
Types of Information Technology Capabilities and Their Role in Competitive Advantage: An Empirical Study

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ABSTRACT: During the past two decades, both business managers and academic researchers have shown considerable interest in understanding how information technologies (IT) help to create competitive advantage for a firm. While recently the idea of competitive differentiation through IT has been challenged, this study contrasts the traditional thinking about competitive advantage with the resource-based view. Specifically, it is argued that by demarcating specific types of capabilities, we can contribute to better understanding of the sources of IT-based competitive advantage. Conceptually, we distinguish here between value, competitive, and dynamic capabilities as three distinct types of capabilities. Within each type, we identify specific capa-

bilities, such as quality of the IT infrastructure, IT business experience, relationship infrastructure, and intensity of organizational learning, and present a model that describes relationships between these capabilities and competitive advantage. We then empirically test the model using data collected via a national mail survey from chief IT executives from 202 manufacturing firms. While the quality of the IT infrastructure is hypothesized as a value capability and expectedly did not have any significant effect on competitive advantage, the quality of IT business expertise and the relationship infrastructure (competitive capabilities) did. The results of the study also indicate that the intensity of organizational learning (dynamic capability) was significantly related to all of the capabilities. These results point to the importance of delineating capabilities such as relationship infrastructure that can facilitate differentiation in the marketplace, and dynamic capabilities such as organizational learning as an important antecedent to IT capability building.

KEY WORDS AND PHRASES: competitive advantage, competitive capabilities, dynamic capabilities, firm performance, IT business experience, IT capabilities, IT infrastructure, organizational learning, relationship infrastructure.

THE ROLE OF INFORMATION TECHNOLOGY (IT) in creating corporate value has been the subject of much research over the past decade. Earlier research findings, discussed under the rubric of the "productivity paradox," indicated a weak relationship between IT investment and productivity. More recent studies have found positive and stronger linkages, and have attributed these to the improvement in business processes, practices, and structures needed to leverage technologies and better metrics to assess intangible IT benefits [13]. However, although the macro-level effect of IT is undisputed, a question remains on whether IT can provide *differential* benefits to individual firms.

The notion of differential benefits accruing from IT investments was the subject of much discussion in the mid-1980s as much-touted strategic systems were noted for their role in creating competitive advantage for their initiators [42]. However, recently, much controversy¹ in corporate boardrooms has been created by the assertions of Carr [15], in his article "IT Doesn't Matter." He argues that IT is ubiquitous, increasingly inexpensive, and accessible to all firms. As such, it cannot provide differential advantage to anyone, because it is scarcity (not ubiquity) that creates the ability to generate supernormal rents. He notes that IT is following the pattern of railroads and telegraphs, where, as a mainly replicable, standardized infrastructural technology, its benefits are accessible to all and cannot create competitive advantage.

We believe that such a position is dangerous, because its implications suggest that corporations reduce their IT investment and innovation, which in turn could have profound implications for IT governance. By not distinguishing between undifferentiated IT assets like the infrastructure, and the ability to manage these assets, Carr comes to the conclusion that firms cannot gain competitive advantage and should therefore assume a defensive and utilitarian posture with respect to IT.

Recently, some researchers have framed the discussion in terms of IT capabilities, and argue that managing IT is a capability that can create uniqueness and provide organizations a competitive advantage [8, 26, 48, 66]. Thus, despite uniformly high investments in technology, such organizational capabilities tend to be heterogeneously distributed across firms leading to differential business value to firms by improving organizational efficiency and effectiveness. We concur with this view and use it to systematically frame a model of IT capabilities and competitive advantage.

Our major motivation is not simply to add to the long tradition of studying IT and firm performance but to carefully examine what we consider reckless assertions by Carr. These assertions seem to have some resonance with nonthinking CEOs who see them as opportunities to reduce IT budgets in tight economic times. As scholars, we see our role as partially to engage in the debate rather than ignoring or dismissing it. And we can do so by going beyond expository methods and carefully studying the issue at hand.

Our research objective is simple: to study IT capabilities and their role in creating competitive advantage. In doing so, we add to prior work in a number of ways. First, we distinguish between three types of capabilities, and argue that one type will not be a source of competitive advantage. Second, we identify and develop measures for key IT capabilities that would lead to competitive advantage. Third, while most prior research uses secondary (financial or published) data to test relationships between IT and performance, we are the first study to use *primary* data from over 200 CIOs of corporations to test our model.

Perspectives on IT and Competitive Advantage

IN THIS SECTION, WE BRIEFLY PRESENT the evolution of thinking on IT and competitive advantage. The objective is to argue that the resource-based view provides the best vantage point for studying our research question, given the limitations of alternate perspectives. We call these the classical, economic, complementary resource, and resource-based theory perspectives.

The *classical* perspective describes competitive advantage in terms of positioning a firm in its industry context. Strategic systems are argued to be the tools that raise entry barriers, increase bargaining power with suppliers and customers, offer new products and services, or change the rules of the competition [49, 55, 56]. The advent of *economic perspectives*, like Williamson's [80] transaction-cost economics, framed competitive advantage in terms of asset-specific investments made by customers that create switching costs. Customers that make asset-specific investments in unique supplier-based IT, processes, or training are subject to switching costs that make it difficult to seamlessly transfer to another supplier [3, 22, 30, 31].

Despite this consideration, many strategic systems failed to sustain any competitive advantage due to imitation by competitors [42, 65, 67]. Further refinement in thinking explained this through the concept of complementary *resources* [22]. Even though competitors may duplicate a technology innovation, relative advantage can be created and sustained where the technology leverages some other critical resource.

