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Curtis P. Armstrong, V. Sambamurthy,

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Information Technology Assimilation in Firms: The Influence of Senior Leadership and IT Infrastructures

Curtis P. Armstrong • V. Sambamurthy
Decision Sciences and Management, Tennessee Technological University, Box 5022, Cookeville, Tennessee 38505
carmstrong@tntech.edu
Decision and Information Technologies, Robert H. Smith School of Business, The University of Maryland, College Park, Maryland 20742-1815
smurthy@rhsmith.umd.edu

IT assimilation is regarded as an important outcome in the efforts of firms to leverage the potential of information technologies in their business activities and strategies. Despite significant investments in information technology, considerable diversity exists in how well firms have been able to assimilate IT and leverage the business value of IT. This research draws upon the emerging knowledge-based and resource-based views of the firm to examine the influence of three factors on IT assimilation: (i) quality of senior leadership, (ii) sophistication of IT infrastructures, and (iii) organizational size. Drawing upon a large-scale sample survey where responses were obtained from CIOs and senior business executives who were members of the firms' top management teams, the study examines a variety of mostly normative prescriptions. The findings provide robust evidence about the impacts of CIOs' business and IT knowledge on IT assimilation. Further, we find that CIOs' membership in top management teams and their informal interactions with TMT members enhance their knowledge, particularly their business knowledge. We find that the intensity of the relationship between CIO's interactions with the top management team and their level of IT and business knowledge is much stronger in firms that articulate a transformational IT vision. The sophistication of IT infrastructures was also found to significantly impact IT assimilation. Surprisingly, the IT knowledge of senior business executives was not found to be a significant influence on IT assimilation. The implications of these findings for evolving a deeper understanding of the dynamics underlying IT assimilation are presented.
(*IT Assimilation*; *IT Infrastructure*; *Senior Leadership*; *Chief Information Officer*; *Top Management Team*; *IT Vision*)

Introduction

Contemporary IS researchers have increasingly directed their interest and attention toward factors that influence success in the strategic and innovative use of IT (Mata et al. 1995, Sambamurthy and Zmud 1994, Feeny and Wilcocks 1998). In particular, prescriptive writings, anecdotal narratives, and limited empirical research point to two influential factors: the quality of senior leadership and the quality of firms' IT infrastructures.

Senior leadership refers to the Chief Information Officer (CIO) and members of the top management team, including the Chief Executive Officer (CEO), the Chief

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Operating Officer (COO), the Chief Financial Officer (CFO), and other senior business executives responsible for key business or functional areas. Through a variety of rich case studies, McKenney et al. (1995) profiled the critical role of senior leadership in facilitating the use of IT in firms historically regarded for their IT innovation success. Other writers suggest that CIOs' technical and business knowledge are essential to innovation success (Synnott 1987, Rockart et al. 1982, Earl 1989). At the same time, an IT-literate business management is also regarded as vital (Keen 1991, Boynton et al. 1994).

Strong partnerships between the CIO and senior business executives are also expected to contribute to firms' IT assimilation. Keen (1991) argues that, "IT successes generally reflect an effective relationship between business managers and Information Services managers and their staffs" (p. 215). Further, he suggests that, "dialogue is needed most right at the top of the firm. It is no exaggeration to say that nothing will contribute more to a firm's ability to take charge of change related to or fueled by IT than to have the firm's business and IS leaders make the issues of economics and integration a mutual priority" (p. 219). Overall, the knowledge of the senior leadership and the interactions among them are expected to have a significant influence on firms' IT assimilation.

Writers also point to the importance of IT infrastructures as the bedrock of firms' ability to sustain IT-based innovation (Gordon 1993, Duncan 1995, Allen and Boynton 1991, Hanseth et al. 1996). IT infrastructures include platform technologies (hardware and operating systems), network and telecommunications technologies, and databases and a variety of shared services, such as EDI, e-mail, universal file access, and videoconferencing and teleconferencing services. They provide the base foundation for enabling sustained IT assimilation in business activities (Keen 1991, Weill and Broadbent 1998).

However, not much rigorous empirical research has examined how senior leadership and IT infrastructures influence firms' ability to assimilate IT. Though Jarvenpaa and Ives (1991) examined the influence of the CEO's characteristics, they advocated examinations of the impacts of the entire top management team, rather than simply the CEO. Therefore, this projects draws upon data from a large-scale survey to test the mostly normative prescriptions about influence of senior leadership and infrastructure on firms' IT assimilation. Two questions frame our research:

i. How does the knowledge of the senior leadership (the CIO and the top management team) influence their firms' ability to assimilate IT in their business strategies and value-chain activities?

ii. How does the existing IT infrastructure influence firms' ability to assimilate IT in their business strategies and value-chain activities?

The next section presents our conceptual model and research hypotheses. Subsequently, we present details of the research methodology. Finally, the paper presents the results of the data analysis and discusses the implications of the study for research and practice.

Conceptual Model and Research Hypotheses

IT assimilation represents an important outcome in firms (DeLone and McLean 1992, Jarvenpaa and Ives 1991, Mahmood and Soon 1991, Sethi and King 1994). Information technologies must become a routinized element of firms' value-chain activities and business strategies before they can exhibit any significant business value (Boynton et al. 1994, Brynjolfsson and Hitt 1996, Cooper and Zmud 1990, Trice and Treacy 1986). While most firms are making significant investments in IT, not all of them are able to apply IT effectively in their business activities (Sambamurthy and Zmud 1994, Feeny and Wilcocks 1998, Brynjolfsson and Hitt 1996). IT assimilation refers to the success achieved by firms in utilizing the capabilities of IT to enhance their business performance. Not only does it refer to the extent to which IT has been infused into specific business activities, but also how effectively IT is enabling the conduct of those activities relative to rivals.

Sabherwal and King (1991) found that most frameworks for understanding IT assimilation are rooted in concepts of generic business strategies and value-chain activities (Porter 1980, 1985). One of the dimensions of IT assimilation is its use in the value-chain activities (Porter 1985, Porter and Millar 1985). Another dimension of IT assimilation refers to its use in competitive strategies such as being a low-cost producer, having

manufacturing/operations flexibility, enhancing supplier or customer linkages, and enhancing or creating new products and services (Parsons 1984, Porter 1980). Therefore, we define IT assimilation as the effective application of IT in supporting, shaping, and enabling firms' business strategies and value-chain activities.

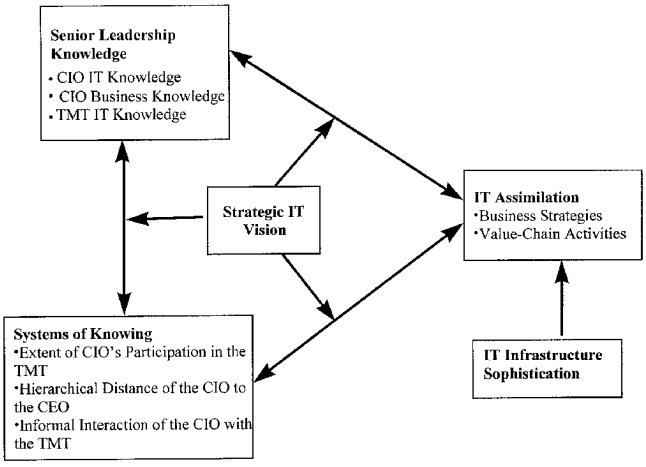
The conceptual model underlying our research (Figure 1) draws upon the resource-based and knowledge-based theories of the firm (Penrose 1995, Conner and Prahalad 1996, Grant, 1996a, Spender 1996). Drawing upon these theoretical arguments, Mata et al. (1995) argue that the ability to blend business and IT knowledge through a mosaic of strong intraorganizational relationships lies at the heart of firms' superior ability to assimilate IT. Similarly, Keen (1991) and Broadbent and Weill (1997) argue that the creation of a robust, enterprise-wide IT infrastructure distinguishes firms' ability to utilize IT (see also Sambamurthy and Zmud 1996). The next few sections elaborate upon the arguments of the knowledge- and resource-based theories to articulate the study's hypotheses.

Senior Leadership Knowledge and Impacts on IT Assimilation

Extending prior conceptualizations and definitions of top management teams (Hambrick and Mason 1984, Wiersema and Bantel 1992), we define senior leadership as the organizational collective consisting of the firm's CEO, COO, CIO, and other senior business executives who are formal members of the top management team. Our focus is on the knowledge of the senior leadership team as an important influence on IT assimilation.

Grant (1996a, 1996b) argues that firms are an economic structure for integrating the knowledge of different individuals in the superior production of value-added products and services (see also Conner and Prahalad 1996). The senior leadership team can be viewed as an organizational structure for integrating members' knowledge. Spender (1996) identifies two distinct components of the structures for knowledge integration: *objective knowledge* and *systems of knowing*. *Objective knowledge* refers to the explicit, visible knowledge possessed by individual team members. *Systems of knowing* refer to structures of interaction among team members for sharing their perspectives, pooling of knowledge, and development of shared understanding (Nahapiet and Ghoshal 1998). Taken together, objective knowledge and systems of knowing describe the absorptive capacity of senior leadership teams (Cohen and Levinthal 1990)—their ability to recognize valuable business and IT information, develop learning, and apply the learning in guiding the IT innovation activities in their firm.

