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Information Technology Infrastructure Capability and Firm Performance: An Empirical Analysis

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Abstract

Information technology (IT) management capabilities have been noted in prior research as having a significant impact on firm performance. However, it is not clear how these capabilities impact firm performance. This research focuses in particular on one salient IT management capability, viz., IT infrastructure capability, and develops a conceptual model linking IT infrastructure capability with firm performance. The model identifies three dynamic capabilities that mediate the links between IT infrastructure capability and firm performance: customer management capability, process management capability, and performance management capability. Data from multiple firms and business units belonging to a conglomerate firm is utilized to empirically evaluate the hypotheses derived from this model. The results provide compelling evidence for the mediating effects of these dynamic capabilities. Further, our empirical tests suggest that the mediated effects model has more validity than a model that posits direct impacts of IT infrastructure capabilities on firm performance. These results have significant implications for future research and practice on how IT management capabilities contribute to the development of business capabilities and enhancement of firm performance.

Keywords*: IT Capability, Customer Management, Process Management, Performance Management, Firm Performance, Resource based view, Dynamic Capabilities.*

1. INTRODUCTION

Information systems researchers have empirically demonstrated that Information technology (IT) investments enhance firms' productivity, consumer welfare, and comparative advantage (Barua and Mukhopadhyay 2000). Further, other studies have demonstrated that IT management capabilities, or the managerial skills associated with acquisition, management and use of information technologies, have significant impact on business performance (Bharadwaj 2000; Santhanam and Hartono 2003). However, not enough attention has been devoted toward understanding how and why these investments and capabilities impact firm performance. Do IT investments and management capabilities directly influence firm performance, or are their effects mediated through other organizational capabilities? In her empirical investigation of the links between IT management capabilities and firm performance, Bharadwaj (2000) notes that, "although the analysis indicates that superior IT capability leads to improved firm performance, the underlying mechanisms through which this is achieved are by no means clear (p. 188)."

In an effort to expose the intervening causal mechanisms between IT management capabilities and firm performance, Sambamurthy, Bharadwaj, and Grover (2003) advocated a nomological network of factors that reflect the integration of IT into critical organizational processes and business capabilities. In particular, they conceptualized the organizational impacts occurring through IT-enabled agility capabilities and digitized organizational processes and knowledge management systems. Other researchers have argued that the true impacts of IT are felt through their complementarities with critical organizational processes (Barua and Mukhopadhyay 2000). Yet, empirical examinations of these mediating organizational factors are sparse and needed.

This paper draws upon the literature in information systems and quality management to hypothesize a conceptual model linking IT capabilities and firm performance. In particular, we focus attention on IT infrastructure capability, an important IT capability that has been conceptualized and examined in prior research (Bharadwaj 2000; Broadbent, Weill and St Clair 1999; Weill and Vitale 1999). We focus on IT infrastructure capability as the composite of IT components (including hardware, software, data storage and networks) and information, applications, and utilities delivered to business users from that foundation

of IT components (Broadbent, Weill and St Clair 1999; Keen 1997). Further, we identify three significant IT-enabled organizational capabilities: (i) Performance management capability, or the ability to develop appropriate monitoring, evaluation, and control systems to observe business performance and guide managerial actions (Bourne et al. 2002), (ii) Customer management capability, or the ability to develop significant customer relationships and nurture customers both as consumers as well as innovation partners in new product development (Nambisan 2002), and (iii) Process management capability, or the ability to develop processes with appropriate reach and richness for guiding manufacturing, supply chain, financial, and other important activities (Sambamurthy, Bharadwaj and Grover 2003). Utilizing data from multiple firms and business units belonging to a conglomerate group, we empirically test the conceptual model of mediating influences with multiple measures of organizational performance.

The remainder of the paper is structured as follows. Section 2 provides a description of the theoretical framework and research hypotheses. Section 3 describes the research design and methodology employed, and section 4 provides data analysis, results and discussion. Section 5 contains concluding remarks.

2. THEORY AND HYPOTHESES

Three streams of literature, information systems management, information technology value, and total quality management inform our research. In this section, we review relevant previous research in these streams of literature and present the theory underlying our hypothesized research model (Figure 1).

2.1 Information Systems Management Literature

The strategy literature, and the resource-based view of the firm in particular, provide the theoretical foundation for research in information systems management that has examined the links between IT capabilities and firm performance. In his analysis of the sources of firm comparative advantage, Makadok (2000) suggests that firms utilize resource-picking and capability-building mechanisms to sustain superior performance. Resource-picking mechanisms are associated with the superior procurement of rare, valuable, and inimitable resources, whereas capability-building mechanisms are associated with the integration of different resources with organizational structure, culture, and history to create inimitable capabilities. Relatedly, Grant (1996) argues that firms develop a hierarchy of capabilities, where the

initial capabilities are built through integration of resources, whereas higher-order capabilities are constructed through bundles of lower-order capabilities. Further, Teece, Pisano, and Shuen (1997) argue that the true locus of competitive advantage and superior firm performance lies in dynamic capabilities that again reflect the ability to configure higher-order capabilities, particularly in response to changing business environments and strategic opportunities.

Consistent with these ideas, information systems management researchers have conceptualized IT capabilities as associated capability-building processes and defined them as managerial skills for the acquisition, management, and use of IT in key business processes and strategies and include IT infrastructure capability, IS-business partnering, solutions delivery, vendor partnering, and strategic planning as key IT capabilities (Bharadwaj, Sambamurthy and Zmud 2002; Weill and Vitale 2002). Sambamurthy et al. (2003) proposed that IT capabilities are antecedents of higher-order business capabilities in the form of digitized processes, knowledge management systems, and agility capabilities.

The implication of this literature stream for the present study is that IT capabilities are necessary but not sufficient antecedents of firm performance. Higher-order organizational capabilities built through integration of IT and business processes might prove to be significant mediators of the links between IT capabilities and firm performance.

