Determinants of a sustainable competitive advantage
due to an IT-enabled strategy

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Abstract

Information technology (IT) has been asserted to be a source of sustainable competitive
advantage. Empirical evidence has shown that IT can improve a company’s performance and
competitive position. We examine the factors that are believed to lead to a sustainable competitive
advantage due to an IT-enabled strategy, and test these factors empirically. Our findings show that
managerial IT skills are positively related to sustainability, and competitor’s knowledge of
competitive advantage is negatively related to sustainability. There was no support for technical IT
skills or IT infrastructure as a source of sustainable competitive advantage.

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1. Introduction

Recent studies have established that the successful use of information technology (IT)
can improve a company’s performance and competitive position (Bharadwaj, 2000;
Stratopoulos and Dehning, 2000). However, there is a widely held belief among the
management community that any performance advantage granted by IT is short lived
because computer-based information systems (IS) are easily replicated (Alter, 1998;
Bharadwaj, 2000; Stratopoulos and Dehning, 2000).
Ballou and Slater, 1994). Competitors will attempt to neutralize the competitive advantage of the successful users by copying and possibly improving the IT used (Kettinger et al., 1994; Mata et al., 1995). In some cases, a competitor’s response may be immediate.²

Contrary to this belief is the theoretical literature on IT and competitive advantage that asserts that it is not effortless to duplicate the performance achieved through successful use of IT, and that IT-enabled strategies can lead to a sustainable competitive advantage (Feeny and Ives, 1990). “Overall there is a growing realization that firms can sustain strategic IT innovation and differentiate business success only by developing superior capabilities for enterprise IT management and use” (Sambamurthy, 2000, p. 246).

2. Theory and hypotheses development

Building on the theory of monopolistic competition, Feeny and Ives (1990) link IT resource heterogeneity to competitive advantage. In this framework, generic lead-time, competitive asymmetry, and pre-emption potential are the primary factors that contribute to sustaining an IT-enabled competitive advantage. Generic lead-time affects how long a firm has before competitors can respond with a similar application. Competitive asymmetry refers to competitors’ ability to replicate the IT application. Pre-emption potential refers to the ability of first movers to effectively pre-empt retaliation by followers.

The framework developed by Feeny and Ives is similar to the resource-based view of the firm (RBV) espoused in the strategic management literature (Barney, 1991, 1997; Dierickx and Cool, 1989; Peteraf, 1993; Wernerfelt, 1984). RBV depicts companies as a collection of resources and capabilities required for product or market competition. Resources are the physical capital, human capital, and organizational capital owned or controlled by a firm that can be used to conceive of and implement strategies (Barney, 1991). Capabilities reflect a company’s ability to combine resources that the organization can muster in ways that promote superior performance in spite of the opposition stemming from the competition and circumstances (Teece et al., 1997). Makadok (2001) identifies two key distinctions between resources and capabilities. First, capabilities are a special type of organizationally embedded, non-transferable, firm-specific resource. Second the purpose of capabilities is to improve the productivity of the other resources possessed by the firm.

RBV assumes that resources are heterogeneous and to some extent immobile. Because the development of capabilities depends on available resources, resource and capability heterogeneity explains firm performance. The potential value of resources and capabilities is re-enforced by sustainability factors. RBV asserts that these factors will allow companies to sustain a competitive advantage that competitors find hard to duplicate. For a definition of sustainability factors, see Table 1 (Barney, 1991, 1997; Bharadwaj, 2000; Collis and Montgomery, 1995; Feeny and Ives, 1990; Mata et al., 1995; Peteraf, 1993; Wernerfelt, 1984).