Figure 1 Conceptual Model



Forms of Objective Knowledge. Two forms of knowledge are important for IT assimilation: strategic IT-related knowledge and business knowledge (Boynton et al. 1994, Cooprider and Victor 1993, Keen 1991). Strategic IT-related knowledge encompasses the potential and limitations of an organization's IT infrastructure, strategic IT actions of its competitors, and the potential of emerging information technologies for an organization's business. This definition reflects a strategic view of IT knowledge, in contrast with knowledge that is associated with tactical IT activities, such as systems development, networking, or programming expertise. The strategic IT knowledge is considered to be more relevant for CIOs and top management teams (Rockart et al. 1982, Keen 1991). Sambamurthy and Zmud (1996) found CIOs' ability to envision likely business impacts of current and emerging ITs as instrumental to IT assimilation. CIOs with a high strategic IT knowledge can better advise their top management teams about IT issues, such as appropriate technologies to invest in, the timing of those investment choices, and the level of investments. With

the recent trend for hiring CIOs from outside the IS function (Applegate and Elam 1992), we anticipate that the strategic IT knowledge of CIOs will vary widely across firms.

The top management teams' strategic IT knowledge should also be an important determinant of firms' ability to assimilate IT. Keen (1991) argues that when top management teams do not possess a high strategic IT knowledge, they could abdicate key IT initiatives to their CIO or the IS department. According to him, such conditions are likely to impair the organization's effective use of IT.

Business knowledge refers to knowledge of business strategies, organizational work processes, firm's products and services, industry recipes for success, and competitor strengths, weaknesses, and potential actions. This knowledge reflects an awareness of relationships between the organization and its stakeholders, the firm's means of competing in the marketplace, and rivals' competitive moves. Since high levels of business knowledge can be assumed for TMT members other than the CIO, we only include the CIO's business knowledge in our inquiry. Prior IS literature advocates the need for CIOs to possess a general-business orientation (Boynton et al. 1994, Rockart 1988, Feeny et al. 1992). Applegate and Elam (1992) found that CIOs must possess "a broad business perspective" (p. 469) and a knowledge of the organization and business expertise. Stephens et al. (1992) suggest that an enhanced level of business-related knowledge distinguishes an IS executive from an IS functional manager.

High strategic IT-related and business knowledge increase the prospects for the "push-pull" dynamics necessary for IT assimilation (Zmud 1984). McKenney et al. (1995) illustrate how firms were able to create IT innovation successes only through a marriage of appropriate IT and business knowledge. High levels of IS and business unit knowledge have generally been found to enhance firms' IT assimilation (Boynton et al. 1994, Cooprider and Victor 1993, Kaiser and Srinivasan 1982). As a result, we hypothesize the following:

Hypothesis 1. *The business and strategic IT knowledge of senior leadership teams will significantly enhance firms' IT assimilation.*

Systems of Knowing. As defined earlier, systems of knowing refer to structures guiding interactions among senior leadership members to facilitate their dialog and sharing and exchange of knowledge. Prior IS literature suggests that there are three possible structures: (1) hierarchical distance from the CEO, evaluated in terms of the hierarchical level of the CIO in the firm (Feeny et al. 1992, Keen 1991, Watson 1990); (2) extent of the CIO's participation in the top management team (Cash et al. 1992, Watson 1990); and (3) frequency of informal interactions between the CIO and TMT members (Lederer and Mendelow 1988, Rohan 1988). These indicators reflect potential avenues available to the senior leadership team to develop rich channels of interaction on strategic business and IT issues.

Lind and Zmud (1991) found that rich interactions between technical and managerial personnel contributed to increased levels of IT-based innovativeness. These systems of knowing provide forums for senior leadership to exchange their strategic IT and business knowledge and blend them together to foster higher levels of IT assimilation. These interactions also enable senior leadership to share ideas and develop a better understanding of the strategic business and IT issues surrounding IT assimilation. Watson (1990) argued that IT assimilation-related information could be disseminated more effectively between the CIO and the CEO through richer channels, especially face-to-face communications. Jarvenpaa and Ives (1991) found that greater interactions between the CEO and the CIO in different IT forums (e.g., steering committees) favorably influenced the firms' use of IT. Similarly, Boynton et al. (1994) found empirical evidence that more frequent interactions between the CIO and line managers positively impact a firm's level of IT assimilation. Therefore, we hypothesize the following:

Hypothesis 2. *The systems of knowing of the senior leadership team will significantly enhance firms' IT assimilation.*

We consider objective knowledge and systems of knowing to be two elements of the absorptive capacity of senior leadership and having a symbiotic relationship. On one hand, richer and more interactions provide pathways for emergence of higher levels of

knowledge (Henderson 1990, Rockart 1988). They enable senior leadership to develop a better appreciation for the "business of the business"—the firm's value proposition, its competition, and its industry forces. Further, the senior leadership team is also able to better understand the "IT business of the business" and enhance their IT-related strategic knowledge.

At the same time, CIOs with high levels of business and IT-related strategic knowledge are able to maintain greater interactions with top management team (TMT) members. CIOs with high levels of business and IT knowledge will be perceived as valuable players and be more easily accepted by the TMT. Further, when TMT members have higher levels of IT-related strategic knowledge, they are more likely to feel involvement with IT issues and recognize the unique role of the CIO and the necessity to include the CIO more frequently in the TMT deliberations (Jarvenpaa and Ives 1991).[1] Therefore, we articulate the following hypothesis to capture this symbiotic relationship:

Hypothesis 3. *Knowledge of the senior leadership will be significantly associated with their systems of knowing.*

The Moderating Effects of Strategic IT Vision

The emerging IS literature suggests that the strategic IT vision could be a significant factor moderating some of the relationships discussed earlier. Strategic IT vision is defined as the shared, aspired state of the role that IT should play in the firm (Robbins and Duncan 1988, Zmud 1988). It connotes institutional values and meanings, symbols, and images that shape members' behaviors (Berger and Luckman 1966, Collins and Porras 1991). Strategic IT visions evoke organizational images of the role that IT will play in the firms' business activities and competitive strategies. Schein (1992) identifies four major categories of strategic IT visions: automate, informate up, informate down, and transform (Table 1).

Scott-Morton (1991) describes strategic IT vision as evolving from *automate* to *informate* and, finally, to *transform.* The configuration perspective on organizations provides an appropriate lens through which to view the role of the strategic IT vision (Doty et al. 1993): The intensity of relationship between senior leadership's knowledge and systems of knowing and IT assimilation will vary across different strategic IT visions. Two theoretical forces underlie this configurational rationale. First, strategic IT vision describes the taken-for-granted organizational reality of IT's role in the firm (Berger and Luckman 1966). When firms espouse an automate vision, the taken-for-granted reality is that of IT as an expense that must be carefully managed. In these firms, most IT initiatives are likely to be shaped as a reaction to key business needs for cost control and cost avoidance. At the polar opposite end, firms with a transform vision view IT to be a key driver or an integral element of the firms' value proposition. Therefore, the strategic IT-related knowledge and IT-related initiatives are more likely to be considered critical organizational resources in these firms.

The strategic contingencies theory argues that firms seek to manage key uncertainties in their business environments by according greater power and influence to units or individuals that enable the firms to effectively manage the sources of these uncertainties (Hickson et al. 1971). In firms that espouse a transform vision, the IT-related uncertainties could become amplified because of tighter coupling between IT initiatives and competitive actions. Vitale (1986) provides examples of growing risks and uncertainties when IT assumes the role of a strategic resource. As these IT-related business risks, uncertainties, and opportunities grow, CIOs are more likely to be recognized as key organizational members and their knowledge and interactions with TMT are expected to be recognized as vital to the firm's competitive success. On the contrary, in firms that espouse an automate vision, the IT-related uncertainties are likely to be buffered from, or subordinated to, business uncertainties; therefore, the impact of the CIO's knowledge and interactions with senior business managers are not expected to fundamentally impact the firm's competitive success.

Overall, we anticipate that relationships between senior leadership's knowledge, structures of interactions, and IT assimilation will be strongly coupled in firms that espouse a transform vision; whereas, they would be the weakest in firms that espouse an automate vision. Our expectations have support in the writings of

[1]Though the focus of the Jarvenpaa and Ives investigation was restricted to the influence of CEO's characteristics, their results could extend to the TMT as the unit of analysis.