Kettinger et al. [42] describe a number of such complementary resources, such as size, structure, culture, and so on, that could make it difficult for competitors to copy the total effect of the technology. The idea of such complementary resources is offered as an explanation of how IT has largely overcome its paradoxical nature and is contributing to business value. Brynjolfsson notes that "computerization does not automatically increase productivity, but it is an essential component of a broader system of organizational changes which does" [13, p. 49].

This view has been further refined through the newer *resource-based view* of organizations. Competitive advantage is rooted in the deployment and use of idiosyncratic, valuable, and inimitable resources and capabilities. Firms leverage two distinct strategic mechanisms: resource-picking and capability-building [47]. Resource-picking mechanisms create economic rents when firms apply superior information and knowledge to gain advantage from resources in the marketplace. Firms that have superior knowledge capabilities do better on acquiring resources and building capabilities. Capability-building refers to the ability of firms to build unique competencies and capabilities that can leverage their resources [73]. These capabilities are embedded, making them comparatively more valuable and inimitable, and therefore superior to resources as determinants of long-term performance. Firms are heterogeneous in developing and nurturing IT capabilities, therefore they are likely to have different potential in leveraging information systems (IS) for their competitiveness [4, 5, 53]. For rapidly changing environments, it has been argued that dynamic capabilities are needed for a firm to learn and configure its internal capabilities [73].

Whereas the earlier perspectives focused on external positioning and idiosyncratic protocols to retain that positioning, the more recent perspectives recognize the importance of firm resources and capabilities in creating competitive advantage. Table 1 summarizes the major tenets and limitations of the four perspectives.²

It is our contention that the resource-based view (RBV) provides a powerful framework for assessing Carr's assertions of IT and competitive advantage. Unlike many of the earlier strategic systems, today's modular and interoperable IT makes it difficult to establish switching costs based solely on idiosyncratic protocols. The RBV emphasizes the importance of building unique, inimitable, and heterogeneously distributed capabilities³ as the source of competitive advantage. Whereas Carr asserts that there is no uniqueness, inimitability, or heterogeneity possible with regard to IT assets, we argue that the ability to leverage these assets is indeed a strategic differentiator. By identifying the IT-based sources of competitive advantage, we can direct future research into the processes that develop these resources—providing directions for both practitioners and researchers on the leveraging of IT value.

IT-Related Capabilities

The question now becomes: What IT-related resources are important? Although there are a number of ways to categorize IT resources, distinctions based on the basic tenets of the RBV are most appropriate. What IT-based capabilities are valuable (i.e., have an effect on performance), heterogeneously distributed across companies (i.e., are

Table 1. Evolution of Four Perspectives on IT and Competitive Advantage

	Classical perspective	Economic perspective	Complementary resource	Resource-based view (adopted for this study)
Unit of analysis	Industry.	Transaction.	Firm.	Firm.
Major constructs	Five forces; generic strategies.	Asset-specific investments; switching costs.	Unique firm resources.	Valuable, rare, and immobile resources.
Thesis	Firms should develop their strategy around activities that give them an attractive position relative to competitors.	Customers are retained through switching costs created by asset-specific investments or the bargaining position of the supplier.	By creating or acquiring unique resource combinations, firms can differentiate themselves.	Firms create valuable, rare, and immobile resources through resource-picking and capability-building mechanisms.
Source of IT-based competitive advantage	The role of IT is in facilitating a superior position with respect to competitive forces, and thereby generating monopolistic rents.	IT can facilitate switching costs through proprietary protocols.	Relative advantage can be created and sustained where the IT leverages some other critical resource of the organization—particularly if that resource cannot be readily acquired.	Firms are heterogeneous in developing and nurturing IS capabilities, therefore they are likely to have different potential in leveraging IT for their competitiveness.
Limitations	Assumes firm structure as static and firms as homogeneous in their abilities.	Provides little insight on how firms can build differentiators or why they cannot be imitated. Too much reliance on idiosyncratic protocols as a source of advantage.	Provides little insight into the dynamics of how resources can be developed and leveraged.	
Implications for this study	These perspectives are less applicable in a dynamic environment with open IT architectures. Not useful in prescribing firm-level sources for competitive advantage.		By identifying specific IT-based resources and their implications for competitive advantage in contemporary environments, we can guide managerial decision making.	

not the same across companies), and imperfectly mobile (i.e., are difficult to acquire in resource markets or develop internally)? The latter factor is concerned with sustainability of competitive advantage, whereas the first two are necessary conditions for any advantage.

We first turn to empirical studies that examine IT resources and capabilities from an RBV perspective. As can be seen from Table 2, very few IT capabilities have been operationalized and examined for their effect on competitive advantage. Some studies use secondary data to assess the performance of firms rated as having high IT capabilities (in popular magazine studies such as *InformationWeek* and *Computerworld*) [8, 66], but do not directly assess capabilities. Others use primary data to assess a narrow set of capabilities such as strategic IT alignment [40] and expertise exploitation [19] or senior IT leadership [2]. However, most of these studies do not use competitive advantage as the dependent variable. An exception is the study by Dehning and Stratopoulos [26], which uses secondary data from *Computerworld* to assess IT capabilities and competitive advantage, and finds support for managerial IT skills as a source of advantage.

In this study, we empirically assess distinct IT capabilities and their relationship with competitive advantage of the firm. In doing so, this study contributes to the above stream in a number of ways. First, we distinguish between three sets of IT capabilities using the well-known edicts of the RBV—and argue that some IT capabilities will not be a source of competitive advantage as argued by Carr. Second, we draw from contemporary perspectives of the RBV by incorporating dynamic capabilities in the form of organizational learning. Third, we use primary data from a large sample of CIOs to assess the relationship between IT capabilities and competitive advantage. Fourth, we use both primary and secondary data to cross-check our assessment of the dependent variable. Below, we develop our hypotheses for three sets of capabilities, which we call value capabilities, competitive capabilities, and dynamic capabilities.