2.2 Information Technology Value Literature

While early studies about the business value of IT examined the direct connections between IT resources and firm performance, Barua et al. (1995; 2000) proposed a theory of IT complementarities to argue that the initial effects of IT should occur at the level of organizational processes that use the IT resources. Their theory suggests a two-stage process through which IT resources impact firm performance: first, IT resources could enhance the quality and efficiency of organizational processes where they are deployed; in turn, these IT-enabled processes enhance organizational performance. Subsequent empirical research has found support for effect of IT on intermediate business processes and how such business processes affect firm performance. For example, Mukhopadhyay, Rajiv, and Srinivasan (1997) found support for the beneficial impacts of IT on the quality and output of

organizational processes, whereas Barua, Konana, Whinston, and Fan (2001) found that increased digitization of key customer-facing and procurement processes enhanced organizational performance. Finally, Marchand, Kettinger and Rollins (2000) have recently elaborated the link between IT and firm performance. Based on a large sample survey of global firms, they concluded that three sets of factors explained these firms' continued success with the deployment of IT: (i) the quality of their information technology management practices (e.g., integrating IT into key operational and managerial processes), (ii) their ability to develop appropriate information management processes for sensing, gathering, organizing, and disseminating information, and (iii) their ability to instill desired information behaviors and values (e.g., proactiveness, sharing, integrity).

An implication of this stream of literature for the present research is that a two-stage model might best describe the links between IT capabilities and firm performance. Further, our model focuses on key IT-enabled processes as the mediators between IT capabilities and firm performance.

2.3 Quality Management Literature

Total quality management has been viewed as a "people-focused management system that aims at continual increase of customer satisfaction at continually lower real cost (Evans 1992, p. 8)." Recognized as a theory of organizational improvement, quality management embraces several concepts, including visionary leadership, organizational systems, process management, process outcomes, and customer satisfaction (Anderson, Fornell and Lehmann 1994). Many firms across the globe have embraced total quality management framework as a way to improve their performance (Chuan and Soon 2000). Empirical research has examined organizational payoffs from quality management programs. Easten and Jarrell (1998) found strong links between TQM and corporate performance in 108 firms that began TQM implementation in ten years since 1981. Hendricks and Singhal (1996; 1997) related the effective implementation of TQM program to market value and operating performance. However, Powell (1995) found that superior firm performance did not accrue just from the TQM features (e.g. quality training, benchmarking) per se, but from certain tacit and imperfectly imitable features such as open culture and executive commitment. Some studies have reported no gains from quality management programs as well

(Mathews and Katel 1992; Sterman, Repenning and Kofman 1997; The Economist 1992). Kaynak (2003) has reviewed these mixed findings and developed an integrative model to test the direct and indirect effects of quality management practices on firm performance. Based on a sample of 382 survey responses, he found that a positive relationship exists between the extent to which firms implement TQM and their performance. Further, his research confirms that different quality management practices are interdependent and, therefore, operate within a nomological network while influencing firm performance.

Realizing the imperative to think about quality management from a total systems perspective, the Malcolm Baldrige National Quality Improvement Act of 1987 offered a template for implementing a set of high-performance management practices, including customer-orientation, business process management, high levels of employee involvement and fact-based management (Das et al. 2000). This framework reinforces the nomological network perspective by emphasizing the tight interconnections between different elements, including information and analysis, process management, customer management, leadership, strategic planning, human resources management. Flynn, Schroeder, and Sakakibara (1994; 1995) provide empirical evidence about the validity of the individual dimensions captured within the Baldrige criteria.

Of particular significance for this research, this framework acknowledges that the management of information technology assets and information flows is a critical enabler of firms' success (Garvin 1987; Garvin 1991; George 1992). Black and Porter (1996) particularly emphasize that information technologies facilitate the availability of information in enabling the performance assessment systems for continuous improvement. In a survey of senior executives responsible for quality management from about 307 firms, Handfield, Jayaram and Ghosh (1999) found that information systems enhanced the effectiveness of business processes in those firms. However, they also note that there is need for more research that examines the role of information technology management in enabling some of the other quality management practices.

An implication of the quality management literature for the present research is that it directs attention to key organizational capabilities and processes that might mediate the links between IT capabilities and

firm performance. Further, the literature provides justification for examining some of these nomological networks within the context of Baldrige Quality Improvement initiatives in firms.

2.4 Theoretical Model and Hypotheses

Figure 1, derived through an integration of the three literature streams reviewed in the previous sections, illustrates the theoretical model for this research. Theoretically, the model is rooted in the dynamic capabilities perspective, whereby we focus on three organizational capabilities (performance management, customer management, and process management) as higher order capabilities enabled through a more fundamental IT capability: IT infrastructure capability. Drawing upon the literature reviewed before, we develop hypotheses linking IT infrastructure capability with firm performance through the mediating roles of the three organizational capabilities. The next few sections define the constructs and relationships in the proposed model.

---Insert Figure 1 about here---

IT infrastructure capability has been defined as the integrated set of reliable IT infrastructure services available to support existing applications and new initiatives in firms (Weill and Vitale 1999; Weill and Vitale 2002). Traditionally, IT infrastructure has been viewed as the foundation of IT components (i.e., hardware, software, and networks), whereas more recent conceptualizations extend IT infrastructure as including shared services, such as data, information, and standardized applications. Consistent with Marchand, Kettinger, and Rollins' conceptualization about information technology practices (2000), our research particularly focuses on IT infrastructure capabilities as: (i) the ability to provide data and information to users with the appropriate levels of accuracy, timeliness, reliability, security, and confidentiality; (ii) the ability to provide universal connectivity and access with adequate reach and range; and, (iii) the ability to tailor the infrastructure to emerging business needs and directions. IT infrastructure capability has been recognized as one of the key dimensions of IT capability in existing information systems research (Bharadwaj 2000; Ross, Beath and Goodhue 1996; Santhanam and Hartono 2003). Though other capabilities are important, our focus upon IT infrastructure capability is guided by the attempt to examine the nomological network around a salient and highly important IT capability; we

hope that this effort will stimulate empirical examinations around other salient IT capabilities in the future.

Organizational Capabilities. Consistent with the dynamic capabilities perspective and Grant's (1996) conceptualization of a hierarchy of capabilities, we propose that IT infrastructure capabilities enable three significant organizational capabilities that are drivers of superior organizational performance. These organizational capabilities are a result of the integration of organizational processes and activities with information technology to create digitized capabilities for the firm. These three organizational capabilities are customer management capability, process management capability, and performance management capability.