Table 1 Categories of Strategic IT Vision (Adapted from Schein 1992)

Category	Definition	Perception of IT
Automate	The ultimate role of IT is to replace expensive, unreliable human labor with information technology.	IT is intended to save money and improve quality. In firms that espouse such a vision, senior management is often more concerned about using IT in squeezing out operating inefficiencies; further, IT itself is regarded as an overhead whose costs have to be carefully managed.
Informate Up	IT provides information to higher levels of the organization more easily and efficiently to aid their organizational control and coordination roles.	Use IT to further tighten and consolidation of power and control by top management and IT as the agent of control. Senior management regards investments in IT as a means of facilitating their access to information about every aspect of their firms' operations so that the timely information will enable them to pinpoint problems and initiate corrective measures rapidly.
Informate Down	IT is used to distribute key information to lower levels of the organization in order to enhance the information reach of "front-line" organizational members and empower them with relevant knowledge and information.	IT is an agent of empowerment and autonomy in the organization. For firms that espouse such a vision, it is more likely that IT will be regarded as an agent of some amount of organizational transformation, since employee empowerment requires changes to organizational architectures of structures, processes, and reward systems.
Transform	IT is a vehicle for fundamentally altering the structure and competitive forces of the industry where the firm operates.	Senior management views IT to be the means for changing the firm's fundamental relationships with its suppliers and customers, and altering the products, markets, organizational structures, and organizational boundaries, interorganizational relationships, and even the management processes themselves.

Keen (1991), who suggests that while IT success is an outgrowth of an effective relationship between senior business and IS executives, the importance of this relationship is dependent upon the strategic importance of IT in the firm or the industry. Similarly, Feeny et al. (1992) found that firms rated as having excellent CEO/CIO relationships possessed a transform IT vision. Therefore, we hypothesize that:

Hypothesis 4. *The relationship between senior leadership's knowledge and systems of knowing will significantly vary across strategic IT visions.*

Hypothesis 5. *The influence of senior leadership's knowledge on IT assimilation will significantly vary across strategic IT visions.*

Hypothesis 6. *The influence of senior leadership's systems of knowing on IT assimilation will significantly vary across strategic IT visions.*

IT Infrastructure Sophistication and Impacts on IT Assimilation

IS researchers also view IT infrastructures as a critical resource of the firm (Keen 1991, Weill and Broadbent 1998). IT infrastructure sophistication refers to the extent to which a firm has diffused key information technologies into its base foundation for supporting business applications. Theoretically, the resource-based view regards IT infrastructure as a strategic option (Bowman and Hurry 1993, Kambil et al. 1993): An option is a resource, whose possession enables firms to exploit emerging opportunities better than its competitors. Firms holding stronger options are positioned to obtain greater organizational advantage and create superior products and services from those assets (Bowman and Hurry 1993).

Keen (1991) argues that a sophisticated infrastructure enhances the business degrees of freedom by

enhancing intraorganizational connectivity (across departmental units throughout the enterprise) and extraorganizational connectivity (with key external business partners). Further, a sophisticated infrastructure provides the flexibility to alter business strategies in response to competitive pressures (Duncan 1995). Weill and Broadbent (1998) provide several examples of linkages between the sophistication of IT infrastructures and IT assimilation. Finally, a sophisticated infrastructure enables firms to develop higher levels of technical knowledge that, in turn, fosters greater innovation and IT assimilation (Dewar and Dutton 1986, Damanpour 1992). In fact, Sambamurthy and Zmud (1996) found that a sophisticated IT infrastructure enhanced the ability and willingness of business managers to shape innovative applications of IT. As a result, we state the following hypothesis:

Hypothesis 7. *The sophistication of IT infrastructures will significantly enhance IT assimilation in firms.*

Organizational Characteristics and Impacts on IT Assimilation

Larger organizations possess more slack resources and, therefore, a greater capacity for assimilating innovations and technologies (Kimberly and Evanisko 1981, Damanpour 1987). Slack resources allow organizations to experiment with technologies and innovations, engage in risk taking and experimentation, absorb failures, bear the costs of implementing innovations, and proactively search for opportunities to innovate with technologies. Therefore, we would anticipate that larger organizations have greater success with assimilating IT into their value-chain activities and business strategies. As a result, we hypothesize that:

Hypothesis 8. *Organizational size will significantly enhance firm's IT assimilation.*

The next section presents the details of our research design for evaluating these hypotheses.

Research Design

Data were gathered through a large sample field survey that tapped responses from senior IS executives (CIOs) and business executives such as the CEO or other formal members of the top management team (Michel and Hambrick 1992, Wiersema and Bantel 1992). Separate questionnaires were developed for the CIO and the TMT members.

The sampling frame was developed by cross-listing firms from *Fortune 500, Service Fortune 500,* and *Business Week 1000* with the *IS Executive* database. The latter database was used to determine CIOs' names. TMT members were identified from the *Standard and Poor's Register of Executives.* This strategy resulted in a sampling frame of 1120 medium to large U.S. firms from eight industries, including manufacturing, transportation, utilities, retail, banking and financial services, petroleum, food, and insurance.

The CIO questionnaire was first mailed to CIOs of the sampled firms. After four weeks, a reminder was mailed in the form of a postcard; after another three weeks, a second wave of questionnaires was sent to the nonresponding firms. In all, a total of 235 usable responses were received, yielding a 21% response rate. Table 2 shows the titles of respondents who returned the CIO questionnaire. For these firms, a different questionnaire was sent to their TMT members. Ques-

Table 2 Characteristics of the Respondents

Title	Frequency (Percentage)
CIO Questionnaire	
Executive Vice President	5 (3%)
Senior Vice President	41 (17%)
Vice President	76 (32%)
Director of MIS	55 (23%)
Manager of MIS	30 (13%)
Other	28 (12%)
Total	235
TMT Questionnaire	
Chief Executive Officer	42 (16%)
Chief Financial Officer	45 (17%)
Chief Operating Officer	22 (8%)
Chairman	7 (3%)
President	22 (8%)
Executive Vice President	50 (19%)
Senior Vice President	25 (9%)
Vice President	42 (16%)
Other	10 (4%)
Total	265

tionnaires were mailed to at least three TMT members at each firm, including the person who was identified as the CIO's immediate superior. After two waves of reminders, questionnaires were mailed to other TMT members at the nonresponding firms. A total of 265 useable TMT questionnaires were received with a response rate of 32%; these responses represent 169 firms where a questionnaire was received from at least one TMT member. Two or more TMT responses were received from 83 firms. For these 83 firms, the averages of the multiple responses were used in the analysis. The only exception to this was for strategic IT vision where the highest-ranking respondent was used. Table 2 summarizes the titles of the TMT respondents. From this table, it is clear that about 80% of the respondents had the title of senior vice president or above.

The use of single responses at about half of the firms could raise concerns about whether the study really captured team and organizational phenomena. While respondents were only able to provide their personal perspective, the issues asked reflect "more objective" organizational and team phenomena. To test the consistency of the responses, correlations were computed on key constructs for those firms where two or more responses were received ($n = 83$). These correlations were significant for all of the six constructs: the CIO's business knowledge (0.41, $p < 0.001$); the CIO's strategic IT knowledge (0.32, $p < 0.01$); IT assimilation in business strategies (0.28, $p < 0.01$); IT assimilation in value-chain activities (0.30, $p < 0.01$); informal interactions of the CIO with TMT (0.36, $p < 0.001$); and the extent of the CIO's participation in TMT (0.35, $p < 0.001$).

To assess potential threats of nonresponse bias, the respondent and nonrespondent firms were compared on sales, net income, and the number of employees through data gathered from COMPUSTAT. While no significant differences were found relative to net income and number of employees, the subsample of responding firms was found to have significantly higher sales revenue than the nonresponding firms (t-statistic $= 2.04$, $p < 0.04$). These comparisons indicate that our study sample might be biased toward larger firms. Further, the distribution of responses across the eight industries was examined. The manufacturing industry was found to be slightly over represented in the respondent group and the transportation industry was slightly under represented.

The corporate strategy literature suggests that highly diversified firms exhibit a different set of dynamics in contrast with related or moderately diversified firms (Rumelt 1974). In our study, since the firm is the unit of analysis, the level of IT assimilation may not be homogenous across business units of highly diversified, or conglomerate, firms. In such instances, tapping the TMT or CIO perspectives about their firm's level of IT assimilation could be problematic since there might not be a uniform enterprise-wide pattern of IT assimilation. Therefore, conglomerate firms were eliminated from our sample. Rumelt's relatedness ratio (1974) was computed using a five-year COMPUSTAT data set on sales in years preceding the study's data gathering effort. This ratio is the fraction of firms' sales attributed to their largest group of related businesses. Related businesses were defined as those business segments in the same two-digit SIC category. Consistent with earlier studies, any firm whose relatedness ratio is less than 0.70 was defined as being a conglomerate, and it was eliminated from the sample (Palepu 1985). Such a process resulted in the elimination of seventeen firms from the sample of 169 responding firms.