Value Capabilities

By drawing on the basic tenets of the RBV, we can classify IT capabilities into those that are characterized by value, heterogeneity, and imperfect mobility. The first two are necessary conditions for competitive advantage, whereas the latter is necessary for sustained advantage. In dividing capabilities, it is important to distinguish between those that have value and those that can be a source of competitive advantage. The first condition (value) is necessary for the second (competitive advantage) to occur.

There has been significant research on IT value—with numerous studies examining and finding a relationship between IT investments and business performance [13]. We would classify these as “value capability” studies and argue that investments in IT infrastructure fall in this category. *IT infrastructure* has been described as an important organizational capability that can be an effective source of value [8, 12, 63, 64, 78]. In today’s environment, a quality IT infrastructure can provide firms with the

Table 2. Empirical Studies That Examine IT Effect from a Resource-Based View

	IT capabilities assessed	Competitive advantage assessed?	Empirical approach	Major finding
Armstrong and Sambamurthy [2]	Size, quality of senior leadership and sophistication of IT infrastructure.	No	Primary data	Strong effect of CIOs' business and IT knowledge on IT assimilation.
Bharadwaj [8]	Conceptualized infrastructure, human IT, and intangibles, but none were measured.	Partially	Secondary data	Firms rated as having superior IT capabilities were found to have better financial performance with respect to a control group.
Christianse and Venkatraman [19]	Expertise exploitation.	No	Primary data from travel agencies	Exploitation of expertise and knowledge rather than lock-in is a major source of performance in interfirm relationships.
Ravichandran and Lertwongsatien [59]	IT capabilities (planning, system development, support, and operations) and their support for core competencies.	No	Primary data	IT capabilities are indirectly related to firm performance.
Dehning and Stratopoulos [26]	Managerial skills, technical skills, infrastructure.	Yes	Secondary data	Managerial skills are positively related to the duration of competitive advantage.
Santharam and Hartono [66]	Not explicitly assessed.	Partially	Secondary data	Firms rated as having superior IT capabilities were found to have better profit and cost ratios compared to the industry average.
Kearns and Lederer [40]	Strategic IT alignment and its process and content components.	Yes	Primary data	The extent to which the IT plan reflects the business plan is related to competitive advantage.

ability to share information across different functions, innovate, and exploit business opportunities, and the flexibility to respond to changes in business strategy [79]. However, the existence of open architectures and standardized enterprise packages suggest that this capability might not be heterogeneously distributed across firms—or, even if it is, that access to infrastructure is not restrictive [16]. Therefore, despite some contrary evidence [18] from data in the early 1990s, IT infrastructure is argued to be valuable but not a source of competitive advantage.

Hypothesis 1: The quality of the IT infrastructure will not be related to the competitive advantage of the firm.

Competitive Capabilities

The second category, which we call “competitive IT capabilities,” includes IT management capabilities. We include two capabilities here: the *IT business experience* (extent to which IT groups understand business) and the *relationship infrastructure* (extent to which there are positive relationships between IT and business managers). We argue that such capabilities are not only valuable but heterogeneously distributed and difficult to transfer. Mata et al. [48] provide two reasons why such managerial IT capabilities are likely to be the major source of competitive advantage. First, they evolve through history and “learning by doing,” making these experiences very heterogeneous across firms. For instance, friendship, trust, and interpersonal communication take years to develop and to reach the point where IT and business functions can work together effectively. Second, the relationship between IT managers and those in other business functions develop over years, are socially complex, and involve a number of minor decisions over time. This makes it difficult to observe and imitate causal influences that might lead to positive outcomes.

IT Business Experience

Sambamurthy and Zmud [65] argue that IT business experience allows a firm the ability to integrate IT strategy and business strategy, develop reliable and cost-effective systems for the business, and anticipate business needs sooner than the competitors. Keen [41] views the competitive advantage of firms as largely attributable to the business judgment and technical skills of IT groups and top management. Ross et al. [63] posit the importance of the IT groups that possess both technical and business problem-solving skills. Clark et al. [20] note that IT groups’ business expertise, in combination with IT skills, directly determines the firm’s ability to rapidly develop and deploy critical systems for the long-term competitive advantage. Kearns and Lederer [40] found that the extent to which the IT plan reflects the business plan is a significant antecedent to competitive advantage.

Therefore, whereas physical assets and tangible resources can be replicated by competitors, long-term advantage in the market often depends on the expertise of the people in the organization. Firms that have IT groups with superior knowledge about

business strategy, competition, and opportunities can continue to leverage them based on their absorptive capability [23]. That means if a firm begins with superior knowledge, it is likely to gain further knowledge because of its prior knowledge. Thus, based on the RBV of the firm, IT business experience is inimitable to competitors; therefore, a firm that possesses superior IT business experience will likely gain the advantage.

Hypothesis 2: Higher quality of the IT business experience will have a positive effect on the competitive advantage of the firm.

Relationship Infrastructure

Relationship infrastructure reflects the ability of the IT group to understand business needs and create a partnership with business groups to work together to meet them and exploit new business opportunities. The ability of a company to leverage IT resources critically depends on the interaction of the IT function with the business units [7].

The relationship infrastructure consists of sharing risk and responsibility of IT application between IT and business unit management [63]. Only business units are in a position to effectively utilize IT in their strategy and everyday work. Therefore, in order to make effective use of IT, the IT responsibilities and roles should be shared between line management and IT management [62]. Unless line management and IT groups can coordinate their responsibilities and accountabilities, the firm is unlikely to acquire, deploy, and leverage its IT resources effectively [61, 65]. One major component of the relationship infrastructure is the trust that is developed between IT groups and business units [50]. Because development of trust takes time, thus, according to Barney and Hansen [6], the relationship infrastructure constitutes a source of competitive advantage for the firm. We posit that once an organization succeeds in forming trust between IT groups and business units, their interaction enables knowledge flow and knowledge diffusion throughout the organization, which is likely to bring a greater appreciation for each unit's work, expertise, and roles in the organization [50].