Customer management capability has emerged as a critical organizational capability in the contemporary business environments. This capability defines the ability of a firm to determine the requirements, expectations, and preferences of its customers and markets. Further, this capability reflects the quality of relationships with customers in terms of how well it is positioned to acquire, satisfy, and retain customers. Customer management capability has been advocated and demonstrated to be an important antecedent of firm performance because it enables firms to leverage the voice of the customer for gaining market intelligence and detecting opportunities for introducing new products, attracting new customers, retaining existing customers, and targeting new markets (Jaworski and Kohli 1993; Treacy and Wiersema 1997). Similarly, Nambisan (2002) argues that customer focus is important because customers serve three important roles: as source of innovation ideas, as co-creators in the design and development of innovative products and services, and as users in testing new products and services and acting as opinion leaders in attracting other customers as users.

Information systems are a critical enabler of firms' customer management capability. Ives and Learmonth (1984) were among the earliest researchers to propose a customer resource lifecycle (CRLC) model depicting how firms can deploy information technology tools to support different stages of their customers' purchasing process. Rathnam, Whinston, and Mahajan (1995) presented evidence about the enabling role of IT in improving the coordination among customer support teams. Karimi , Somers and

Gupta (2001) reported that firms with better IT planning and integration are more effective at managing IT for improving customer service. Most recently, Sambamurthy et al (2003) argued that capability-building processes and actions in firms tie IT infrastructure capabilities with the development of customer management capability. Better IT infrastructure capabilities enable firms to position their IT assets and data and information services to capture information about customers as well as disseminate information to customers through the Internet, virtual communities, and personalized information channels (Nambisan 2002). Consistent with our theoretical conceptualization, we expect that IT infrastructure capability will positively enhance the development of customer management capability as a higher-order dynamic capability.

H1 *Higher levels of IT infrastructure capability will enhance the customer management capability in firms.*

Process management capability is a second organizational capability that we depict as a mediating link between IT infrastructure capability and firm performance. Process management is firms' ability to attain flexibility, speed, and cost economy through the design and management of three major types of processes: (i) product design and delivery processes, including new product development and manufacturing; (ii) business growth processes, including innovation, research and development, supply chain management, supplier partnering, outsourcing, mergers and acquisitions, global expansion and project management; and, (iii) support processes, such as finance and accounting, facilities management, and human resources management. Process management has been recognized as a key dynamic capability for competing in the contemporary business environments and a superior source of organizational comparative advantage (Garvin 1991; Teece, Piasno and Shuen 1997). Even more importantly, the ability to manage the organizational portfolio of processes, including reconfiguring them for continued effectiveness, designing and utilizing appropriate metrics and controls, and applying them as strategic options, has emerged as an organizational imperative (Kalakota and Marcia 2003; Robinson, Tapscott and Kalakota 2000).

Information technologies are considered to be a significant enabler of process management capability (Davenport 1993; Davenport 2000). An empirical study in the retail banking industry by Frei et al. (1999) found that information technology minimized process variability by providing a common blueprint used by all workers in performing their jobs; this, in turn, enhanced organizational performance. Similarly, in the automotive manufacturing industry, Srinivasan, Kekre and Mukhopadhyay (1994) found that IT infrastructures enhanced process quality and output. Fisher, Raman and McClelland (2000) note that IT-enabled data accuracy is critical for ensuring efficient forecasting and to design agile supply chain management processes. Sambamurthy et al. (2003) argue that IT capabilities have a positive impact on the quality of organizational processes and the development of digital process capabilities. We argue that IT infrastructure capability offers the appropriate support for process management by providing the reach and connectivity to design and manage processes that connect the firm with its customers, suppliers, and other significant business partners (Davenport 1993). Further, a high level of IT infrastructure capability enables firms to design metrics and analytics to provide visibility into the real-time performance of various processes, the integration between the various processes, and advance warnings about performance degradation in processes (Kalakota and Marcia 2003). Finally, a high level of IT infrastructure capability enables faster and more responsive redesign and reconfiguration of processes in response to changes in business conditions. Therefore, we propose that:

H2 *Higher levels of IT infrastructure capability will enhance process management capability in firms.*

Performance management capability is the third organizational capability that we advocate as mediating the links between IT infrastructure capability and firm performance. Performance management capability describes firms' ability to design and manage an effective performance measurement and analysis system, including selection of appropriate metrics, gathering of data from appropriate sources of performance, analysis of data to support managerial decision-making, communication of performance to appropriate stakeholders, and alignment of the performance management system to the current and future business needs and directions (NIST 2002). Contemporary business environments have been

characterized as "sense-and-respond," where firms succeed through real-time synchronization of key strategic, tactical, and operational decisions with the challenges and opportunities available in the business environments (D'Aveni 1994). For example, an effective performance management system can enable a firm to detect deterioration in customer order fulfillment rates, understand the drivers of this problem, and experiment with alternative solutions. A good performance management capability enables firms to conduct "strategic experiments," whereby firms can evaluate the performance consequences of alternative product introduction, channel configuration, or supplier partnering decisions.

Information technologies are a significant enabler of performance management capabilities in firms. While the early focus of most information technology infrastructures was on automation, current information technologies offer the potential for "informating" the firm (Armstrong and Sambamurthy 1999; Schein 1992; Zuboff 1988). When appropriately deployed, IT infrastructures enable firms to gather electronic and real-time operational data of different kinds (customer-related, financial, supplier-related) from different sources (e.g., point-of-sales registers, internet, intranets, manufacturing plants, and third-party and other external sources). Further, well-developed IT infrastructures enable real-time analysis and decision support to provide the appropriate insights for different operational, tactical, and strategic decisions. Lederer and Mendelow (1987) highlight the importance of IT in synchronizing the objectives of upper management, middle management and other employees with firms' evolving goals and market conditions. Likewise, Porter and Millar (1985) note that: "By using information systems, companies can measure their activities more precisely and help motivate managers to implement strategies successfully (p.13)." Therefore, we hypothesize that a well-developed IT infrastructure capability will facilitate a superior performance management capability.

H3 *Higher levels of IT infrastructure capability will enhance the performance management capability in firms.*

Finally, our theoretical model hypothesizes that organizational capabilities will mediate the links between IT infrastructure capability and firm performance. We define firm performance as a multi-dimensional construct, comprising of: (i) customer-focused performance, including customer satisfaction

and product or service performance, (ii) financial and market performance, including revenue, profits, market position, cash-to-cash cycle time, and earnings per share, (iii) human resource performance, including employee satisfaction, (iv) organizational effectiveness, including time-to-market, level of innovation, and production and supply chain flexibility. Consistent with our theoretical foundations in dynamic capabilities and higher-order capabilities, we argue that organizational capabilities will enhance firm performance. Organizational capabilities are viewed as rent-generating assets that allow firms to earn super-normal returns (Barney 1991; Wernerfelt 1984). Our hypotheses are consistent with the arguments proposed by Sambamurthy et al. (2003) who also propose that organizational capabilities are more direct drivers of performance compared with IT capabilities. Thus, we hypothesize the following:

H4a. Higher levels of customer management capabilities will enhance organizational performance.
H4b. Higher levels of process management capabilities will enhance organizational performance.
H4c. Higher levels of performance management capabilities will enhance organizational performance.