² For example, in the mid-90s, FedEx and UPS repeatedly copied the services the other was offering on the Internet within months of new services being introduced by the other (Nash, 1996; Walsh, 1997, as cited in O’Brien (1999)).
An IT-enabled strategy is a corporate strategy that uses IT at its core to support and enable major economic activities performed by the firm. Theoretical and empirical evidence indicates that companies implementing an IT-enabled strategy are able to gain a competitive advantage over their direct competitors (Andersen, 2001; Bharadwaj, 2000; Feeny and Ives, 1990; Konsynski and McFarlan, 1990; Mata et al., 1995; McFarlan, 1984; Porter and Millar, 1985; Stratopoulos and Dehning, 2000). Selection, implementation, and adoption of the appropriate IT is a necessary condition for the success of such a strategy. “During the last 15 years strong evidence and managerial belief have

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Table 1
Definitions of sustainability factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Causal ambiguity</td>
<td>Competing firms may be unable to imitate another firm’s resources and capabilities because they do not understand how these resources are related to competitive advantage.</td>
</tr>
<tr>
<td>Lead-time</td>
<td>A set of factors that determine the amount of time from project launch until competitors have a substantive response in place.</td>
</tr>
<tr>
<td>Path dependency</td>
<td>Describes choices made during the early stages of project planning and implementation that have significant implications on current choices, decisions, and expected outcomes.</td>
</tr>
<tr>
<td>Role of history</td>
<td>Refers to unique historical conditions that allow a company to either acquire or develop resources at a low cost. New competitors that do not have these resources will have to pay a higher price in order to have them.</td>
</tr>
<tr>
<td>Socially complex links</td>
<td>Social factors which are beyond the ability of firms to control and influence in a systematic fashion, causing a firm’s resources to be difficult to imitate.</td>
</tr>
<tr>
<td>Time compression diseconomies</td>
<td>Refers to resources, which are relatively easy or inexpensive to imitate, but the process is time consuming.</td>
</tr>
</tbody>
</table>

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3 Similar definitions are given by Sambamurthy (2000), who refers to this as IT differentiation, and Weill and Broadbent (1998).

4 Given the nature of our research, we decided not to reiterate the early research on IT and business performance (the IT productivity paradox). We believe that although there is a significant body of literature that found little or no evidence of a relation between IT and firm performance (Panko, 1991; Brynjolfsson, 1993; Barua et al., 1995; Weill, 1992) or productivity (Roach, 1987; Loveman, 1988), recent studies have adequately addressed this issue (Brynjolfsson and Hitt, 1996; Bharadwaj et al., 1999a; Bharadwaj, 2000; Stratopoulos and Dehning, 2000). For a review of the literature on IT and business performance, see Barua and Mukhopadhyay (2000).
accumulated that IT, when it is effectively deployed, contributes to superior firm performance” (Sambamurthy, 2000, p. 245).

The theoretical argument that sustainability is possible can be attributed to certain IT resources and capabilities that are difficult to imitate. When an IT-enabled strategy is combined with such resources and capabilities, firms will be able to gain a sustained competitive advantage through barriers to entry, switching costs, and mobility barriers (Porter, 1979, 1980; Mata et al., 1995; McFarlan, 1984; Sambamurthy, 2000). These may include managerial IT skills, technical IT skills, and IT infrastructure.

Managerial IT skills refer to management’s ability to conceive, develop, and exploit IT applications (Mata et al., 1995). There are four primary reasons why managerial IT skills are believed to be a source of sustainable competitive advantage. First, these skills enable companies to manage the technical as well as market risks associated with investment in IT (Bharadwaj, 2000; Mata et al., 1995). Second, they are developed over time through the accumulation of experience (Katz, 1974). Third, they are tacit and causally ambiguous (Castanias and Helfat, 1991; Mata et al., 1995). Fourth, they are the result of socially complex processes (Mata et al., 1995). These theoretical arguments lead directly to the first hypothesis.

**Hypothesis 1.** Companies with superior managerial IT skills will have a longer duration of sustained competitive advantage.

