on the quality of (a) the IT infrastructure, (b) IT-business expertise, and (c) the relationship infrastructure.

In the present competitive environment, a number of firms are placing heavy emphasis on learning, because they are convinced that learning contributes to the effectiveness of their resources and capabilities for their competitiveness (Prahalad and Hamel 1990). The intensity of learning is considered to increase an organization’s problem-solving capacity and its behavior in such ways that lead to improved performance at the individual, team, and organizational levels. Senge (1990) argues that one source of competitive advantage in the present global environment is the ability and rate at which an organization can learn and react more quickly than its competitors. Mabey and Salaman (1995) have shown that the intensity of organization learning is a key variable in determining profitability.

Hypothesis 5. Higher level intensity of learning will have a positive effect on the competitive advantages of the firm.

Methods

Data Collection

A survey design was used for this study and questionnaires were sent to 1,200 top or senior IT executives (chief information officer, vice president of IT, director of IT) randomly selected from a directory of 3,000 manufacturing firms, supplied by a marketing vendor. A total of 202 usable responses were received, resulting a response rate of about 17 percent. This kind of low response rate is not uncommon in the IS area, as it reflects the challenges in obtaining responses from top management (Ferratt et al. 1999).

Response Rate and Nonresponse Bias

Our sample represented a wide range of manufacturing companies: 25 percent were in computer/electronics, 25 percent were in heavy machinery and automobiles, 17 percent were in chemicals/pharmaceuticals, 13 percent were in industrial and farm equipment, and the remainder were forest/wood, home assemblies, and leather manufacturing businesses. The annual revenues of the firms in the sampling frame ranged from $50 million to $140 billion.

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We conducted a Chi-square test to determine whether responses varied by the manufacturing sectors and their revenues. No significant differences in Chi-square at the .05 level were noted, which suggests that perceptual measures of IS competence and competitiveness are unbiased by variations in the manufacturing sectors and their revenues.

**Operationalization of Measures**

Table 1 shows the operationalization of variables. All of the questions were asked from a scale ranging from 1 to 5, where 1 refers to the lowest score in the measure and 5 represents the highest score on the measure. The scales for various constructs were adopted from a review of the literature. If existing measures were not available, a list of items covering the domain of the variables under investigation was developed.

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Dimensions</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS Competence</td>
<td>IT infrastructure</td>
<td>The extent to which systems are (1) compatible, (2) modular, (3) scalable, and (4) transparent. (5) The extent to which systems can handle multiple applications. (6) Use of commonly agreed IT standards</td>
</tr>
<tr>
<td></td>
<td>IT-business expertise</td>
<td>The extent to which IT groups are knowledgeable about (1) business strategy, (2) competitive priorities, (3) business policies, and (4) business opportunities. (5) The extent to which IT groups possess requisite IT expertise</td>
</tr>
<tr>
<td></td>
<td>Relationship infrastructure</td>
<td>The extent to which IT groups and line-management (1) trust, (2) appreciate, (3) consult with, (4) account for, and (5) respect each other in setting business and IT strategy</td>
</tr>
<tr>
<td>Competitive advantages of the firm</td>
<td>Relative performance with respect to the competitors for the past 3 years</td>
<td>Financial performance, and sales growth</td>
</tr>
<tr>
<td></td>
<td>Performance for the last 3 years</td>
<td>Profitability, financial performance, and sales growth</td>
</tr>
<tr>
<td>The intensity of organizational learning</td>
<td>Knowledge exploration</td>
<td>The ability of the firm to (1) search and (2) acquire new and relevant knowledge</td>
</tr>
<tr>
<td></td>
<td>Knowledge exploitation</td>
<td>The ability of the firm to (1) assimilate and (2) apply relevant knowledge</td>
</tr>
<tr>
<td></td>
<td>Focus</td>
<td>The extent of concerted efforts for the exploitation of existing competencies and exploration of new knowledge</td>
</tr>
</tbody>
</table>

**Reliability Analysis**

The items used for measuring the intensity of organizational learning, IT infrastructure, IT-business expertise, relationship infrastructure, and competitive advantage were theoretically selected *a priori*. The verification of this model was done through confirmatory analysis.

LISREL was used for data analysis because of its advantages over other techniques. Following Gerbing and Anderson’s (1988) work, we purified the measures by assessing their reliability and unidimensionality, where the measurement model was evaluated separately from the full structural equation model. The measurement model was iteratively revised by dropping one at a time those
items sharing a high degree of residual variance with other items (Gerbing and Anderson 1988). This was done for all of the constructs until the CFA (confirmatory factor analysis) and RMR (root mean square residual) were within limits.

**Convergent Validity**

To test the convergent validity, we calculated composite reliability of the construct. A high value of composite reliability, ranging from .72 to .86, suggests the convergent validity of the constructs. The values of RMSEA (root mean square error of approximation) and CFI (comparative fit index) were close to .03 and .98 respectively.