Control Variables

As illustrated in Figure 1, we identify two other organizational factors as control variables in our models of organizational capabilities: quality of organizational leadership and strategic planning. Organizational leadership is defined as senior management's ability to balance expectations of customers and other stakeholders, set long-term and short-term direction, and create an environment for organizational innovation, experimentation, agility, and learning. Consistent with Sambamurthy et al. (2003), organizational leadership is an indicator of entrepreneurial alertness, or the ability to appreciate the value of important organizational capabilities as a platform for competitive strategy and the ability to marshal the necessary IT and business resources and lower-order capabilities for building these organizational capabilities. Ghoshal and Bartlett (1995) argue that one of the significant contributions of senior leadership is to articulate the organizational purpose and mission and nurture the development of organizational capabilities as a platform for competitive moves. Rosenbloom (2000) provides a rich description of the importance of leadership at NCR in its organizational transformation. Therefore, we

anticipate that organizational leadership will be an important influence on the development of organizational capabilities.

The quality of strategic planning is expected to be another key influence on the development of organizational capabilities. Strategic planning refers to the strategy making process, including analysis of customer needs, competition, technology, and strengths, weaknesses, and risks (Hamel and Prahalad 1995; Porter 1996; Porter 2001). A good strategic planning process provides a template for blending business and IT resources in the development of desired organizational capabilities (Segars and Grover 1999; Venkatraman and Henderson 1998). Therefore, we expect strategic planning to be an important control variable.

Note that both leadership and strategic planning could also be viewed as antecedents of organizational performance. However, our view is consistent with the theory of dynamic capabilities, whereby the primary influence of these factors occurs first in the development of organizational capabilities, and subsequently on performance.

Finally, consistent with previous research, we controlled for firm size and industry sector as control variables to account for any difference in firm performance attributable to organizational resources, slack or inter-industry differences (Capon, Farley and Hoenig 1990; Hendricks and Singhal 2001).

3. RESEARCH DESIGN AND METHODOLOGY

Data for testing the hypotheses were gathered from firms and business units within a large conglomerate that has about 80 companies with combined annual revenue in excess of $9 billion during 2002. These firms and business units operate in a wide range of industries, including manufacturing (such as steel, automotive, chemicals, consumer durables) and services (such as financial, telecommunications, and hospitality). More than 80% of the firms and business units in our sample have employees in the range of 200 to 20000. The firms varied in the extent to which they had adopted and assimilated ERP systems, supply chain platforms, data warehouses, process management tools, and helpdesk software such as call logging in their infrastructures. Therefore, their IT infrastructures varied in sophistication in terms of reach and range (Keen 1991). Most firms and business units had a website both for informational

purposes and transactional purposes. Some of the firms had won national and international awards for the design and excellence of their websites. Several business units reported use of Intranets to share knowledge among widely dispersed work groups. Overall, there existed enough variation in the IT infrastructure capability across these firms.

Data gathering for this study occurred in the context of the conglomerate's decision to adopt and institutionalize the Baldrige Quality award criteria and process for continuous improvement (NIST 2002). The Baldrige Quality framework includes all of the constructs in our research model and provides well-developed and validated descriptions for how to assess these constructs (Flynn and Saladin 2001; Handfield, Jayaram and Ghosh 1999). The first step in the process is for firms or business units to engage in self-analysis and report on their performance as well as the status of development of their key capabilities within the Baldrige framework. Detailed criteria are provided for firms to develop rich descriptions of their performance relative to each of the constructs in the Baldrige framework. Appendix A illustrates the questions that participating firms are required to think about while developing descriptions about their capabilities and performance. As a next step, multiple trained examiners independently review a firm's responses and allocate scores solely based on the detailed responses provided by a firm. Scores are assigned according to a well-documented approach, where the examiners focus on how appropriate the firms' practices as described are to the development of that capability and how well developed the actual capability itself is (NIST 2002). These evaluations are documented on a 100-point scale, where a low score is indicative of poor development of the capability (e.g., IT infrastructure, or customer management) and a high score is indicative of a high state of development. Once the examiners complete their initial scoring, consensus meetings are held where the independent examiners clarify their understanding through structured discussions with fellow examiners and arrive at a common score. Finally, these examiners make site visits and amend the consensus scores based on site inspection findings.

Some of the advantages of this examination process are that it is based on multiple sources of input (self-reports, discussion, and site visit) and that it uses external reviewers rather than solely relying on

self-reports from the executives of the firms. Further, a well-developed and validated training process for the examiners reduces biases or drifts in the scoring, and it enhances confidence that the scores are reflective of the true phenomena. Finally, the use of multiple examiners reduces the potential for mono-methods bias in measures of the antecedent and outcome constructs. Handfield et al. (1999) examined the detailed criteria for each construct and found good evidence of construct validity, discriminant validity, and reliability for the items for these constructs.

The conglomerate firm created a separate unit of full-time examiners and also invested resources in training and development of examiners at most of the firms and business unit. These examiners were responsible for applying the evaluation process described above and generating scores for the various firms and business units through scoring of self-reports, consensus meetings, and site visits. Our examination of the level of pairwise inter-rater reliability among examiners at this conglomerate found it to be in the range of 0.7-0.8. This range of inter-rater reliability is again an indicator of the robustness of the Baldrige examination process and training of examiners at our research site.

Based on the foregoing discussion, we believe that the data extracted from the Baldrige process provides a robust lens through which our research model may be analyzed. We obtained the data from the evaluations generated by these examiners for firms and business units within the conglomerate during 2002. Some of the firms in the conglomerate operated as multidivisional firms; in such cases, the individual units themselves participated in the Baldrige process and were evaluated independently. Thus, our data set includes fifty-two firms that were operated as complete entities and eighty-two business units in other firms that were evaluated as the unit of analysis in the Baldrige process. Overall, we obtained a sample size of 134 for our study.