Technical IT skills refer to the expertise needed to build and use IT applications (Copeland and McKenney, 1988). Mata et al. (1995) assert that technical IT skills are indispensable for the effective use of IT, but do not possess the characteristics required to be a source of sustainable competitive advantage. “Technical IT skills …are usually not heterogeneously distributed across firms…” and “…even when they are …they are typically highly mobile” (Mata et al., 1995, p. 498). This mobility is due to the codifiable nature of technical IT skills, making them easy to transfer among organizations. In addition, firms can acquire technical IT skills or develop their own through education and training of current employees. Contrary to this argument is one that training and education are prime examples of a time consuming activity (time compression diseconomies) making them immobile and therefore a source of sustainability.

The argument that employees with technical IT skills are homogeneously distributed and/or mobile is highly disputed. Opponents claim that IT employees are not interchangeable and cannot be replaced at will by purchasing them from the ‘People Store’ (Brooks, 1995; Demarco and Lister, 1987). Demarco and Lister, evaluating productivity among programmers, found that the best performers tend to congregate in a few organizations, an outcome they attribute to environmental and corporate cultures that tend to attract and keep good IT employees. On the other hand, companies with management that treats IT employees as interchangeable parts tend to experience ‘pathologically high turnover’ (Demarco and Lister, 1987, p. 108). This suggests that technical IT skills can provide a source of sustainable competitive advantage.

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5 In Bharadwaj et al. (1999b), this is introduced as ‘business IT strategic thinking’. 
Bharadwaj (2000) presents additional evidence supporting this argument. She argues that successful development of IS applications requires teams rather than individuals. This is a potential source of sustainability because building IT teams that will be receptive to new technology is a long-term investment; teams are less mobile than individuals, and team-embodied knowledge decays at a slower rate as it passes to new generations of team members. Demarco and Lister (1987) stress the importance of teams in successfully managing employees in IT environments. There are a variety of arguments that teams contribute to a sustained competitive advantage through reduced immitability of technical IT skills. For example, Schneider (2000) argues that a company cannot implement a team culture until it has trained a cadre of team leaders, thus making successful use of teams difficult to copy due to socially complex links. Edmondson (1999) stresses the importance of a team’s history for the development of a climate of supportiveness among its members (the role of history). Expectations about how others will react cannot be created by single act of management, and such culture is established over time, making replication difficult due to path dependency and time compression diseconomies. This discussion leads to our second hypothesis.

**Hypothesis 2.** Companies with superior technical IT skills will have a longer duration of sustained competitive advantage.

Weill and Broadbent (2000, p. 333) define IT infrastructure as “the base foundation of IT capability, delivered as reliable services shared throughout the firm and coordinated centrally, usually by the information systems group”. IT infrastructure is viewed as being difficult to imitate because it is a complex combination of technology and personnel. Although competitors might find the cost of acquiring similar hardware and software prohibitive, the creation of a deeply embedded IS may require a wide variety of socially complex links and may be imperfectly understood (Barney, 1986, 1991, 1997; Weill and Broadbent, 1998). In addition, creation of successful IT infrastructure takes time and effort, often involves experiential learning, and has unique characteristics in each firm (Bharadwaj, 2000; Cash et al., 1992; Duncan, 1995; Neo, 1988; Venkatraman, 1991; Weill and Broadbent, 1998). It has been estimated that IT infrastructure is a capability that takes 5–7 years to emulate (Weill and Broadbent, 2000). This leads to the third hypothesis.

**Hypothesis 3.** Companies with superior IT infrastructure will have a longer duration of sustained competitive advantage.

It has been theoretically argued (Porter, 1980, 1985; Scherer and Ross, 1990), and empirically validated (Chen and Miller, 1994) that when a company’s strategic initiatives are neutralized by competitors’ counteractions, it has an adverse effect on the company’s performance. Chen and Miller (1994) identify the following factors that lessen competitor’s retaliatory behavior: (1) reduced visibility of strategic initiatives; (2) competitor’s perceived inability to respond successfully; (3) reduced value that rivals perceive in retaliatory behavior.