Hypothesis 3: Higher quality of the relationship infrastructure will have a positive effect on the competitive advantage of the firm.

Dynamic Capabilities

Although infrastructure and managerial IT capabilities are important, we also need to recognize the dynamic nature of both the IT and competitive environment. The concept of dynamic capabilities reflects the importance of renewal of *organizational* capabilities "so as to achieve congruence with the changing business environment" [73, p. 515]. Superior IT capabilities described above allow firms to respond quickly to environmental threats and leverage opportunities. This broader organizational capability captures the ability to search, explore, acquire, assimilate, and apply knowledge about resources, opportunities, and how resources can be configured to exploit opportunities. Firms that are involved in such knowledge activities have greater absorptive

capacity [23] and can build and renew organizational capabilities, which could be a source of competitive advantage [38, 44]. We frame this construct as *the intensity of organizational learning*, which involves accumulation, sharing, and application of knowledge [23; 36, p. 90; 81]. Unlike the capabilities described earlier that are IT capabilities, this is an organizational capability. Learning is a dynamic concept and its use in theory emphasizes the continually changing nature of organizations [70, 81]. We argue that it could be heterogeneous across firms, and thereby also a source of competitive advantage in contemporary environments where awareness and responsiveness buttressed by knowledge activities are pivotal.

Since the development of IT capabilities requires learning and experience, the intensity of learning is instrumental in facilitating this. For example, Neo [51] found that firms that were successful in IT implementations had already implemented similar systems in the past and had accumulated experience. Similarly, Cash et al. [17] argue that an IT infrastructure evolves through learning and assimilation of a firm's information requirements. Exploration of the environment can facilitate the ability to build appropriate capabilities. Research has also shown that development of IT skills, embedded into specific business practices, requires knowledge assimilation over time [7, 48]. Sambamurthy and Zmud [65] argue that technical and business skills evolve through learning by doing. Bharadwaj [8] argues that creating cordial relationships between IT groups and line management might take several years. Often, IT projects that are delivered quickly to meet the business needs require continuous interaction and communication between IT groups and other functional groups. Therefore, firms that have strong learning capabilities can leverage feedback cycles of experience more effectively, thereby building stronger IT capabilities. Recently, Zhang and McCullough [81] found support for the influence of organizational learning on IT capabilities.

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

In the present competitive and dynamic environment, a number of firms are placing a strong emphasis on learning, because they are convinced that learning contributes to the effectiveness of their resources and capabilities for their competitiveness [58]. The intensity of learning is considered to increase an organization's problem-solving capacity and its behavior in ways that lead to improved performance at the individual, team, and organizational levels. Senge [69] argues that one source of competitive advantage in the present global environment is the ability and rate at which an organization can learn and react more quickly than its competitors. Mabey and Salaman [45] have shown that the intensity of organization learning is a key variable in determining profitability. Huber [36, p. 92] suggests that learning leads to the acquisition of useful knowledge for competitive advantage of the firm.

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

Research Model

IN SUM, THE STUDY PRESENTED HERE provides empirical data to examine the effect of three factors—IT infrastructure, IT business experience, and relationship infrastructure—on competitive advantage at the firm level. In addition, the study examines a broader antecedent, the learning intensity of the organization, as an important driver of capabilities and competitive advantage. The research model is described in Figure 1. The model posits that competitive advantage is based on the ability of a firm to learn, develop, nurture, and exploit IT. Such advantage could be the result of superior understanding of how IT can add business value as well as how to effectively deploy it. The intensity of organizational learning is critical, as it enhances the absorptive capacity of the firm and helps reassess and renew the current state of competence. We thus untangle the relative effect of different factors associated with IT capabilities and competitive advantage, and reexamine assertions made by Carr in light of our results.

Methodology

Data Collection

UNLIKE PRIOR WORK THAT HAS MOSTLY RELIED on secondary data, this study used survey data. An instrument was targeted at 1,200 senior IT executives (CIO, vice president of IT, director of IT) randomly selected from a directory of 3,000 manufacturing firms supplied by a marketing vendor. The senior IT executive is the appropriate respondent, being well versed with organizational capabilities pertaining to IT as well as competitive positioning of the organization. This is consistent with Huber and Power's [37] recommendation that, in the case where one respondent per unit is solicited, it should be the most informed respondent. There were 202 usable responses received, resulting in about a 17 percent response rate. This low response rate is not uncommon in the IS area, as it reflects the challenges in obtaining responses from top management [32].

Sample

Our sample represented a wide range of manufacturing companies. Twenty-five percent of manufacturing firms were in computer/electronics; 25 percent were in heavy machinery and automobile; 17 percent in chemical/pharmaceuticals; 13 percent in industrial and farm equipment; and the rest in forest/wood, home assemblies, and leather manufacturing business. The annual revenues of the firms in the sampling frame ranged from \$50 million to \$140 billion.