**Discriminant Validity**

Discriminant validity is inferred when measures of each factor converge on their respective score that are unique from the scores of other factors. We tested estimates of an unconstrained model that free the correlation between the pairs of factors and constrained model that sets the correlation between the constructs to unity. A significant difference between the Chi-square indicates that the unconstrained model is a better fit than the constrained one. This pair-wise test was performed by combining two constructs. Thus, we conducted 10 pair-wise tests between technical infrastructure, IT-business expertise, relationship infrastructure, intensity of organizational learning, and competitive advantages. The significant results of all Chi-square difference between the original model and constrained models show the discriminant validity between different constructs.

**Substantive Analyses and Results**

Having demonstrated that our measures possessed adequate validity and reliability, we then proceeded to test our substantive hypotheses in a structural equation model. The result of the confirmatory structural model, which includes the hypotheses, is shown in the Figure 2. Overall, our model was found to show an excellent fit (CFI = .98).

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**Figure 2. Results of the Model**

- **Model Fit Summary**
  - $\chi^2 = 136.80$ df = 112 p = .054 ** = p < .001
  - GFI = .93 ** = p < .01
  - RMSEA = .033 * = p < .05
  - CFI = .98 + = p < .10

- **Significance Levels**
  - Standardized parameter estimates shown; item loadings and error terms not displayed.
  - ----- wavy line shows insignificant path
With regard to the specific hypotheses, we found:

**Hypothesis 1:** Our results failed to support the hypothesis that higher quality IT infrastructure would have a significant positive effect on the competitive advantages of the firm \( t = .20, p > .10 \).

**Hypothesis 2:** As expected, higher level IT-business expertise had a significant positive effect on the competitive advantages of the firm \( t = 1.66, p < .10 \).

**Hypothesis 3:** As expected, higher quality relationship infrastructure had a significant positive effect on the competitive advantages of the firm \( t = 2.82, p < .01 \).

**Hypotheses 4a, b, and c:** As predicted, higher levels of intensity of organizational learning had a strong significant positive effect on (a) the quality of the IT infrastructure, (b) the level of IT-business expertise, and (c) the quality of relationship infrastructure \([a] t = 5.63, p < .001; [b] t = 6.77, p < .001; [c] t = 3.83, p < .001\).

**Hypothesis 5:** Our results failed to support that higher level intensity of organizational learning would have a significant positive effect on competitive advantages of the firm \( t = -0.53, p > .10 \).

**Discussion and Conclusions**

Ross et al. (1996) argue that the IT infrastructure, IT-business expertise, and the relationship infrastructure are tightly interrelated, and a firm is required to have all three components in place for achieving sustainable competitive advantages. Our results, however, find that the quality of the IT infrastructure may not directly contribute to sustainable competitive advantages. It is rather IT-business expertise and the relationship infrastructure that lead to competitive advantages. Moreover, IT-business expertise has a lower effect on competitive advantages than the relationship infrastructure.

In pragmatic terms, these results contradict the commonly held view that development of an IT infrastructure is ambiguous and path-dependent. The rationale for our results could be that at the present time, almost all of the established firms might have gained a better understanding for developing IT infrastructures. Therefore, until a firm is able to predominantly shape the principles of IT infrastructure, IT infrastructure might not be a critical contributor to create competitive advantages.

The effect of IT-business expertise in the present study is moderate. We believe that the development of skills requires organizational time and efforts; therefore, a firm that possesses highly competent IS people may sustain competitive advantages. However, this relationship is moderately significant, and this leads us to conjecture that, in the future, IT-business might not be a source of competitive advantages, because all of the firms can easily hire people with high expertise from the marketplace.

Since relationship infrastructure was found to significantly affect competitive advantage, this shows that building relations could be path-specific, complex, and internalized within organizational practices. This is because the relationship infrastructure is more akin to trust building between IS groups and business units within the organization. Research has shown that the use of trust between different units leads to cooperation, and collaboration among organizational participants, as trust reduces the monitoring cost, thus, increases the effectiveness of the coordination between different organizations.

The intensity of learning was found to significantly affect IT infrastructure, IT-business expertise, and relationship infrastructure. These results are expected, because learning is usually associated with knowledge acquisition, knowledge accumulation, and knowledge enhancement. The role of intensity of learning especially becomes critical in the infrastructure quality, skill enhancement (learning new things as the technology changes), and initiating and maintaining the relational infrastructure.

With regard to the intensity of learning, we find that intensity of learning does not directly contribute to competitive advantages. This could be true because learning does not take place in a vacuum. Learning needs to be available for use in specific projects. Simply searching and acquiring knowledge may not directly affect the competitiveness of the firm. In other words, only through the mediation of path-specific knowledge will learning lead to competitive advantages. In this regard, we believe that the alignment of intensity of learning with existing competence will provide the advantage of knowledge assimilation and deployment (Cohen and Levinthal 1990). The advantage that is accrued as a result of the assimilation of relevant and complementary knowledge within the organization would positively affect the competitive advantages of the firms.
References