The first of these, low visibility, has long been viewed as a necessary condition for a successful competitive strategy (Porter, 1980; Feeney and Ives, 1990; Chen et al.,
Chen et al. (1992, p. 442–443) claim “competitors can offer response to a competitive move only if they are aware of the move”. Porter (1980) argues that companies can avoid retaliation from their competitors and therefore sustain their competitive advantage when they introduce new strategies “away from competitors’ center of attention” (p. 96). Feeny and Ives (1990) argue that companies with a competitive advantage that is not widely recognized or understood are more likely to be able to sustain that advantage. Likewise, widespread knowledge of a company’s competitive advantage is likely to lead to increased imitation, which would decrease the sustainability of that advantage. More companies are likely to imitate the more successful companies in their industry. This increased imitation will decrease the sustainability of the competitive advantage held by the industry leaders. This leads directly to the final hypothesis.

**Hypothesis 4.** Companies with a widely recognized competitive advantage will have a shorter duration of sustained competitive advantage.

### 3. Methodology

#### 3.1. Dataset

Empirical testing of our research questions implies a longitudinal comparison between a set of companies that have a competitive advantage due to an IT-enabled strategy and their competitors who do not. In the late 1980s and the 1990s, two IT publications, *ComputerWorld* and *InformationWeek*, annually compiled a list of companies that have been recognized for their effective use of IT. These lists are well received in the professional IT community, and various aspects of these surveys have been used to support numerous research projects (Bharadwaj, 2000; Bharadwaj et al., 1999a; Brynjolfsson and Hitt, 1996; Hitt and Brynjolfsson, 1996; Lichtenberg, 1995; Mahmood et al., 1998; Stratopoulos and Dehning, 2000). Analyzing the criteria used to select the companies in *ComputerWorld*’s Premier 100 list in 1993 we see an alignment between the criteria and the factors that previous literature assert might lead to a sustainable competitive advantage due to an IT-enabled strategy.

The creation of *ComputerWorld*’s Premier 100 was based on the following nine criteria: total spending on IS as a percentage of revenue, total spending on IS staff as a percentage of total IS spending, total spending on IS staff training as a percentage of total IS spending, total market value of the company’s processors as a percentage of revenue, percentage of employees with a personal computer (PC), peer rating of the most successful users of IS within their industry, a rating of how well IS management has positioned the IS to service business needs (developed by *ComputerWorld* in conjunction with IT consultants), how well top management believes the organization is using IT, and 5 year growth rate in profits. In 1993, the peer evaluation component carried double weight in the creation of the final weighted average score that was used for the ranking of the companies (*ComputerWorld, 1993*).
The ComputerWorld criteria identify companies with a competitive advantage due to an IT-enabled strategy. These companies are committed to IT (total spending on IS as a percentage of revenue), and are using IT successfully (peer rating of the most successful users of IS within their industry) as part of an IT-enabled strategy (how well the IS is positioned to match the business needs of the organization). In addition, these criteria serve as surrogate measures for the IT resources and capabilities that may lead to a sustained competitive advantage due to an IT-enabled strategy (see Fig. 1).

Managerial IT skills have been defined as management’s ability to conceive, develop, and exploit IT applications (Mata et al., 1995). This is captured by ComputerWorld’s rating of how well management has positioned the IS of the organization to service their business needs. The amount that a company spends on IS budget for staff and training reflects its commitment to hire and retain technical expertise. Therefore, ComputerWorld’s criteria (spending on IS staff, training and other IS spending) are a reasonable proxy for technical IT skills. The market value of processors, the number of PCs, and the percentage of employees with a PC are IT infrastructure components. Finally, we consider ComputerWorld’s peer rating of the most successful users of IS within their industry as a surrogate measure of the visibility of the CWP100 companies’ competitive advantages, as defined in Porter (1980), Feeny and Ives (1990) and Chen et al. (1992). These measures allow an

![Diagram](image-url)

Fig. 1. Mapping the ComputerWorld Premier 100 criteria to managerial IT skills, technical IT skills, IT infrastructure, and visibility.
empirical test of which of the factors mentioned in the theoretical literature lead to a sustained competitive advantage.