Operationalization

Knowledge. CIOs were asked to indicate their TMT's IT-related strategic knowledge, whereas TMT respondents provided measures of the CIO's business and IT-related strategic knowledge. Items for each dimension of knowledge were adapted from an earlier review done by Jarvenpaa and Ives (1991); the specific items are illustrated in Appendix A. Each item was measured on a five-point Likert scale, with the cues ranging from "extremely well informed" to "not well informed." Factor and reliability analyses were conducted to assess unidimensionality and internal consistency of the items. As illustrated in Appendix B, these measures exhibit good psychometric properties.

The CIO's knowledge was assessed from the CIO's immediate superior. Therefore, in each sampled firm, one questionnaire was mailed to the TMT member who was also the CIO's immediate superior. CIOs

were asked to identify this individual. We were successful in obtaining responses from the CIO's immediate superior in 83 firms. For the remaining firms, the responses of other TMT members were used. To verify that there were no systematic differences in assessments of CIOs' knowledge by their immediate superiors and by other TMT members, we identified a subsample of 46 firms where both the CIO's immediate superior and another TMT member had provided responses. Correlations between the measures obtained from the immediate superior and another TMT member were significant: $r = 0.53$ ($p < 0.05$) for the CIO's business knowledge and $r = 0.29$ ($p < 0.05$) for the CIO's IT-related strategic knowledge.

Another important concern with using TMT members to evaluate CIOs' IT-related strategic knowledge is the bias that their own personal IT knowledge might have on their impressions of the CIO's IT knowledge. Members with high levels of personal IT knowledge might assess the CIO's IT knowledge differently from those who have low levels of personal IT knowledge. To assess the potential confounding influences of TMT respondents' personal IT knowledge on their assessments of the CIO's IT knowledge, TMT respondents were asked to rate their own knowledge about eight key information technologies (client/server computing, CASE, EDI, LANs, relational database management systems, imaging technology, object-oriented technology, and graphical user interfaces). These ratings were gathered on a five-point Likert scale, with the cues again ranging from "extremely well informed" to "not well informed." Factor and reliability analysis provided assurance that these items collectively tapped the construct of personal IT knowledge unidimensionally and with high internal consistency (Cronbach's alpha = 0.90).

The personal IT knowledge of TMT members was indeed found to be significantly correlated with their assessments of the CIO's IT knowledge ($r = 0.28$, $p < 0.01$). Therefore, as a next step, the distribution of scores on TMT respondents' personal IT knowledge was examined. More than half of the TMT respondents rated themselves as being "well informed" to "extremely well informed." Further, the average score of 3.37 on a five-point Likert scale, indicated that most of the sample of TMT respondents considered themselves to be well informed about IT. Five TMT respondents considered themselves to be "not well informed" about IT; therefore, their responses were dropped from the study's data set. Further, as will be described later, a sensitivity analysis was conducted to assess the robustness of the hypothesis testing results by dropping the responses of a larger proportion of TMT respondents, including those who rated themselves as only "somewhat informed" ($n = 57$).

Systems of Knowing. As illustrated in Appendix A, the hierarchical distance of the CIO from the CEO was measured by asking CIOs to indicate the position of their immediate superior. Next, the *Standard and Poor's Register of Corporations, Directors, and Executives* was consulted to assess the distance between the CIO's superior and the CEO. As an example, if the CIO reported to a senior vice president, and the archival sources showed the reporting chain to be CIO → Senior Vice President → COO and President → CEO, then the hierarchical distance would be three.

The extent of CIO participation in the TMT was assessed through a response from TMT members via a single-item question (Appendix A). The frequency of informal interactions was assessed from CIOs, using a five-point Likert scale (Appendix A). A similar assessment was also obtained from the TMT respondents; the two measures were found to be correlated ($r = 0.33$, $p < 0.01$). However, we used the CIO's responses, since individual TMT members might vary in their frequency of informal interactions with the CIO. On the contrary, the CIO might be in a better position to provide an aggregated response about informal interactions with the entire TMT.

Strategic IT Vision. TMT respondents were presented with a brief description of the four strategic IT visions that were derived from Feeny et al. (1992) (see Appendix A). They were asked to identify the vision that best described the business role of IT in their firm. When multiple TMT responses were received, the response of the highest-ranking TMT member was used in the analysis.

IT Assimilation. The focus of our research is upon understanding superior firm performance in the use of IT in value-chain activities and business strategies.

Therefore, we developed a set of items that described the use of IT in different value-chain activities and business strategies (Porter 1985, Porter and Millar 1985). TMT members were asked to first think of firms in their industry that they considered the most successful in applying IT for those activities and strategies. Relative to this ideal firm, they were asked to rate their own firm's performance. Our rationale is that senior business executives should be aware of their rivals and their relative success with different initiatives. By cueing them toward relative performance, we sought to ensure that our measures tapped the relative performance of firms on IT assimilation.

Responses were subjected to factor analysis to obtain three distinct dimensions: IT assimilation in business strategies, IT assimilation in marketing activities, and IT assimilation in logistics activities (Appendix B). Assessments of reliability using Cronbach's alpha provided assurance about the internal consistency of the scales (see Appendix B).

Data on IT assimilation were also gathered from CIOs using the same scales. Table 3 depicts the responses on the three dimensions of IT assimilation from both the TMT and the CIO respondents. As is evident, these responses are significantly correlated providing evidence of the validity of the data as capturing the organization-level IT assimilation. The TMT responses were used for model testing and analysis because of a potential concern that CIOs might overrate their firms' IT assimilation performance compared to business executives. This could be a legitimate concern since the CIOs are responsible and often evaluated for their firm's IT assimilation performance relative to competition. Therefore, they could be more biased in their assessments. We judged TMT members to be more "neutral" in their judgments about IT assimilation.

However, there is one potential concern with this approach: Will business executives be able to provide an assessment of the enterprise-wide assimilation of IT? Or, will their perspectives be shaped by their observations of a specific business unit or department? There are two reasons why we do not consider this issue to be problematic. First, as Table 2 illustrates, most TMT respondents (more than 80%) had titles that conveyed their role to be enterprise-wide rather than limited to a business unit or department (for example, chairman, CEO, president, COO, senior vice president, etc.). Being members of the TMT, these executives should possess an enterprise-wide perspectives about key issues, including IT assimilation. Second, as explained earlier in our discussion of the sampling strategy, we had eliminated conglomerate firms and included only those in the related diversification mode. Related diversification firms exhibit greater homogeneity across the actions of business units (Rumelt 1974). Therefore, we expect fewer discrepancies between the enterprise and business unit levels of IT assimilation in the firms in our sample. Overall, our ability to tap TMT members' perspectives about their enterprise assimilation of IT is a strength of the research design.

Table 3 **Means and Standard Deviations for CIO and TMT Respondents on IT Assimilation**

	TMT (N = 153)		CIO (N = 235)		
IT Assimilation	Mean	S.D.	Mean	S.D.	Correlation
Logistics Activities	6.44	1.56	6.41	1.71	0.305****
Marketing Activities	6.29	1.80	6.59	1.78	0.287****
Business Strategies	6.21	1.47	6.36	1.69	0.336****

Note. Responses are measured on a ten-point Likert scale with a score of 10 representing high levels of IT assimilation.

****$p < 0.0001$

Infrastructure Sophistication. CIOs were presented with a list of four key information technologies and asked to indicate the extent to which their firm had diffused these technologies into their organizational IT infrastructures (Appendix A). Factor analysis indicated that these responses loaded together onto a single construct with acceptable internal consistency (Cronbach's alpha = 0.70).

Organizational Size. COMPUSTAT data were gathered on three commonly accepted indicators of organizational size: sales revenue, net income, and number of employees. To smoothen out potential annual fluctuations in these indicators, three-year averages

were computed by extracting data for three years prior to the period when the survey data were gathered (1992–1994).

Analysis and Results

Out of the sample of 169 firms where we had complete responses, we eliminated firms that exhibited high diversification index (n = 17). Further, we also eliminated responses of TMT members whose personal IT knowledge was found to be "not well informed" (n = 5). These criteria resulted in a final data set of 153 complete observations.

Table 4a illustrates the means and standard deviations of different constructs for the overall sample and the subsamples of firms categorized according to their strategic IT visions. One-way ANOVA tests revealed significant differences in knowledge across firms with different IT visions. Subsequent pairwise contrast analysis showed that CIOs' IT and business knowledge were significantly higher in firms with a transform vision. No significant differences in knowledge were found among firms with the other three types of IT visions (automate, informate up, and informate down). Similarly, TMT's IT knowledge was found to be significantly higher in firms with a transform IT vision. Further, firms with a transform IT vision exhibited greater levels of formal CIO participation in the top management team. CIOs were located in greater organizational proximity (reporting relationship) to the CEO in firms with a transform vision. None of the other constructs exhibited significant differences across the IT visions.