We conducted a chi-square test to determine whether responses varied by the manufacturing sectors and their revenues. No significant differences in chi-square at the 0.05 level were noted, which suggests that perceptual measures of IT capabilities and

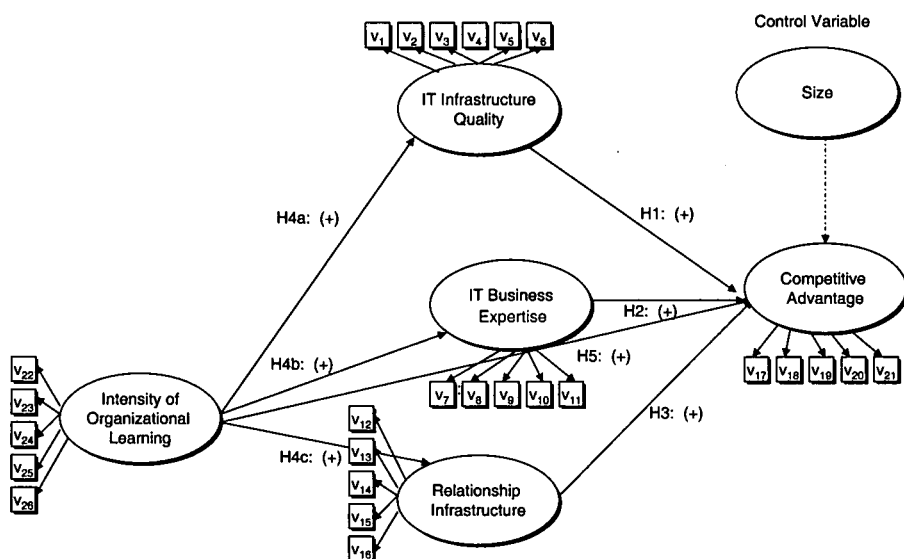


Figure 1. Conceptual Model

competitiveness are not biased by variations in the manufacturing sectors and their revenues.

Operationalization

Table 3 shows the operationalization of variables. All of the questions were asked from a scale ranging from 1 to 5, where 1 refers to the lowest score in the measure and 5 the highest. The scales for various constructs were adopted from a review of the past IS management literature. If existing measures were not available, a list of items covering the domain of the variables under the investigation was developed. Sources of the items used are depicted in the table.

Regarding the dependent variable, several researchers have used perceptual measures for business value, productivity, or profitability (e.g., [57, 72]). In discussing the choice of outcome variables, Wade and Hulland [77] suggest that any dependent variable in an RBV study needs to exhibit three key attributes: (1) it should provide an assessment of performance, (2) it should incorporate a competitive assessment element, and (3) it should address the notion of performance over time. In this study, we used absolute and relative assessments of a number of dimensions of financial performance with respect to competition over a period of three years. Items were consistent with Spanos and Lioukas's [71] empirical study of the RBV and have been shown to correlate strongly with the traditional objective measures [76].

As recommended by Tourangeau et al. [75], we took precautions in improving scale items—simplifying the items, avoiding double-barreled questions and ambiguous terms. Since our items were targeted to the IT professionals and the questions were specific enough, we believe that this could have reduced method variance.

Table 3. Operationalization of Constructs

Constructs	Dimensions	Indicators
IT capabilities	IT infrastructure.	The extent to which systems (1) are compatible [34, 41], (2) are modular [9, 46], (3) are scalable [41, 46, 62], (4) are transparent [10, 29], (5) are the extent to which systems can handle multiple applications [14, 62], and (6) use commonly agreed IT standards [35, 62, 63].
	IT business experience.	The extent to which IT groups are knowledgeable about (1) business strategy [24, 43, 62], (2) competitive priorities [43, 63], (3) business policies [13, 30, 63], (4) business opportunities [11, 43, 62, 63, 74], and (5) initiate change in the organization [24, 43, 62].
	Relationship infrastructure.	The extent to which IT groups and line management (1) trust [63], (2) appreciate [63], (3) consult with [63], (4) account for [63], and (5) respect each other in setting business and IT strategy [63].
Competitive advantage of the firm	Relative performance with respect to the competitors for the past three years.	Financial performance [57, 71] and sales growth [57].
	Performance for the past three years.	Profitability, financial performance [57], and sales growth [57].
The intensity of organizational learning	Knowledge exploration.	The ability of the firm to (1) search [36] and (2) acquire new and relevant knowledge [36].
	Knowledge exploitation. Focus.	The ability of the firm to (1) assimilate [36] and (2) apply relevant knowledge [25, 52]. The extent of concerted efforts for the exploitation of existing competences and exploration of new knowledge [25, 69].

Reliability Analysis

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

LISREL was used for data analysis because of its advantages over other techniques. Following Gerbing and Anderson's [33] work, we purified the measures by assessing their reliability and unidimensionality, where the measurement model was evaluated separately from the full structural equation model. The measurement model was iteratively revised by dropping items one at a time for those that share a high degree of residual variance with other items [33, 68]. The final value of comparative fit index (CFI) and root mean square residual (RMR) for the measurement model ranged from (0.90 to 0.95) and (0.01 to 0.03), respectively.

Convergent Validity

To test the convergent validity, we calculated composite reliability of the construct. A high value of composite reliability, ranging from 0.72 to 0.86, suggests reasonable convergent validity of the constructs. The correlation, mean, standard deviation, and reliability of constructs are shown in Table 4.

Given the importance of the dependent variable, we compiled objective data on competitive advantage for the three-year period and tested their convergence with our perceptual measures. Sixty-one companies were identifiable by name in our sample. For each company, we used the Hoover's database to compile the average return on assets (ROA) and return on sales (ROS) for that three-year period for all companies within the same Standard Industrial Classification (SIC) code. An industry-normalized ROA and ROS was then computed for each firm, and these results were correlated with the perceptual measures. Pearson correlation between industry-normalized ROA and the perceptual measures was 0.638 ($p = 0.000$) and for ROS it was 0.660 ($p = 0.000$). These results indicated significant convergence among the perceptual and objective measures of competitive advantage, adding further credence to the measure.