Principle components factor analysis was used to analyze the six variables in the model that proxy for technical IT skills and IT infrastructure, to see if the variables were measuring what we propose that they measure. The results of the factor analysis can be found in Table 2. There were two factors with an eigenvalue of more than 1.0. Each of the variables aligns within a single factor with the other variables that measure the underlying construct proposed.

3.2. Measure of competitive advantage

Researchers and managers are interested in the relation between strategic actions that a firm takes and its performance relative to the competition (Rumelt et al., 1991). Firms that are successful in creating non-replicable complementarities across activities with an IT-enabled strategy will enjoy superior financial performance by raising revenues or decreasing costs (Bharadwaj, 2000). Hence, traditional accounting variables are most likely to capture an IT-enabled competitive advantage.

Return on assets (ROA) is used as a measure for competitive advantage. The most frequently used measure in the strategic management literature, ROA has been shown to be related to several other measures of financial performance and is the best overall measure of financial performance (Barber and Lyon, 1996; Keats and Hitt, 1988; Lenz, 1981). ROA has been used in studies on the relation between investment in IT and productivity (Barua et al., 1995; Hitt and Brynjolfsson, 1996; Weill, 1992), as well as in recent studies on the relation between IT and competitive advantage (Bharadwaj, 2000; Stratopoulos and Dehning, 2000). These studies show that the ComputerWorld and InformationWeek IT leaders outperform their direct competitors on a number of performance measures, including ROA.

A matched-pair design is used to test our research questions. A matched control group will be used as a benchmark to measure differential performance. Competitive
advantage is defined as positive ROA differential between the ComputerWorld Premier 100 (CWP100) company and a direct competitor. The control group is matched on SIC code, sales, and total assets to control for industry effects, size, and capital intensity.\textsuperscript{6} Matching on these variables helps to rule them out as alternative explanations for any difference found in performance between the two groups. By definition, any company not appearing on the Premier 100 list has less of a competitive advantage due to an IT-enabled strategy.

Each CWP100 company was matched with their closest competitor using the following procedure. First, all companies with the same primary 4 digit SIC code as the CWP100 company were identified. Second, any company twice as large or half as small as the CWP100 company on sales or total assets was removed from the list of potential matches.\textsuperscript{7} Third, the nearest competitor was selected by simultaneously matching on sales and total assets. The nearest competitor was identified as the company with the minimum Euclidean distance from the CWP100 company. Euclidean distance was measured using equation one.

\[
D_i = \sqrt{(S_i - S_{CWP})^2 + (A_i - A_{CWP})^2}
\]

where \(D_i\) is the Euclidean distance for potential match company \(i\); \(S_i\), sales for potential match company \(i\); \(A_i\), total assets for potential match company \(i\); \(S_{CWP}\), sales for the CWP100 company to match; \(A_{CWP}\) is the total assets for CWP100 company to match.

After completing the matching procedure there were 65 usable pairs left in the study. Table 3 contains a resolution of the original CWP100 and the 65 pairs left in the final study. Of the 65 ComputerWorld companies, 38 were matched by 4 digit SIC code, 8 were matched by 3 digit SIC code, and 19 were matched by 2 digit SIC code.

Table 4 provides summary statistics for the two groups in terms of total assets and net sales. By design, the groups should have mean sales and total assets that are approximately equal. A \(t\)-test for difference in means was not significant for total assets \((p = 0.61)\) or Net Sales \((p = 0.34)\).

### 3.3. Data analysis

As defined earlier, positive ROA differential between the CWP100 company and their direct competitor is evidence of competitive advantage. The results reported use ROA as the performance measure, where ROA is Income from Continuing Operations before Interest Expense divided by Assets. To calculate the duration of competitive advantage we counted the number of consecutive years the CWP100 firm has positive ROA differential relative to their direct competitor.

\textsuperscript{6} Equality in capital intensity between two companies is defined here as two companies with the same level of sales employing the same level of assets to achieve those sales. Our definition may vary from the definition of capital intensity in other studies.