Since our sample of firms was drawn from eight different industries, ANOVA tests were used to verify if there were any systematic industry effects on the research constructs. We did not find any significant differences indicating that industry differences did not affect the key research constructs. Therefore, we do not explicitly include industry as a control variable in our analysis models. Table 4b shows intercorrelations among the research variables. None of the pairwise intercorrelations exceed the product of the square roots of the Cronbach alpha coefficients of the respective constructs ($\alpha_i^{1/2}\ \alpha_j^{1/2}$, where i and j are the two constructs), thereby providing evidence of discriminant validity among measures of the constructs (Howell 1987, p. 121; Szulanski 1996).

The partial least squares (PLS) analysis method was used for hypothesis testing (Fornell and Bookstein 1982, Wold 1982, Löhmoller 1984). Knowledge and systems of knowing were implemented as formative constructs, whereas IT assimilation was implemented as a reflective construct. The entire data set was used to conduct analysis for Hypotheses 1 to 3 and 7 and 8. Hypotheses 4 through 6 were evaluated through analysis on the subsamples categorized according to IT vision. However, due to limited sample sizes in the automate and the informate up vision categories (n = 15 and 23, respectively), our analysis was performed only on subsamples representing the informate-down and transform visions (n = 53 and 62, respectively). PLS is considered to be particularly robust for such sample sizes and, therefore, appropriate as an analytic approach (Barclay et al. 1995). Further, since the PLS approach does not provide parameter estimates to evaluate the significance of the path coefficients, a bootstrapping approach was used to generate 250 random samples of observations from the original data set by sampling through replacement (each sample size was kept similar to the size of the original data set used for hypothesis testing). The path coefficients were reestimated using each one of these random samples of observations; as a next step, this vector of parameter estimates was used to compute the parameter means and standard errors. These statistics were then used to compute t-statistics as estimates of the significance of the path coefficients. Finally, the approach was replicated with 500 random samples of observations with replacement to assess the stability of the significance of the path coefficients. Such an approach provides valid estimates of the significance of the path coefficients in the PLS models (Mooney and Duval 1993).

Consistent with Hypothesis 1, the knowledge of the senior leadership team was found to significantly influence IT assimilation (Table 5). CIOs' business and IT knowledge were found to be significant influences, whereas TMT's IT knowledge did not prove to be significant. At the same time, all three indicators of IT assimilation were found to be significant. To further

Table 4a Summary Statistics (Means and Standard Deviations) on Research Variables

	Overall (N = 153)		Automate (N = 15)		Informate up (N = 23)		Informate down (N = 53)		Transform (N = 62)	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
CIO IT knowledge	3.77	0.72	3.31	0.87	3.73	0.51	3.63	0.73	4.05	0.67
CIO business knowledge	3.63	0.71	3.36	0.85	3.62	0.75	3.48	0.69	3.87	0.62
TMT IT knowledge	2.56	0.76	2.40	0.68	2.40	0.59	2.54	0.74	2.70	0.87
CIO's distance from CEO	2.85	0.72	3.00	0.92	2.75	0.71	2.70	0.76	3.07	0.60
CIO's participation	3.10	0.73	2.95	1.05	2.91	0.70	2.98	0.66	3.36	0.67
Informal interactions	4.21	0.71	4.18	1.25	4.08	0.86	4.14	0.62	4.35	0.54
IT assimilation in logistics activities	6.49	1.56	6.12	2.02	6.45	1.36	6.25	1.57	6.86	1.53
IT assimilation in marketing activities	6.27	1.81	5.75	2.41	6.30	1.81	6.08	1.70	6.60	1.78
IT assimilation in business strategies	6.24	1.54	6.25	1.76	6.12	1.23	5.89	1.44	6.69	1.59
Infrastructure sophistication	45.33	15.75	44.57	13.63	45.05	13.30	42.83	16.87	48.61	15.6
Sales revenue ($ millions)	3481	6384	2410	2990	1841	1883	4618	7292	3271	7061
Net income ($ millions)	165	294	296	408	117	255	178	311	153	277
Employee base (thousands)	16.52	26.04	11.62	10.24	11.37	12.03	22.0	34.0	14.17	22.78

Note. Boldfaced constructs exhibit significant differences in means across the categories of strategic IT visions. Pairwise contrast analyses revealed that the CIOs had significantly high IT and business knowledge in firms with the transform vision. Further, TMT's IT knowledge was significantly higher in firms with the transform vision. In firms with a transform vision, CIOs exhibited greater formal participation in the top management team and were located in closer proximity to the CEO.

explore the effects of CIO knowledge on IT assimilation, a median-split analysis was adopted: Firms were classified as being either high or low on CIOs' business and IT knowledge by using the median values as cutoffs. Table 6 illustrates IT assimilation in the four cells representing different combinations of CIOs' knowledge. Two-way ANOVA and pairwise contrast analyses were used to explore differences in IT assimilation across these cells. Firms where CIOs possessed high levels of business and IT knowledge exhibited significantly superior IT assimilation compared to firms in the other three cells. Further, firms whose CIOs possessed low levels of business and IT knowledge exhibited significantly low IT assimilation compared with firms in the other cells. However, there were no significant differences in IT assimilation between cells where CIOs rated high in either business or IT knowledge. These findings clearly suggest that CIOs must have high levels of *both* business and IT knowledge for enhancing IT assimilation.

No support was found for the hypothesized influence of systems of knowing on IT assimilation (Hypothesis 2). However, consistent with Hypothesis 3, a significant relationship was found between knowledge and the systems of knowing. Table 5 shows that CIOs' IT and business knowledge are significant elements in the relationship on the knowledge side, whereas the extent of CIOs' formal participation in the TMT and frequency of their informal interactions with the TMT are significant on the systems of knowing side. An additional examination of this hypothesis was conducted through a canonical correlation analysis between the multidimensional constructs of knowledge and the systems of knowing (Stevens 1986). The results revealed one significant canonical variate ($R_c = 0.86$; $p = 0.0001$) as evidence of strong association between the two constructs. Further, the loadings and weights of respective indicators of the two constructs revealed that the CIOs' IT and business knowledge were significant elements on the knowledge side, while the extent of CIO participation in the top management team was found to a significant element on the systems of knowing side. Cumulatively, these results suggest that the CIO's IT and business knowledge and their extent of participation in the top management team have significant associations with each other.

Table 4b Intercorrelations Between the Research Variables

	1	2	3	4	5	6	7	8	9	10	11	12
1. CIO IT knowledge	1.00	—	—	—	—	—	—	—	—	—	—	
2. CIO business knowledge	0.02	1.00	—	—	—	—	—	—	—	—	—	
3. TMT IT knowledge	0.05	0.17*	1.00	—	—	—	—	—	—	—	—	
4. Distance from CEO	0.06	0.01	0.17*	1.00	—	—	—	—	—	—	—	
5. CIO's participation	0.40**	0.32**	0.17*	0.32**	1.00	—	—	—	—	—	—	
6. Informal interactions	0.16*	0.17*	0.14	0.27**	0.37**	1.00	—	—	—	—	—	
7. IT assimilation in logistics	0.13	0.27**	−0.03	0.10	0.08	0.13	1.00	—	—	—	—	
8. IT assimilation in marketing	0.31**	0.34**	0.17*	−0.06	0.28**	0.003	0.003	1.00	—	—	—	
9. IT assimilation in strategies	0.37**	0.44**	0.14	0.06	0.37**	0.19*	0.58**	0.59**	1.00	—	—	
10. Infrastructure maturity	0.07	0.11	0.27**	0.04	0.07	0.06	0.13	0.17*	0.29**	1.00	—	
11. Sales revenue	−0.07	0.17	0.12	−0.16	−0.06	−0.09	0.13	−0.15	0.005	−0.02	1.00	
12. Net income	−0.04	0.05	0.14	−0.09	−0.09	−0.18	−0.05	0.06	−0.02	0.14	0.56**	1.00
13. Employee base	−0.04	0.30**	0.08	−0.12	0.02	−0.05	0.09	−0.14	−0.03	−0.08	0.80**	0.36**

*$p < 0.05$

**$p < 0.01$

Hypothesis 4 anticipates that the strategic IT vision will moderate the strength of association between knowledge and systems of knowing. Table 5 reveals that the path coefficient from knowledge to systems of knowing is highly significant only in the category of firms with the transform vision, but not in the firms with an informate down vision. Further, the CIO's business and IT knowledge along with their extent of formal participation in the TMT appear to be significant indicators in the relationship. These results support the assertion of Hypothesis 4 that the strongest relationship between knowledge and systems of knowing will occur in firms with a transform vision.

Hypothesis 5 postulates that the effects of knowledge on IT assimilation will be the strongest in firms that articulate a transform vision compared with firms that articulate the other visions. Table 5 shows evidence in partial support of this hypothesis. Knowledge was found to be a predictor of IT assimilation both in firms with transform and infomate-down visions. As explained earlier, limited sample sizes precluded us from testing this relationship in the case of firms with automate or informate-up visions. Hypothesis 6 anticipates that the effects of systems of knowing will be the strongest on IT assimilation in firms that have a transform vision. However, we did not find support for this hypothesis, since the relationship was not found to be significant in either the transform or the informate down visions.