Construct Operationalization

As mentioned before, Appendix A illustrates the items that comprised assessments of the scores for the different constructs used in this study. In all cases, our study used the final scores generated through the multi-stage process used by the examiners to evaluate each firm and business unit. Each variable was assessed on a scale of 0-100.

IT infrastructure capability (ITINF) was measured as an indicator of the quality of the hardware, software, and data architectures in terms of reliability and reach. In addition, this construct also assessed the appropriateness of the IT infrastructure to the business needs and directions. Among the organizational capabilities, Customer management capability (CUSTMGMT) was assessed as the ability to determine customer needs and requirements and to foster relationships with customers for effective acquisition, retention, and satisfaction. Process management capability (PROCMGMT) was assessed as the ability to design and manage product and service processes, growth processes, and support processes for agility, speed, and cost-effectiveness. Finally, performance management capability (PERMGMT) was measured through a focus on the ability to gather and monitor key performance metrics and the ability to link their analysis with decision-making.

We measured organizational performance on several dimensions: customer, financial, human resources and organizational effectiveness. Customer performance (CUSTPERF) was measured through the levels and trends in customer satisfaction, customer retention, positive referral and product and service performance parameters that are important to customers. Financial performance (FINPERF) was measured through trends in return on investment, profitability, liquidity, market share and business growth. Human resources performance (HUMPERF) was measured through employee satisfaction, employee development, job rotation, work layout and organizational learning. Finally, organizational effectiveness (ORGEFFECT) was measured through indicators of operational performance of key design, production, delivery, business and support processes such as productivity, cycle time, supplier performance and other indicators of accomplishment of organizational strategy.

In addition, the control variable, leadership quality (LEAD) was measured through a reference to the effectiveness with which senior leaders guide a business unit through values, directions, performance expectations and their review of organizational performance. Strategic planning quality (STRAT) refers to the strategic planning process in a business unit including strategy development and strategy deployment processes. Better score on this variable reflects that the organization has a well-designed process in place to consider various risks and opportunities in the short and long term and organization

has translated its strategic objectives into action plans and performance projections. Firm size (SIZE) was measured through an ordinal scale depending on number of employees in a firm or a business unit (1=0-200 employees, 2=200-2000, 3=2000-20000, 4=more than 20000). Finally, industry sector (INDUSTRY) of firms and business units was coded through an indicator variable where services were coded as one while manufacturing units were coded as zero.

Recall that our data sample had two sets of observations. One set of observations were for the firms, whereas another set of observations were for business units in multidivisional firms. We controlled for this difference in organizational unit through the use of the dummy term, GRUNIT, that assumed a value of 1 in case the observations were at the level of a complete firm, or 0 otherwise.

Table 1 provides summary statistics for the variables used in this study. The ranges show that there is adequate variation in scores across all of the constructs. Further, the mean values for organizational capabilities and firm performance are in the 30-45% range, compared to a potential maximum score of 100%, implying that there is no halo effects bias in the observed scores. Table 2 provides co-relations among key variables. Not only do the predictor and outcome variables show substantive inter-correlations that are consistent with our hypotheses, but also there are significant inter-correlations within the antecedents and outcome measures.

---Insert Tables 1 and 2 about here---

4. ANALYSIS AND RESULTS

We used a linear model estimation approach to relate IT infrastructure capability to organizational performance mediated through customer management, process management, and performance management capabilities. Our empirical models are shown below:

4.1 Organizational Capability models

$$PERFMGMT = \alpha_0 + \alpha_1 ITINF + \alpha_2 LEAD + \alpha_3 STRAT + \alpha_4 GRUNIT + \varepsilon_{1A} \quad (1A)$$

$$CUSTMGMT = \alpha_0 + \alpha_1 ITINF + \alpha_2 LEAD + \alpha_3 STRAT + \alpha_4 GRUNIT + \varepsilon_{1B} \quad (1B)$$

$$PROCMGMT = \alpha_0 + \alpha_1 ITINF + \alpha_2 LEAD + \alpha_3 STRAT + \alpha_4 GRUNIT + \varepsilon_{1C} \quad (1C)$$

4.2 Firm Performance Models

$$CUSTPERF = \beta_0 + \beta_1 PERFMGMT + \beta_2 PROCMGMT + \beta_3 CUSTMGMT + \beta_4 GRUNIT + \beta_5.SIZE + \beta_6 INDUSTRY + \varepsilon_{2A} \quad (2A)$$

$$FINPERF = \beta_0 + \beta_1 PERFMGMT + \beta_2 PROCMGMT + \beta_3 CUSTMGMT + \beta_4 GRUNIT + \beta_5.SIZE + \beta_6 INDUSTRY + \varepsilon_{2B} \quad (2B)$$

$$HUMPERF = \beta_0 + \beta_1 PERFMGMT + \beta_2 PROCMGMT + \beta_3 CUSTMGMT + \beta_4 GRUNIT + \beta_5.SIZE + \beta_6 INDUSTRY + \varepsilon_{2C} \quad (2C)$$

$$ORGEFFECT = \beta_0 + \beta_1 PERFMGMT + \beta_2 PROCMGMT + \beta_3 CUSTMGMT + \beta_4 GRUNIT + \beta_5.SIZE + \beta_6 INDUSTRY + \varepsilon_{2D} \quad (2D)$$

Due to recursive structure of our research model, it is possible to estimate each equation independently using ordinary least squares approach. However, the error terms of the individual equations in the organizational capability as well as firm performance models may be co-related because these equations pertain to the same business unit. We allowed for these potentially correlated errors to obtain consistent and efficient estimates of parameters through seemingly unrelated regression estimation (SURE) technique. The Breusch-Pagan test for independence of error terms across equations was rejected providing support for the appropriateness of SURE technique (Greene 2000). In order to obtain more precise estimates of our parameters in the performance models, we restricted the slope parameters within equations 1A-1C and 2A-2D to be equal (Brynjolfsson and Hitt 1996). Restricting the slope coefficients to be equal within the 1A-1C and 2A-2D equation systems allows more precise estimates as shown in column (1) of Tables 3 and 4. In order to check the robustness of our results, we also estimated SURE parameters without restricting slope parameters to be equal and obtained broadly similar results as shown in columns (2)-(4) of Table 3 and columns (2)-(5) of Table 4.