\textsuperscript{7} If there was no competitor that was no more than twice as large or half as small as the CWP100 company, 3 digit and 2 digit SIC code industry groups were used to find the nearest competitor.
We have seen that managerial IT skills, technical IT skills, and IT infrastructure are the most likely contributors to the sustainability of competitive advantage. The criteria used to select the CWP100 allow us to gauge each factor’s importance in contributing to the duration of sustained competitive advantage. In the empirical tests, seven variables will be used as proxies for the factors in question and as control variables. As shown previously in Fig. 1, seven of the variables map directly onto managerial IT skills, technical IT skills, and IT infrastructure. Two new variables were constructed, one for technical IT skills and one for IT infrastructure. These variables are the sum of the weights from the factor analysis times the standardized variables. Peer rating serves as a proxy for a widely recognized competitive advantage.

Three variables serve as control variables. Control variables are added to the model to eliminate any significant results from correlated omitted variables, and to reduce the unexplained variance in the model, which makes the model more efficient. CEO rating of how well top management believes the company is using IT is included as a control variable, and no predictions are made regarding whether duration should be positively or negatively related to CEO rating. The difference in 5-year growth rate in profits from 1988 to 1992, and the difference in ROA in 1993 between the CWP100 firm and matched control firm are in the model to control for differences in the

Table 3
Reconciliation of the original ComputerWorld Premiere 100 (CWP100) companies and the 65 CWP100 companies in the study

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Companies not on Compustat</td>
<td>2</td>
</tr>
<tr>
<td>Companies not in the Compustat active file</td>
<td>22</td>
</tr>
<tr>
<td>Companies not matched</td>
<td>11</td>
</tr>
<tr>
<td>Total firm pairs left in the study</td>
<td>65</td>
</tr>
</tbody>
</table>

Table 4
Comparative statistics (Year = 1993)

<table>
<thead>
<tr>
<th>Variable</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CWP100</td>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>TOTAL ASSETS&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>65</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>10.520</td>
<td>10.906</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>18,189</td>
<td>22,030</td>
<td></td>
</tr>
<tr>
<td>SALES&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CWP100</td>
<td>65</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>65</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>6503</td>
<td>5949</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>9244</td>
<td>6563</td>
<td></td>
</tr>
</tbody>
</table>

Results reported are the mean and standard deviation of 1993 total assets and 1993 sales for the 65 ComputerWorld Premier 100 companies (CWP100) and their matched control group companies. <sup>a</sup> t-value for difference in means = -0.51, p = 0.61.

<sup>b</sup> t-value for difference in means = 0.96, p = 0.34.
duration of competitive advantage that are not due to an IT-enabled strategy. This results in the following model:

\[
\text{DURATION} = b_0 + b_1\text{MNGMTRATE} + b_2\text{TECH FACTOR} \\
+ b_3\text{INFRA FACTOR} + b_4\text{PEEREVAL} \\
+ b_5\text{CEORATE} + b_6\text{GROWDIFF} + b_7\text{ROADIFF} + e
\]

(2)

where DURATION is the number of consecutive years the CWP100 firm has a competitive advantage; MNGMTRATE, rating of how well IS management has positioned the IS to service business needs; TECH FACTOR, factor representing technical IT skills; INFRA FACTOR, factor representing IT infrastructure; PEEREVAL, peer rating of the most successful users of IS within the industry; CEORATE, how well top management believes the organization is using its IT; GROWDIFF, differential in 5-year growth rate in profits from 1988 to 1992 between the CWP100 firms and matched control firms; ROADIFF is the differential in ROA in 1993 between the CWP100 firms and matched control firms.