Finally, as discussed earlier, we had identified one potential concern with the use of TMT members as sources of assessment of the CIO's IT knowledge: Would the TMT members' own level of personal knowledge bias their assessments of the CIO's IT knowledge? Recall that we had found a significant correlation between the TMT members' personal IT knowledge and their assessment of the CIO's IT knowledge. The analysis reported so far had, therefore, excluded the responses of TMT members who reported their personal IT knowledge to be "not well informed." Would the results of our hypothesis testing change if we adopt a more stringent criterion, viz., eliminating the responses of TMT members whose personal IT knowledge bordered on "somewhat informed" as well? To perform this sensitivity analysis, we removed a total of 57 responses, or 22 firms, from the original sample ($n = 147$). While space limitations preclude a detailed reporting of the analysis results, overall, we found that the results did not change significantly.[2] This sensitivity analysis provides additional evidence in support of the robustness of the study's findings.

[2]Results of the sensitivity analysis can be obtained upon request from the first author.

Table 5 Results of the PLS Models

Path Coefficients

	Path Coefficients		
Paths	Total sample (N = 153)	Informate down (N = 53)	Transform (N = 62)
Knowledge to Systems of knowing	.51 (.07)*	.31 (.23)	.68 (.08)*
Knowledge to IT assimilation	.53 (.09)*	.50 (.20)*	.51 (.20)*
Systems of knowing to IT assimilation	.08 (.11)	.08 (.27)	.19 (.23)
Infrastructure sophistication to IT assimilation	.19 (.06)*	.16 (.13)	.06 (.10)
Organizational size to IT assimilation	.10 (.12)	.01 (.19)	.14 (.25)

Loadings of the Indicator Variables

	Loadings		
Constructs and Indicators	Total sample (N = 153)	Informate down (N = 53)	Transform (N = 62)
Knowledge			
CIO IT knowledge	0.85 (.09)*	0.58 (.29)*	0.72 (.11)*
CIO business knowledge	0.86 (.09)*	0.72 (.25)*	0.72 (.14)*
TMT IT knowledge	0.02 (.10)	0.28 (.26)	0.10 (.17)
Systems of knowing			
Distance from CEO	0.08 (.13)	0.22 (.40)	.18 (.20)
CIO's participation	0.82 (.03)*	0.83 (.36)*	.94 (.07)*
Informal interactions	0.37 (.13)*	0.45 (.44)	.56 (.15)*
IT assimilation			
Logistics	0.57 (.11)*	0.64 (.20)*	0.54 (.17)*
Marketing	0.75 (.06)*	0.71 (.30)*	0.78 (.10)*
Strategies	0.96 (.02)*	0.95 (.11)*	0.96 (.04)*
Organizational size			
Sales	0.89 (.27)*	0.91 (.27)*	0.91 (.23)*
Income	0.42 (.32)	0.93 (.28)*	0.67 (.42)
Employee size	0.96 (.32)*	0.58 (.29)*	0.91 (.21)*

Note. Figures in parenthesis represent standard errors; all parameters marked by an * indicate significance at the 0.05 level

Consistent with Hypothesis 7, IT infrastructure sophistication had a significant influence on extent of IT assimilation. Finally, contrary to Hypothesis 8, organization size was not found to have significant impacts. Table 7 summarizes the results of our hypothesis testing.

Discussion of Results and Conclusions

This study examined the impacts of senior leadership and IT infrastructures on firms' assimilation of IT into their value-chain activities and business strategies. Further, the study also examined the moderating impact of firms' strategic IT vision. Following are the highlights of our study:

i. CIOs' business and IT knowledge have a significant synergistic relationship with their participation in their firms' TMT as well as the frequency of their informal interactions with other TMT members.

ii. CIOs' business and IT knowledge significantly influence their firms' IT assimilation; this influence was found to be significant across firms with both the transform and informate down visions.

iii. The sophistication of IT infrastructures has a significant influence on IT assimilation.

Table 6 **Exploring the Influence of CIO Knowledge on IT Assimilation**

		CIO IT Knowledge	
		High	Low
Cio Business Knowledge	High	Strategy = 7.28 (1.22) Marketing = 7.38 (1.56) Logistics = 7.17 (1.34) (N = 42)	Strategy = 6.08 (1.38) Marketing = 6.28 (1.65) Logistics = 6.56 (1.58) (N = 42)
	Low	Strategy = 5.96 (1.15) Marketing = 6.25 (1.30) Logistics = 6.14 (1.43) (N = 35)	Strategy = 5.26 (1.35) Marketing = 4.99 (1.86) Logistics = 5.66 (1.53) (N = 34)

Note. Figures in each cell indicate means and standard deviations for IT assimilation on a 10-point scale.

iv. Senior business executives' IT knowledge did not have a significant influence on IT assimilation.

v. Interactions between the CIO and members of the top management team did not have a significant influence on IT assimilation.

vi. Organizational size did not have a direct impact on IT assimilation.

We found evidence of a mutually reinforcing relationship between CIOs' business and strategic IT knowledge and their formal and informal interactions with top management team members. Knowledgeable CIOs can provide value-added and unique perspectives to other members of the top management team (Applegate and Elam 1992, Earl and Feeny 1994, Watson 1990). Therefore, they are more likely to gain formal membership of top management teams and avail of the frequent opportunities for informal interactions. At the same time, such interactions sensitize the CIOs to their firm's "business of the business," its value propositions, its long-term competitive challenges and opportunities, and the leverage points for application of current and emerging information technologies. As Earl and Feeny (1994) suggest, "It is only through dialogue with the CEO and other executives that the CIO can tease out the motivations, meanings, and priorities; know the mind of the business, sense the impending changes, and maintain the relevance and timeliness of the IS effort" (p. 14). Our findings about significant impacts of CIOs' formal participation in the TMT and the frequency of their informal interactions with other members of the senior leadership team are consistent with others recommendations (Earl and Feeny 1994, Feeny et al. 1992, Rockart et al. 1996). However, in contrast with Watson (1990), we did not find the CIOs' reporting relationship to be significant. In fact, only about 12% of the CIOs in our data set had a direct reporting relationship with their CEO. Watson did not examine the influence of alternative systems of knowing and focused only on the reporting relationship. Further, recent writings on IT management practice acknowledge that CIOs' participation on top management teams is more important than their reporting relationships (Earl and Feeny 1994).

Our study found CIOs' business and IT knowledge to be key influences on firm's IT assimilation. Absorptive capacity arguments suggest that CIOs' superior business and IT knowledge enable them to facilitate the "push-pull" dynamics of IT innovation and identify innovative ways for blending technology capabilities and business requirements (Zmud 1984). These results are consistent with the findings of previous studies, particularly, Boynton et al. (1994), Cooprider and Victor (1993), and Kaiser and Srinivasan (1982).

However, we did not find the TMT members' IT knowledge to be a significant influence on IT assimilation. Keen (1991) argues that top management teams must possess IT knowledge in order to enhance their understanding of the role of IT in their business activities and strategies and to ensure that they do not abdicate the IT assimilation responsibilities entirely to their CIOs or their IS staff. However, our results do not support this assertion. These nonsignificant results might in part be due to the nature of our sample. Recall that our sample of firms is biased toward large *Fortune 500* firms. In such organizations, senior business executives might not wish to replicate the high IT knowledge of their CIO, but rather rely upon a knowledgeable CIO for strategic guidance. In fact, Hambrick (1995) suggests that the top management teams' overall characteristics might have less predictive value; rather, the characteristics of the senior executive most responsible for specific organizational initiatives might have the strongest predictive power. Our study finds that IT assimilation will be most significantly impacted

Table 7 Summary of Hypotheses Testing

Hypothesis	Description	Result	Comments
1	Knowledge of the senior leadership team will significantly enhance firms' IT assimilation	Supported	CIO's business and IT knowledge significantly influenced IT assimilation.
2	Systems of knowing of the senior leadership team will significantly enhance firms' IT assimilation	Not supported	Systems of knowing do not appear to have a direct influence on IT assimilation
3	Knowledge will be significantly associated with systems of knowing of the senior leadership team	Supported	CIO's knowledge was significantly associated with their formal participation in the top management team and frequency of informal interactions with the TMT members.
4	The relationship between senior leadership's knowledge and systems of knowing will vary across IT visions.	Supported	Significant links found in firms with a transform vision but not in those firms with an informate down vision.
5	The influence of senior leadership's knowledge on IT assimilation will vary across IT visions	Partially supported	CIO's business and IT knowledge were significant influences on IT assimilation in firms with a transform and informate down visions. However, we could not test for firms with other types of visions.
6	The influence of senior leadership's systems of knowing on IT assimilation will significantly vary across IT visions	Not supported	Systems of knowing do not seem to have a direct impact on IT assimilation
7	The sophistication of IT infrastructures will significantly enhance IT assimilation in firms	Supported	Sophisticated IT infrastructures provide the base foundation for enhanced IT assimilation
8	Organizational size will significantly enhance firm's IT assimilation	Not supported	IT infrastructure sophistication could mediate the impacts of size on IT assimilation

not by raising the IT knowledge of the business executives; instead, firms must ensure that their CIO has high IT and business knowledge and that this individual is a formal member of the top management team.