---Insert Tables 3 and 4 about here---

We tested for the standard assumptions of linear regression for all the models. We tested for multi-collinearity by computing the condition numbers (Belsley, Kuh and Welsch 1980). The highest condition

index in all cases was less than 30 indicating that multi-collinearity is not a serious concern in our analysis. We also tested for outliers and influential observations in our sample and did not detect any significant problems (Belsley, Kuh and Welsch 1980). We plotted the residuals obtained from our models and they showed normally distributed patterns.

We use the analytical approach suggested by Baron and Kenny (1986) to test for the mediation effects. We analyzed organizational capability mediated effects of IT capability using the Sobel's test (1982). The results of these tests based on constrained parameter models shown in column 1 of Tables 3 and 4 are presented in Table 5.

---Insert Table 5 about here---

4.3 Results

Hypotheses 1 through 3 predicted that the IT infrastructure capability would have a positive effect on the three organizational capabilities of customer management, process management, and performance management. As shown in Model 1 of Table 3 (constrained model), IT infrastructure capability was significantly related to customer management, process management, and performance management (coef=0.189, one-tailed t=3.72; p<.01). Models 2-4 in Table 3 show the effects of the IT infrastructure capability on individual organizational capabilities. These results suggest that IT infrastructure capability was significantly related to customer management (one-tailed t=1.50; p<.10), process management (one-tailed t =2.15 ; p<.05), and performance management (coef=0.325, one-tailed t=4.48; p<.01). Thus, we find support for all three hypothesized effects of IT infrastructure capability. At the same time, we observe that IT infrastructure has the strongest impact on performance management, followed by process management, and the least on customer management. Table 3 also shows that firm's leadership and strategic planning have significant influence on development of organizational capabilities.

Hypotheses 4a-4c predicted that organizational capabilities would have a significant impact on organizational performance. The results in Table 4 support these hypotheses. Model 1 shows that all three organizational capabilities have a significant effect on performance: customer management (coefficient=.24, p<.01), process management (coefficient=.24, p<.01), and performance management

(coefficient=.31, p<.01). Models 2-5 in Table 4 show the effects of the capabilities on individual component measures of firm performance. Customer performance is most significantly impacted by customer management capability (coefficient=.56, p<.01) and performance management capability (coefficient=.22, p<.05). Financial performance is impacted by process management capability (coefficient=.34, p<.01) and performance management capability (coefficient=.38, p<.01). Human resource performance was impacted by customer management capability (coefficient=.26, p<.05) and performance management capability (coefficient=.28, p<.01). Finally, organizational effectiveness is impacted by all three capabilities: customer management (coefficient=.31, p<.01), process management (coefficient=.29, p<.01), and performance management (coefficient=.33, p<.01). Among these results, it is clear that performance management capability significantly influences all dimensions of firm performance. However, we did not find statistical significance for the effects of customer management capability on financial performance. Further, we did not find statistical significance for the effects of process management on customer performance and human resource performance. In view of these specific non-significance results, we tested for the joint significance of all the organizational capabilities by applying Wald type tests. These Wald tests rejected the null hypotheses (β_1, β_2 and β_3 being jointly zero) at $p < 0.05$, providing evidence in support of the argument that, in concert, organizational capabilities of customer management, process management, and performance management have a significant influence on all the measures of firm performance even if it may be difficult to detect the significant impact of individual capabilities on firm performance.

Finally, since our nomological network model hypothesized that the effects of IT infrastructure capability would be mediated by organizational capabilities, we performed mediation analysis using Sobel tests (Baron and Kenny 1986; Sobel 1982). As shown in Table 5, we find that the effects of IT infrastructure capability on all measures of firm performance are mediated through customer management, process management, and performance management capabilities. We also tested for the extent of mediation by including IT infrastructure capability as a variable in the firm performance models. A non-significant effect of IT infrastructure capability on firm performance when controlled for

organization capabilities suggested that the effects of IT infrastructure capability on firm performance are *fully* mediated through organizational capabilities. These results are consistent with the theoretical reasoning linking IT capabilities with other organizational capabilities and firm performance as discussed in the theory section (Bharadwaj, Sambamurthy and Zmud 2002; Sambamurthy, Bharadwaj and Grover 2003).

6. CONCLUSION

The goal of this study was to extend existing insights into how IT management capabilities impact firm performance. Our theoretical arguments proposed that rather than directly impacting firm performance, IT management capabilities enable other significant organizational capabilities that, in turn, impact firm performance. Focusing our empirical efforts on a salient IT management capability, the IT infrastructure capability, we argued that three organizational capabilities in the form of customer management, process management, and performance management, would mediate the links between IT infrastructure capability and firm performance. Drawing upon data in the context of the utilization of the Baldrige quality process at the firms and divisions within a large conglomerate, we find support for the nomological network model that we proposed. Essentially, our results confirm that organizational capabilities mediate the impacts of IT infrastructure capabilities on firm performance.

Before examining the implications of these results, it is worthwhile to note the limitations of this research. First, we have restricted our focus to a specific IT infrastructure capability and three specific organizational capabilities. Though the results are significant, there will certainly be other important IT infrastructure and organizational capabilities. Future research could extend our nomological network model by incorporating other IT infrastructure capabilities, such as IS/line partnerships, IT planning, and vendor relationship management (Feeny and Willcocks 1998). Second, our dataset is limited to firms and divisions within a single conglomerate firm. Though one of the strengths of this design is it that it allows us to control the effect of factors such as organizational culture, there could be some concerns about the generalizability of the results. Future research is needed to extend tests of our model into other corporate and non-profit settings.

Our results have significant implications for research and practice. For researchers, our model and results point to the need to expand investigations about the performance impacts of IT management capabilities through nomological network models. Further, consistent with Sambamurthy et al. (2003), our research points to the role of IT management capabilities as enablers of dynamic organizational capabilities. In this regard, we offer evidence that IT management capabilities provide the base capabilities through which firms can build higher order capabilities. In turn, these higher order capabilities have a more direct relationship with firm performance. For quality management researchers, our research provides additional evidence about the relationships among the constructs embodied within the Baldrige quality process. Most existing research has focused on validating the Baldrige process and its constructs. We extend those studies by proposing and testing nomological models of inter-relationships among these constructs.