Discriminant Validity

Discriminant validity is inferred when measures of each factor converge on their respective scores that are unique from the scores of other factors. We tested estimates of an unconstrained model that frees the correlations between pairs of factors and a constrained model that sets the correlation between the constructs to unity. A significant difference between the chi-squares indicates that the unconstrained model is better fit than the constrained model. This pairwise test was performed by combining two constructs together. Thus, we conducted ten pairwise tests between the technical infrastructure, IT business experience, the relationship infrastructure, intensity of or-

Table 4. Correlations, Mean, Standard Deviation, and Reliabilities of Constructs

Constructs	IT infrastructure	IT business experience	Relationship infrastructure	Competitive advantage of the firm	Intensity of organizational learning	Mean	Standard deviation	Composite reliability
IT infrastructure	1					3.52	0.92	0.78
IT business experience	0.59*	1				3.30	0.76	0.80
Relationship infrastructure	0.41	0.67*	1			3.30	0.74	0.74
Competitive advantage of the firm	0.41	0.46	0.48	1		3.21	0.82	0.86
Intensity of organizational learning	0.37	0.47	0.55*	0.55*	1	3.13	0.75	0.72

Notes: * $p < 0.01$; χ^2 (df) = 118.30 (109), $P = 0.242$; root mean square error of approximation (RMSEA) = 0.021, normed fit index (NFI) = 0.97, goodness-of-fit index (GFI) = 0.93, adjusted goodness-of-fit index (AGFI) = 0.91, comparative fit index (CFI) = 0.983.

Table 5. Discriminant Analysis

Model	χ^2 (df)*
Original model	118 (109)
Constrained IT infrastructure and IT business experience = 1	147 (110)
Constrained IT infrastructure and relationship infrastructure = 1	148 (110)
Constrained IT business experience and relationship infrastructure = 1	140 (110)
Constrained intensity of organizational learning and IT infrastructure = 1	153 (110)
Constrained intensity of organizational learning and IT business experience = 1	150 (110)
Constrained intensity of organizational learning and relationship infrastructure = 1	150 (110)
Constrained intensity of organizational learning and competitive advantage of the firm = 1	160 (110)
Constrained competitive advantage of the firm and IT business experience = 1	152 (110)
Constrained competitive advantage of the firm and IT infrastructure = 1	155 (110)
Constrained competitive advantage of the firm and relationship infrastructure = 1	140 (110)

* Significant at $p < 0.000$.

ganizational learning, and competitive advantage. The significant results of all chi-square difference between the original model and constrained models show the discriminant validity between different constructs, as shown in Table 5.

Method Bias

One potential issue in having a single respondent assess both predictor and criterion variables is common-method bias. We would argue that, although specificity of the items and use of different scale anchors reduced such bias considerably, it probably would not eliminate it. Two tests were conducted to check whether common-method bias was an issue of concern. First, Harmon's single-factor test was conducted using exploratory factor analysis [54]. The unrotated factor solution did not exhibit a single factor, but four factors, indicating that a high level of common-method variance is not present. Second, as described earlier, the correlation analysis between the objective measures of performance of the respondent company obtained from secondary sources with the scaled (perceptual) measures of financial performance was conducted. A high degree of correlation ($p < 0.00$) between these measures indicates that independent measures of the criterion variable exhibit convergence.

Control

Larger firms can enjoy advantages of certain economies of scale, scope, and network effects that might not be accessible to smaller firms. In order to control for the core

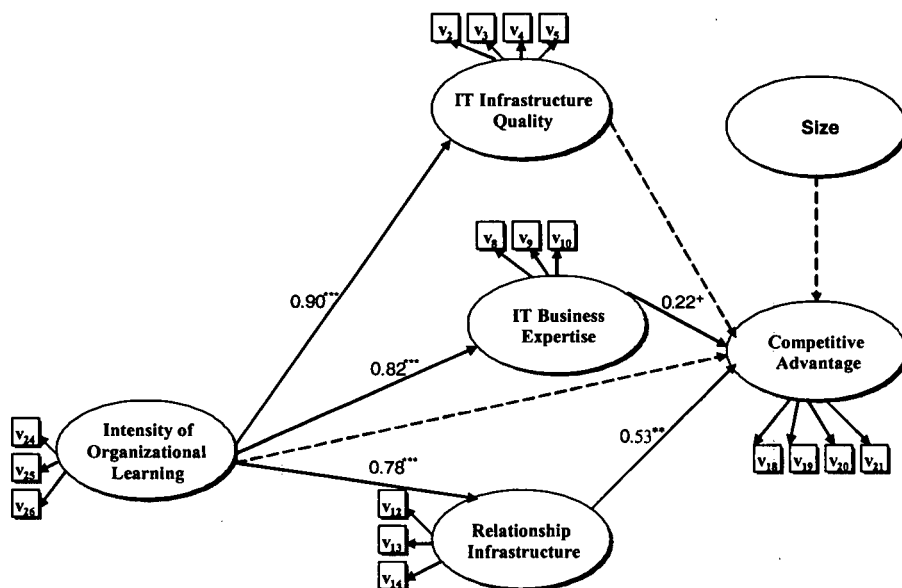


Figure 2. Results of the Model.

Notes: Model fit summary: $\chi^2 = 149.90$, $df = 126$, $p = 0.24^{**}$, GFI = 0.93**, AGFI = 0.91**, RMSEA = 0.029, CFI = 0.98; significance levels: * $p < 0.001$, ** $p < 0.01$, *** $p < 0.05$, * $p < 0.10$; standardized parameter estimates are shown; item loadings and error terms are not displayed; dashed line shows insignificant path.

resource base reflected by size effects, we introduced size, as measured by the number of employees, as a control variable in the model.

Results

STRUCTURAL EQUATION MODELING WAS USED to test our hypotheses. The results of the confirmatory structural model are shown in Figure 2. Overall, the model demonstrated an excellent fit (CFI = 0.98).