Would similar results be found in medium size or smaller firms? Our research must be replicated in other samples to verify if similar dynamics would hold. Why do our results contrast with earlier studies that found the IT knowledge of business executives to be a significant influence on IT assimilation (Lind and Zmud 1991, Boynton et al. 1994, Cooprider and Victor 1993)? We argue that the prior studies have studied the influences of IT assimilation at the level of line management and IS staff, whereas our study is at the level of the top management team and CIOs. We suspect that the dynamics of knowledge and systems of knowing are different at these two levels.

Consistent with recent attention on IT infrastructures, we find support for the influence of IT infrastructure sophistication on IT assimilation. Firms that develop the base foundation of IT capability through investments in platform technologies, such as database management systems, LANs, EDI, and document imaging systems are more likely to foster IT use in their value-chain activities and business strategies. Interestingly, organizational size was not found to be a significant influence on IT assimilation. IT infrastructure sophistication is a more significant influence on IT assimilation. Of course, larger organizations are more likely to have the slack resources that are required for investing in sophisticated IT infrastructures.

One of the interesting nonsignificant findings is that the systems of knowing did not have a direct impact on IT assimilation. Instead, the constructs representing these systems of knowing had an indirect effect on IT assimilation through their impacts on CIOs' business and IT knowledge. These findings shed greater light on the role of CIOs' membership in top management teams and their informal interactions with senior business executives. Such interactions play a key role in enhancing CIOs' knowledge; therefore, future researchers should focus their attention on these indirect effects rather than the direct effects of systems of knowing on IT assimilation.

Finally, though we had anticipated that the strategic IT vision would present significant differences in impacts of knowledge and systems of knowing on IT assimilation, the results were mixed. With the caveat that we were able to test these moderating effects only in the transform and informate-down visions, we found that CIOs' knowledge influenced IT assimilation across both visions. However, we found a significant association between knowledge and systems of knowing only in the transform category and not in the informate-down category. Finally, while CIOs' participation in the top management team was found to be a significant element of the systems of knowing in both vision categories, informal interactions were significant only in the transform category. These results suggest that CIOs' knowledge has robust effects on IT assimilation across different vision categories. On the contrary, CIOs' membership in top management teams and their informal interactions with senior business executives have a strong influence on knowledge only when firms have a transform IT vision.

In order to assess the study's contributions, it is important to examine some of its limitations. First, we examined IT assimilation at the enterprise level. We recognize that many of the specific initiatives that comprise IT assimilation occur at the level of individual business processes, business units, or departments. Therefore, our enterprise-level measure might be a coarse representation of IT assimilation. However, since our sample of firms was deliberately restricted to firms in the related diversification mode and since our respondents were members of the top management team, our measures should be capturing valid aspects of the enterprise use of IT. However, we do recommend that future research should construct alternative measures of IT assimilation by focusing upon key business processes, business units, or departments. A second limitation of our research is the use of single-item questions for some of the constructs, specifically, the frequency of informal interactions. Future research should operationalize this construct in a more robust manner to identify if our operationalization might have limited the observed influence of informal interactions. In addition, some of the other measures were also based on single-item measures; future research should attempt to capture these variables, particularly strategic IT vision, through multiitem assessments.

Further, we acknowledge that the relationship between knowledge, systems of knowing, IT vision, and IT assimilation may unfold through mutual causation links. Our cross-sectional study does not permit an examination of this rich cycle of mutual causation. Similarly, while we examined the moderating role of IT vision, we do acknowledge that the level of knowledge, systems of knowing, and IT assimilation may facilitate a specific IT vision. However, it is important to emphasize that we did not hypothesize the IT vision to be a predictor, but rather to be a moderator. While our theory base seems appropriate for our investigation, it is clear that there is a fertile agenda for research on the relationships among these constructs that could benefit from adoption of alternative theoretical viewpoints and research designs. However, the strength of our study is its use of a large-sample size with responses gathered from both the CIO and the TMT members. Our study is one of the few large-sample studies to test the relationships between knowledge, systems of knowing, IT vision, and IT assimilation.

As mentioned earlier, single respondents provided data about top management teams in about half of the firms in our sample. The fact that there were significant correlations among the perspectives of TMT members in firms that had yielded multiple respondents gives some credence to the use of single respondents for the TMT. However, this still must be recognized as a limitation to the data.

Finally, our study does not examine the effects on business performance. IT assimilation is an appropriate dependent variable for examinations of IT management phenomena at the enterprise level (DeLone and McLean 1992, Boynton et al. 1994, Jarvenpaa and Ives 1991). Further, the productivity and business benefits of IT will be evident only when it has become a routinized element of business activities (Trice and Treacy 1986, Cooper and Zmud 1990). Therefore, an examination of the factors that facilitate higher IT assimilation is a significant contribution to our knowledge.

Implications of the Research

Our research empirically examined a variety of mostly normative prescriptions about the influence of senior

leadership and IT infrastructures on firms' ability to assimilate IT into their value-chain activities and business strategies. Collectively, when our findings are juxtaposed with earlier research on IT assimilation and innovation (Boynton et al. 1994, Cooprider and Victor 1993), we begin to discern the glimpses of an emerging theory of IT assimilation. This theory is multilevel and suggests that enterprise-level IT assimilation is influenced by three different factors: the knowledge of senior leadership, the knowledge of line management and IS staff, and the sophistication of IT infrastructures. Consistent with the findings of Sambamurthy and Zmud (1996), this theory suggests that IT assimilation emerges from two distinct arenas of action. First, IT assimilation is linked with the ability of line managers and IS staff to examine the synergistic opportunities for business use of IT and craft innovation ideas. Research by Cooprider and Victor (1993) and Boynton et al. (1994) suggests that these innovation actions require IS managers that are knowledgeable about the business and line managers that are knowledgeable about IT. However, such innovations are risky and consume significant organizational resources. Therefore, they require championship and executive support. Senior leadership's role becomes critical for such championship. Our study suggests that the executive support for IT assimilation actions is linked with CIOs' IT and business knowledge and their access to formal and informal interactions with other senior business executives of the firm.

Thus, there are two distinct sets of dynamics underlying increased IT assimilation in firms: (i) the actions and knowledge of line managers and IS staff and (ii) the actions and knowledge of senior leadership. Most of the previous research has focused on line managers and IT staff (e.g., Boynton et al. 1994, Cooprider and Victor 1993), CIOs (e.g., Applegate and Elam 1994, Stephens et al. 1994), or CEOs (Jarvenpaa and Ives 1991, Earl and Feeny 1994). In contrast, our study directs attention toward the importance of senior leadership. The senior leadership perspective integrates the knowledge and actions of the CEO, other senior business executives, and the CIO. It recognizes the contemporary business reality that leadership teams are more influential than individual executives are.

The above ideas extend the findings of McKenney et al. (1995) that sustained IT-based innovation requires a CEO who is willing to sponsor competitive use of IT, a technical visionary who can direct IT-based innovation activities, and a team that can implement innovations. Most of their case studies refer to innovations that occurred earlier than the mid-1980s; in contemporary contexts, the senior leadership team, consisting of the CEO, additional senior business executives, and the CIO, may be a more critical influence on firms' ability to assimilate IT.

Another important implication of our research is the finding that CIOs' business and IT knowledge are both essential for enhanced IT assimilation. Prior thinking about CIO knowledge has alternated between emphasizing their IT and business knowledge. Applegate and Elam (1994) described the preference toward hiring business executives as CIOs in some firms because of the desire to have CIOs who have high business knowledge. Yet, the growing complexities of IT infrastructures and the IT markets have begun to place a premium on IT knowledge as well (Weill and Broadbent 1998, Earl and Feeny 1994). Our results suggest that firms need CIOs who have high level of both types of knowledge. How are such CIOs to be found and nurtured? Future research should focus upon organizational mechanisms and CIO attributes that foster high levels of IT and business knowledge? For instance, Brown and Sambamurthy (1999) found that CIOs are increasingly adopting a new organizational mechanism, called the IT management council. This council consists of the CIO and other senior IS executives in the corporate IS and divisions. One of the key objectives of this council is to sensitize the CIO to the emerging IT issues and be the forum for development of IT strategies.

Finally, we found that sophisticated IT infrastructures foster greater IT assimilation. Interestingly, we did not find any direct effects of organizational size on IT assimilation; thereby raising the possibility that size might in fact confer the slack resources for building sophisticated IT infrastructures.

While these outlines of a theory of IT assimilation are based on empirical findings from our study and earlier research, there is a need for further validation of this theory. Further, we examined only one set of

structures for the senior leadership's systems of knowing : the top management team. Firms use other structures, such as executive councils for fostering greater interactions between the CIO and senior business executives (Rockart et al. 1996). Future research should examine the influence of these structures as well. Additionally, such a theory must be extended to account for IT assimilation within individual business units, functional departments, and business processes. Overall, we encourage other researchers to direct their attention toward this exciting research arena.