For managers, the fundamental implication of our study is the necessity to recognize the importance of IT infrastructure capabilities as an important capability that enables valuable dynamic capabilities. Given the uncertainties and concerns about how to value IT infrastructure investments, our research suggests that without well-developed IT infrastructures, firms will not succeed in developing the requisite customer management, process management, or performance management capabilities. Therefore, executives must think about IT infrastructure and other IT management capabilities as foundations of their firms' competitive capabilities. Further, such capabilities cannot be developed without well developed governance and coordination mechanisms for fostering joint business and IT attention toward IT management and organizational capabilities (Clark et al. 1997). Therefore, senior executives must examine how well their organization designs are promoting IT infrastructure capabilities.

In conclusion, while the need for understanding the role of IT on intermediate functional outcomes has been emphasized earlier, our empirical study is one of the first to identify the underlying mechanisms of how value is created through IT capabilities. Future research can extend our model to validate these mechanisms on quantitative business value measures such as profitability and shareholder returns. We

hope that our findings will also lead to new industry benchmarks on IT based functional performance in addition to the aggregate IT investment and productivity benchmarks already in vogue.

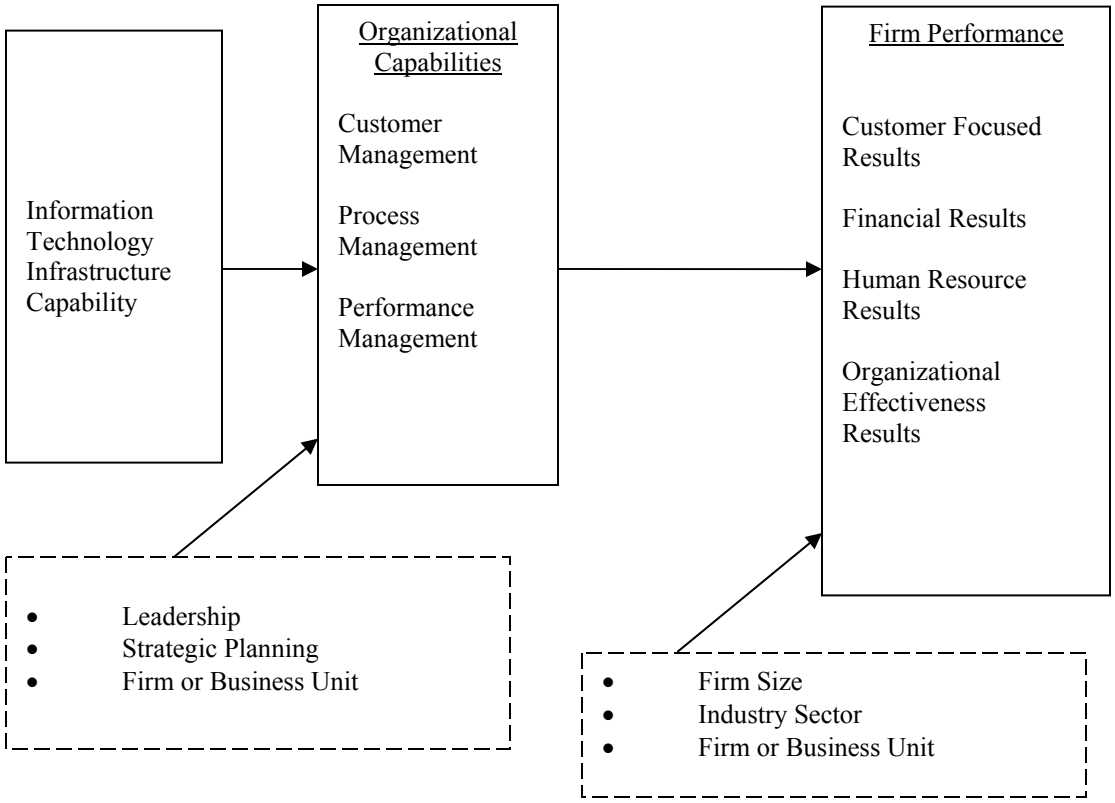

Figure 1. Research Model

Table 1. Summary Statistics for Key Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
LEAD	134	44.8	11.9	10.0	80.0
STRAT	134	36.9	11.9	10.0	70.6
ITINF	134	38.9	14.0	10.0	80.0
PERFMGMT	134	35.6	13.6	2.7	70.0
CUSTMGMT	134	41.8	12.2	15.0	72.4
PROCMGMT	134	41.3	11.7	8.0	70.0
CUSTPERF	134	31.7	13.5	0.0	60.0
FINPERF	134	35.9	12.9	10.0	70.0
HUMPERF	134	30.1	12.3	0.0	60.0
ORGEFFECT	134	35.1	13.8	0.0	70.0
SIZE	134	2.3	0.7	1.0	4.0
INDUSTRY (Services=1)	134	0.4	0.5	0.0	1.0
GRUNIT (Firm=1, Business Unit=0)	134	0.4	0.5	0.0	1.0

Table 2. Correlations Among Variables (N=134)

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	LEAD	1.00												
2	STRAT	0.79	1.00											
3	ITINF	0.67	0.71	1.00										
4	PERFMGMT	0.75	0.72	0.72	1.00									
5	CUSTMGMT	0.74	0.76	0.64	0.76	1.00								
6	PROCMGMT	0.74	0.74	0.65	0.70	0.76	1.00							
7	CUSTPERF	0.68	0.71	0.61	0.70	0.77	0.66	1.00						
8	FINPERF	0.56	0.64	0.58	0.57	0.52	0.59	0.53	1.00					
9	HUMPERF	0.72	0.63	0.55	0.69	0.70	0.65	0.77	0.57	1.00				
10	ORGEFFECT	0.76	0.70	0.66	0.76	0.77	0.74	0.81	0.57	0.81	1.00			
11	SIZE (Firm Size)	0.34	0.32	0.28	0.24	0.40	0.41	0.29	0.42	0.41	0.37	1.00		
12	INDUSTRY (Services=1)	-0.15	-0.14	-0.09	-0.06	-0.17	-0.20	-0.11	-0.10	-0.17	-0.21	-0.34	1.00	
13	GRUNIT (Firm=1, Business Unit=0)	-0.23	-0.20	-0.14	-0.27	-0.15	-0.09	-0.22	0.05	-0.21	-0.22	0.25	-0.13	1.00

Table 3. Parameter Estimates of the Organizational Capability Models *(p values are in parentheses)*