With regard to the specific hypotheses, we found:

- Hypothesis 1: Our results supported the hypothesis that higher quality of the IT infrastructure would not have a significant positive effect on the competitive advantage of the firm ($t = 0.20$, $p > 0.10$).
- Hypothesis 2: As expected, higher level of IT business experience had a significant but weak positive effect on the competitive advantage of the firm ($t = 1.66$, $p < 0.10$).
- Hypothesis 3: As expected, higher quality of the relationship infrastructure had a significant positive effect on the competitive advantage of the firm ($t = 2.82$, $p < 0.01$).

- Hypotheses 4a, 4b, and 4c: As predicted, higher levels of the intensity of organizational learning had a strong significant positive effect on (a) the quality of the IT infrastructure, (b) the level of IT business experience, and (c) the quality of relationship infrastructure ([a] $t = 5.63, p < 0.001$; [b] $t = 6.77, p < 0.001$; [c] $t = 3.83, p < 0.001$).
- Hypothesis 5: Our results failed to support that higher level of the intensity of organizational learning would have a significant positive effect on the competitive advantage of the firm ($t = -0.53, p > 0.10$).

Discussion

We argue for three types of capabilities—value, competitive, and dynamic—as antecedents to the competitive advantage of the firm. The results generally support this distinction, with four of the five hypotheses supported. Ross et al. [63] argue that the IT infrastructure, IT business experience, and relationship infrastructure are tightly related, and a firm is required to have all three components in place for achieving sustainable competitive advantage. However, our results demonstrate a lack of significance between quality of IT infrastructure and competitive advantage. This suggests that the quality of the IT infrastructure may not *directly* contribute to differential performance. However, it is IT business experience and, more significantly, the relationship infrastructure that are related to competitive advantage.

In pragmatic terms, these results challenge the commonly held view that development of a high-quality IT infrastructure is ambiguous, follows a unique (path-dependent) development, and provides first-mover advantage to the firm. The rationale for our results could be that in the present time, there might be little difference among well-established firms with regard to the quality of IT infrastructure. Given the increasingly open standards, modular development approaches, and lower cost with respect to transaction platforms, enterprise resource planning (ERP), TCP/IP-based communication and packaged software, most established firms might have convergent (rather than heterogeneous) IT infrastructures and widely understood knowledge of its effective deployment. This argument is closely aligned with Carr, who states that the ubiquity of sophisticated infrastructures is accessible to all and not a source of differentiation. Also, perhaps because of the massive investment that has already been made in the buildup of IT infrastructure, opportunities lie in collective benefits for industries or the economy rather than individual benefits for a firm. Therefore, until a firm is able to predominantly shape unique principles of IT infrastructure, it might not be a critical contributor to competitive advantage.

We believe that IT infrastructure is valuable and may have reshaped the business outlook for IT. However, when almost all of the established firms begin to capitalize on the same resources, which, over time, either become available in the marketplace or can be imitated by the competitors, these resources become commodities. Having said this, lack of a quality IT infrastructure could be a serious disadvantage, as it becomes a competitive necessity for firms [21].

The danger in Carr's position becomes evident when we look at the other two capabilities that allow us to leverage IT infrastructure successfully. The effect of IT business experience in the present study is significant but not very strong ($p < 0.10$). We believe that the development of skills requires organizational time and effort; therefore, a firm that possesses highly competent IT people may be able to create and sustain competitive advantage. If IT personnel are not conversant with the business side of the organization, they are unlikely to develop the kinds of systems that provide proper alignment between business strategy and IT strategy. This leads us to believe that hiring IT people with business skills will be increasingly important. Although outsourcing of technical (programming) skills is increasing, IT business experience might be the sticky component that is valuable, inimitable, immobile, and heterogeneously distributed across firms. Firms that develop routines to hire business-savvy IT people and develop processes to enable them to work constructively toward progressive IT solutions will be able to garner competitive advantage. Such people can leverage IT infrastructure to take advantage of market arbitrage opportunities when they arise.

Even more important is the relationship infrastructure that was found to significantly affect competitive advantage. This indicates that building relations could be path-specific, complex, and internalized within the organizational practices. Relationship infrastructure is akin to "trust building" between IT groups and business units within the organization. Research has shown that the use of trust between different units leads to cooperation and collaboration among organizational participants, as trust reduces the monitoring cost and thus increases the effectiveness of the coordination between different organizations. We would argue that, although competitors might easily imitate the coordination mechanisms used for the relationship infrastructure, they would still find it difficult to understand or *replicate rapidly and completely the complexities involved in creating an environment of trust and knowledge sharing*. Therefore, the firms that have been successful in creating an open environment of trust are likely to gain competitive advantage as compared to the competitors. Both IT business experience and relationship infrastructure allow firms to effectively deploy IT resources to take advantage of business opportunities.

The dynamic capability we call intensity of organizational learning was found to be significantly related to the quality of IT infrastructure, IT business experience, and relationship infrastructure. Since learning is usually associated with absorptive capacity of the firm, it enhances knowledge exploration and exploitation. The role of intensity of learning especially becomes critical when rapidly changing environments require firms to assimilate knowledge that can be used to improve IT infrastructure quality, enhance IT business skills (learning new ways to use IT), and initiate and maintain the relational infrastructure. We would also argue that a high level of learning intensity allows a firm to rapidly change its IT infrastructure, IT business experience, and the state of the relationship infrastructure to meet its future business application needs.

Interestingly, intensity of learning does not directly contribute to competitive advantage, whereas the manifestations of learning in the form of IT capabilities do. This

suggests that learning capabilities are mediated by firm-level capabilities before they translate into competitive benefits. This occurs because learning does not take place in a vacuum and needs to be applied to specific projects. Simply searching and acquiring knowledge may not directly affect the competitiveness of the firm, unless this knowledge is assimilated with the existing knowledge. In other words, only through the mediation of path-specific knowledge would learning lead to competitive advantage. In this regard, we believe that the alignment of intensity of learning with existing competence will provide the advantage of knowledge assimilation and deployment [23]. The advantage accrued as a result of the assimilation of relevant and complementary knowledge within the organization would positively affect the firms' competitive advantage.