For practitioners, our study reinforces the growing recognition that IT assimilation requires a prominent role for CIOs in their firm's senior leadership. Further, such CIOs must have high levels of IT and business knowledge. Finally, sophisticated IT infrastructures provide the foundation for enhancing the assimilation of IT in firms' business strategies and value chain activities.

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Appendix A. CIO and TMT Questionnaires

CIO Questionnaire

Questions 1 to 4 focus on the view of IT held by your organization's top management team. Typically, top management team consists of the CEO and other senior executives responsible for the various functions and business groups (for example, the Executive Vice President, Chief Operating Officer, and Senior Vice President). Please circle the appropriate response for Questions 1–4.

1. On average, what is the frequency of informal contact between you and (other) members of the top management team?
   daily weekly monthly few times a year once a year

2. How knowledgeable is the top management team about potential and limitations of current IT?

   extremely knowledgeable very informed well informed somewhat informed weakly informed

3. How knowledgeable is the top management team about potential and limitations of "next generation" IT?

   extremely knowledgeable very informed well informed somewhat informed weakly informed

4. How knowledgeable is the top management team about how your competitors are applying IT?

   extremely knowledgeable very informed well informed somewhat informed weakly informed

For Questions 5 and 6, assume that a score of "10" would be assigned to that firm in your industry whom you personally view as being most successful in applying IT for that specific activity. Now, relative to this firm, indicate the score you would assign your firm.

5. How do you evaluate your firm's performance in applying IT to support each of the following business strategies relative to other firms in your own industry?

a. being a low-cost producer	1	2	3	4	5	6	7	8	9	10
b. having manufacturing/operations flexibility	1	2	3	4	5	6	7	8	9	10
c. enhancing supplier linkages	1	2	3	4	5	6	7	8	9	10
d. enhancing customer linkages	1	2	3	4	5	6	7	8	9	10
e. providing value-added services	1	2	3	4	5	6	7	8	9	10
f. enhancing existing products/services	1	2	3	4	5	6	7	8	9	10
g. creating new products/services	1	2	3	4	5	6	7	8	9	10
h. entering new markets	1	2	3	4	5	6	7	8	9	10

6. How do you evaluate your firm's performance in applying IT to execute each of the following activities relative to other firms in your own industry?

a. inbound logistics (e.g., purchasing)	1	2	3	4	5	6	7	8	9	10
b. outbound logistics (e.g. warehousing)	1	2	3	4	5	6	7	8	9	10
c. manufacturing/operations	1	2	3	4	5	6	7	8	9	10
d. marketing	1	2	3	4	5	6	7	8	9	10
e. sales	1	2	3	4	5	6	7	8	9	10
f. customer services	1	2	3	4	5	6	7	8	9	10

7. The numbers below indicate percentages. Please circle the appropriate percentage for each of the following:

a. enterprise data maintained within database management system	0	10	20	30	40	50	60	70	80	90	100
b. applications developed by your IS staff using fourth-generation languages or CASE technologies	0	10	20	30	40	50	60	70	80	90	100
c. microcomputers linked by LANs	0	10	20	30	40	50	60	70	80	90	100
d. documents maintained using imaging technologies	0	10	20	30	40	50	60	70	80	90	100
e. business transactions conducted with suppliers/customers using EDI	0	10	20	30	40	50	60	70	80	90	100

8. Which of the following best describes the senior IS executive's involvement with the top management team?

formal member frequently involved occasionally involved rarely or never involved

TMT Questionnaire

Questions 1 to 3 focus on your firm's senior IS executive. This person's responsibilities would be predominantly focused on directing the IT resources in your firm. The term top management team refers to the CEO, COO, CFO, and other senior executives responsible for the various functions and business groups. This group may or may not include the senior IS executive. Please circle the appropriate response for questions 1–3.

1. On average, what is the frequency of informal contact between members of your top management team and the senior IS executive?

daily weekly monthly few times a year once a year

2. For each of the following areas, please evaluate the level of knowledge of your firm's senior IS executive:

	extremely well informed	very well informed	well informed	somewhat informed	not well informed
a. Your firm's present and future products, markets, business strategies, and business processes	1	2	3	4	5
b. Your industry's practices	1	2	3	4	5
c. Your firm's competitors	1	2	3	4	5
d. How your competitors are applying IT in their business	1	2	3	4	5
e. How to utilize your IT infrastructure to address your firm's current business needs	1	2	3	4	5
f. How to identify relevant emerging IT for supporting your firm's products, markets business strategies, and business processes	1	2	3	4	5
g. How to guide your firm's decisions related to the timing and level of investment in emerging technologies	1	2	3	4	5

3. Which of the following best describes the senior IS executive's involvement with the top management team?

formal member frequently involved occasionally involved rarely or never involved

4. Please check the box that best describes the top management team's vision of the business role of IT.

☐ The role of IT is to replace human labor or at least transform its productivity. The potential of IT is cost saving or quality improvement.

☐ The role of IT is to provide data and transactions that allow more clear and organized management views of the state and dynamics of the business. The potential of IT is increased managerial control over the business.

☐ The role of IT is to provide data and transactions that yield a far fuller picture at the "operation" level and to provide members of the work force greater insights into their own activities. The potential of IT is employee driven performance improvements.

☐ The role of IT is to fundamentally alter our industry or organization through new products or business strategies often including redefinition of relationships with our customers and suppliers.

For Questions 5 and 6, assume that a score of "10" would be assigned to that firm in your industry whom you personally view as being most successful in applying IT for that specific activity. Now, relative to this firm, indicate the score you would assign your firm.

5. How do you evaluate your firm's performance in applying IT to support each of the following business strategies relative to other firms in your own industry?

a. being a low-cost producer	1	2	3	4	5	6	7	8	9	10
b. having manufacturing/operations flexibility	1	2	3	4	5	6	7	8	9	10
c. enhancing supplier linkages	1	2	3	4	5	6	7	8	9	10
d. enhancing customer linkages	1	2	3	4	5	6	7	8	9	10
e. providing value-added services	1	2	3	4	5	6	7	8	9	10
f. enhancing existing products/services	1	2	3	4	5	6	7	8	9	10
g. creating new products/services	1	2	3	4	5	6	7	8	9	10
h. entering new markets	1	2	3	4	5	6	7	8	9	10

6. How do you evaluate your firm's performance in applying IT to execute each of the following activities relative to other firms in your own industry?

a. inbound logistics (e.g., purchasing)	1	2	3	4	5	6	7	8	9	10
b. outbound logistics (e.g. warehousing)	1	2	3	4	5	6	7	8	9	10
c. manufacturing/operations	1	2	3	4	5	6	7	8	9	10
d. marketing	1	2	3	4	5	6	7	8	9	10
e. sales	1	2	3	4	5	6	7	8	9	10
f. customer services	1	2	3	4	5	6	7	8	9	10

7. Please rate your personal knowledge about the following information technologies:

	extremely well informed	very well informed	well informed	somewhat informed	not well informed
a. client/server computing	1	2	3	4	5
b. Local Area Networks (LANs)	1	2	3	4	5
c. imaging technology	1	2	3	4	5
d. Computer Aided Software Technology (CASE)	1	2	3	4	5
e. relational database management system	1	2	3	4	5
f. Electronic Data Interchange (EDI)	1	2	3	4	5
g. object oriented database	1	2	3	4	5
h. graphical user interface	1	2	3	4	5

Appendix B Operationalization of Some Key Constructs

Construct	Respondent	Items	Factor Loadings	Cronbach's alpha
Senior Leadership Knowledge				
CIO business knowledge	TMT members	Firm's present and future products and services	0.70	0.90
		Industry practices	0.85	
		Firm's competitors	0.88	
CIO IT-related strategic knowledge	TMT members	IT infrastructure to support firm's needs	0.80	0.87
		Relevant emerging ITs	0.90	
		Timing and investment strategies in emerging ITs	0.86	
		Competitor's use of IT	0.65	
TMT IT-related strategic knowledge	CIO	Potential and limitations of current ITs	0.90	0.84
		Potential and limitations of emerging ITs	0.90	
		Competitor's use of IT	0.80	
IT Assimilation				

Business strategies	TMT members	Being a low-cost producer	0.66	0.91
	CIO	Developing manufacturing/operations flexibility	0.79	
		Enhancing supplier linkages	0.69	
		Enhancing customer linkages	0.77	
		Providing value-added services	0.89	
		Enhancing existing products	0.89	
		Creating new products	0.81	
		Entering new markets	0.85	
Logistics activities	TMT members	Inbound logistics	0.89	0.92
	CIO	Outbound logistics	0.85	
		Manufacturing/operations	0.80	
Marketing	TMT members	Marketing	0.90	0.91
	CIO	Sales	0.91	
		Customer service	0.64	

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