Model		1	2	3	4
Dependent Variable →		All measures of organizational capability[1]	Performance Management (eqn 1A)	Customer Management (eqn 1B)	Process Management (eqn 1C)
IT infrastructure capability	$\alpha 1$	0.189***	0.325***	0.104*	0.141**
		(0.000)	(0.000)	(0.062)	(0.016)
Leadership	$\alpha 2$	0.367***	0.403***	0.349***	0.352***
		(0.000)	(0.000)	(0.000)	(0.000)
Strategy	$\alpha 3$	0.322***	0.207**	0.419***	0.345***
		(0.000)	(0.023)	(0.000)	(0.000)
GRUNIT (Firm =1, BU=0)	$\alpha 4$	0.136	-3.882**	-1.950	2.040*
		(0.446)	(0.019)	(0.291)	(0.062)
Constant	$\alpha 0$	-0.094	-1.573	6.394**	6.465***
		(0.487)	(0.296)	(0.011)	(0.007)
N		134	134	134	134
R Sq		0.642	0.668	0.631	0.631
F		105.06***	64.92***	55.04***	55.11***

[1]All slope parameters are restricted to be equal across three measures of organizational capabilities (i.e. across equations 1A-1C).
* p<0.10; ** p<0.05; *** p<0.01 (one tailed tests)

Table 4. Parameter Estimates of the Firm Performance Models *(p values are in parentheses)*

Model		1	2	3	4	5
Dependent Variable→		All Measures of Firm Performance[1]	CUSTPERF (eqn 2A)	FINPERF (eqn 2B)	HUMPERF (eqn 2C)	ORGEFFECT (eqn 2D)
PERFMGMT	β_1	0.311*** (0.000)	0.217** (0.016)	0.380*** (0.000)	0.280*** (0.001)	0.333*** (0.000)
PROCMGMT	β_2	0.238*** (0.001)	0.129 (0.212)	0.339*** (0.005)	0.136 (0.167)	0.292*** (0.002)
CUSTMGMT	β_3	0.245*** (0.001)	0.556*** (0.000)	-0.084 (0.503)	0.265** (0.011)	0.306*** (0.002)
GRUNIT (Firm =1, BU=0)	β_4	-1.135 (0.322)	-2.056 (0.212)	3.555* (0.061)	-3.268** (0.037)	-2.806* (0.058)
INDUSTRY (Services=1)	β_5	-0.538 (0.627)	0.002 (0.999)	1.664 (0.364)	-0.822 (0.588)	-2.395* (0.095)
SIZE	β_6	2.288*** (0.008)	0.048 (0.969)	3.957*** (0.006)	3.368*** (0.005)	1.541 (0.168)
Constant	β_0	-3.961 (0.113)	-3.971 (0.257)	0.865 (0.830)	-2.567 (0.441)	-3.060 (0.331)
N		134	134	134	134	134
R Sq		0.597	0.632	0.462	0.595	0.714
F		64.65*** (0.000)	36.30*** (0.000)	18.15*** (0.000)	31.15*** (0.000)	52.82*** (0.000)

[1]All slope parameters are restricted to be equal across four measures of firm performance (i.e. across equations 2A-2D).

*** Significant at p<0.01; ** Significant at p<0.05; * Significant at p<0.10

Table 5. Mediation Analysis *(p values for the Sobel test are in parentheses)*

	1	2	3
	PERFMGMT mediated effect of IT Infrastructure Capability on	PROCMGMT Mediated effect of IT Infrastructure Capability on	CUSTMGMT Mediated effect of IT Infrastructure Capability on
Customer Performance	*** (0.008)	*** (0.009)	*** (0.004)
Financial Performance	*** (0.008)	*** (0.009)	*** (0.004)
Human Resource Performance	*** (0.008)	*** (0.009)	*** (0.004)
Organizational Effectiveness	*** (0.008)	*** (0.009)	*** (0.004)

*** Significant at p<0.01; ** Significant at p<0.05; * Significant at p<0.10

Appendix A: Brief Description of Key Baldrige Variables

Variable	Description
Information Technology Infrastructure Capability (ITINF)	…how your organization ensures the availability of high quality, timely data and information for all your key users-employees, suppliers/partners, and customers. …how you ensure that your hardware systems and software are reliable and user friendly so that access is facilitated and encouraged. ---how you keep your data availability mechanisms, software, and hardware current with changing business needs and directions.
Performance Management Capability (PERFMGMT)	…your organization's selection, management, and use of data and information for performance measurement and analysis in support of organizational planning and performance improvement. …The aim of the measurement and analysis is to guide your organization toward the achievement of key business results and strategic objectives.
Customer Management Capability (CUSTMGMT)	…how organization determines requirements, expectations, and preferences of customers and markets...how your organization builds relationship with customers and determines the key factors that lead to customer acquisition, satisfaction, and retention and to business expansion.
Process Management Capability (PROCMGMT)	..how your organization manages key aspects of your organization 's process management including customer focused design, product and service delivery, key business and support processes…how do you incorporate new technology including e-technology into products/services and into production/delivery systems and processes…what are key performance indicators used for control and improvement of processes…
Customer focused results (CUSTPERF)	…your organization's customer focused performance results, with the aim of demonstrating how well your organization has been satisfying your customers and delivering product and service quality that lead to satisfaction, loyalty, and positive referral.
Financial Results (FINPERF)	…your organization's financial and market results, with the aim of understanding your marketplace challenges and opportunities.
Human Resources Results (HUMPERF)	…your organization's human resource results, with the aim of demonstrating how well your organization has been creating and maintaining a positive, productive, learning and caring work environment for all employees.
Organizational Effectiveness Results(ORGEFFECT)	…your organization's other key operational performance results, with the aim of achieving organizational effectiveness, attaining key organizational goals, and demonstrating good organizational citizenship.
Leadership Quality (LEAD)	…how senior leaders set and deploy organizational values, short- and longer-term directions…how senior leaders communicate values, directions and expectations…how do senior leaders create an environment for empowerment, innovation, organizational agility, and organizational and employee learning…How do senior leaders review organizational performance and capabilities to assess organizational success, competitive performance, progress…how are organizational performance review findings translated into priorities for improvement and opportunities for innovation…how do senior leaders use organizational performance review findings to improve both their own leadership effectiveness…
Strategic Planning Quality (STRAT)	…how do you ensure that planning addresses the following key factors…customer and market needs, competitive environment, technological and other key changes, strengths and weaknesses, supplier and partner strengths and weaknesses, risks…how do you ensure that your strategic objectives balance the needs of all key stakeholders…

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