Practical Implications

THE RESULTS ALERT PRACTITIONERS TO THE DANGERS of blindly heeding biased and shrill voices such as Carr's in making important IT investment decisions. There are indeed some IT capabilities, such as IT infrastructure, that are standardized, scalable, and can form the platform upon which new applications can be developed and integrated. These capabilities might provide value in terms of efficient outputs, but by themselves might not be a source of differential advantage. It is important to note, however, that these capabilities are competitive necessities, since their absence can create a competitive disadvantage. Therefore, investing in quality IT infrastructure is important, but paying a premium to be at the cutting edge of infrastructure innovation may not yield the best returns. On the other hand, firms should invest in planning [35], communication channels, and relationships between IT and business functions. These could be critical in identifying and leveraging business opportunities. Finally, cultivating dynamic capabilities such as learning intensity, or ways to capture, assimilate, and apply knowledge efficiently, is an important antecedent to capability building.

Limitations and Future Research

ONE LIMITATION OF THIS STUDY is the use of the same respondent for both our independent and dependent variables. Statistically, common-method bias does not seem to be a major issue. However, we recognize that it might have upwardly biased our results. Future studies should use multiple methods of measurement to alleviate any potential bias.

Another caveat of this study is that it takes a static cross-sectional picture of capabilities and competitive advantage. This makes it difficult to address the issue of how capabilities are created over a run of several years. Future study that focuses on "state changes" over longer periods of time can add more depth to our understanding of how to create and leverage capabilities for competitive advantage. In our minds, this represents a fertile area of research, particularly the extension of the inherently static

character of this work toward the development of process-based (rather than variance-based) models that focus on how capabilities are created and leveraged. Perhaps qualitative ethnographic methodologies would be particularly useful here.

Some might criticize the nature and time duration of our dependent variable. We chose perceptual measures of financial performance relative to competitors over a three-year period, similar to Sponos and Lioukas [71], and cross-checked our measures with objective data. Recent work has suggested that empirical studies of RBV might, in some circumstances, adopt the effectiveness of business processes rather than firm performance as the dependent variable. For instance, Ray et al. [60] indicate that firm-level measures are aggregations of various process outcomes and might mask the true relationships between capabilities and performance. We would argue that most IT capabilities and organizational learning are not targeted at specific processes and should have organizational-level effects. We view the fact that effects were detected as a positive indication. However, more granular assessment of both capabilities and outcomes, including the use of process-level outcomes, offers strong opportunities for future research.

Regarding time duration, we did not measure the duration of competitive advantage directly. The RBV uses the concept of immobility of resources to gauge sustainability of competitive advantage. Although we believe that the competitive capabilities such as IT business experience and relationship infrastructure are immobile resources, does the three-year period we used capture sustainability? As discussed by Sponos and Lioukas: "The time period . . . is admittedly short (i.e., the previous three years) to account for any business cycle effects or transient problems. It is important to note, however, that a longer time frame (e.g., five instead of three years) could endanger the reliability of the responses" [71, p. 923].

In this study, we distinguished between three types of capabilities. In moving forward from here, researchers should further validate this typology and possible capability sets that map into each category. Then, by testing for factors that are useful in building different kinds of capabilities, a more refined examination of the RBV is possible. More importantly, examination of other organizational capabilities (e.g., marketing capabilities) and their internal interconnectedness can enhance our understanding of the embeddedness of IT capabilities and the importance of mutual dependence in creating new capabilities that are even more immobile [1].

This study did not specifically look at firms in the service sector. There is some evidence that industry-level effects on performance or competitive advantage exist [38, 71]. Testing of capabilities across industries with varying information intensity can provide us with an understanding of how IT infrastructure, IT business experience, and relationship infrastructure affect the competitiveness of these sectors differently.

Finally, in this study, we largely equated competencies with capabilities. How IT competence can be rapidly integrated into potential capabilities to meet changing market realities is an intriguing line of inquiry. As we evolve in our understanding of IT business performance relationships, examining complementary relationships between IT competence and organizational capabilities can provide richer insight into organizational routines that create value.

Concluding Comments

THIS IS ONE OF THE FIRST LARGE-SCALE EMPIRICAL STUDIES that has over 200 senior IT executives assess their capabilities and competitive advantage. The study adds more granularity to our understanding of the IT-competitive advantage relationship. Drawing from the RBV, we can argue that although the quality of IT infrastructure may not be a direct source of differentiation, the ability to effectively leverage that infrastructure is. Companies that have IT personnel who are knowledgeable about business strategy, competition, and business opportunities, either through "learning by doing," organizational processes, or skill sets, create a unique competence that can lead to better leveraging of "commodity" infrastructure, thereby leading to competitive advantage. It is unlikely that these capabilities are symmetrical, because such skills evolve through history and experience, and are very difficult to observe and imitate. The empirical evidence bears this out, and provides guidance for progressive firms on where to direct their resources.

NOTES

1. See comment.cio.com/comments/12790.html for comments on Carr's article [15]. Also see www.nicholasgcarr.com/articles/matter.html for responses to Carr's article from academics and practitioners.

2. It is useful to note that there is also a stream of research that examines IT announcements and their relationship with value [18, 27, 28, 39]. Although these studies do not explicitly examine competitive advantage, they do highlight some IT factors that tie into firm value. For instance, Chatterjee et al. [18] found that IT infrastructure investments reflect positive market value, whereas Dehning et al. [27] argue that IT investment made for transformation purposes is likely to be more durable for the firm's competitiveness.

3. We use the terms *capabilities* and *competencies* interchangeably. Although some purists would take issue with this, we do not believe parsing these terms is useful for this study.

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