When a company has a competitive advantage due to an IT-enabled strategy, its duration is a positive number. When the company is in a position of competitive parity or competitive disadvantage the duration is recorded as zero. As measured, the duration of competitive advantage cannot be negative, so the sample is left censored. The regression model based on a censored dependent variable is referred to as the censored regression model, or the Tobit model. The dependent variable of the model conveys qualitative (company with competitive advantage or not) as well as quantitative information (duration of advantage). Conventional regression methods fail to account for the qualitative difference between limit (zero) observations and non-limit continuous observations. When data are censored, the distribution that applies to the sample data is a mixture of discrete and continuous distributions. Estimating this model with OLS will lead to inconsistent estimates; OLS estimates tend to be biased, even asymptotically (Green, 1997; Kennedy, 1998; Maddala, 1989). For a more detailed discussion of the censored regression model used, see Appendix A. The mean and standard deviation of the variables used in the model are presented in Table 5.

4. Discussion of empirical results

Table 6 summarizes the results of the Tobit analysis. Three variables in the model are significant predictors of the duration of competitive advantage at the \( p = 5\% \) level or better. Management rating is positively related to duration; peer evaluation and CEO rating are negatively related to duration.

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8 Other micro and macroeconomic factors are controlled through the matching process. Matched companies are from the same industry, with similar size, and are compared concurrently over time. This accounts for the impact of economy wide factors and industry factors such as technological development.

9 Left censored refers to distributions that have a minimum point on the left side of the distribution. This means that no element of the distribution can have a value less than the minimum, in this case zero.
The positive sign on management rating is as predicted. Based on prior literature, we predicted that companies with superior managerial IT skills are more likely to sustain an IT-enabled competitive advantage (Bharadwaj, 2000; Castanias and Helfat, 1991; Katz, 1974; Mata et al., 1995). Our empirical analysis offers strong evidence in support of this argument. In the development of the hypotheses, we argue that technical IT skills and IT infrastructure would contribute to a sustained competitive advantage. As argued in Mata et al. (1995), the technical IT skills factor was not significantly related to duration. The IT infrastructure factor was also not significantly related to duration. The negative sign on peer evaluation is as predicted. It means that ceteris paribus, companies that receive a higher rating in terms of peer evaluation will have a shorter duration of competitive advantage. The importance our results are apparent when seen in the context of previous research. Chen and Miller (1994) use data from the airline industry to study drivers of competitive rivalry. They find a positive relation between the visibility of strategic Table 5
Variable descriptive statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DURATION</td>
<td>5.31</td>
<td>6.31</td>
</tr>
<tr>
<td>MNGMTRATE</td>
<td>8254.51</td>
<td>334.21</td>
</tr>
<tr>
<td>TECH FACTOR</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>INFRA FACTOR</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>PEEREVAL</td>
<td>16,215.56</td>
<td>513.06</td>
</tr>
<tr>
<td>CEO RATE</td>
<td>7020.83</td>
<td>1196.20</td>
</tr>
<tr>
<td>GROWDIFF</td>
<td>6.05</td>
<td>295.17</td>
</tr>
<tr>
<td>ROADIFF</td>
<td>2.35</td>
<td>5.67</td>
</tr>
</tbody>
</table>

The positive sign on management rating is as predicted. Based on prior literature, we predicted that companies with superior managerial IT skills are more likely to sustain an IT-enabled competitive advantage (Bharadwaj, 2000; Castanias and Helfat, 1991; Katz, 1974; Mata et al., 1995). Our empirical analysis offers strong evidence in support of this argument. In the development of the hypotheses, we argue that technical IT skills and IT infrastructure would contribute to a sustained competitive advantage. As argued in Mata et al. (1995), the technical IT skills factor was not significantly related to duration. The IT infrastructure factor was also not significantly related to duration. The negative sign on peer evaluation is as predicted. It means that ceteris paribus, companies that receive a higher rating in terms of peer evaluation will have a shorter duration of competitive advantage. The importance our results are apparent when seen in the context of previous research. Chen and Miller (1994) use data from the airline industry to study drivers of competitive rivalry. They find a positive relation between the visibility of strategic Table 6
Censored regression model results from Eq. (2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Predicted sign</th>
<th>Parameter estimate</th>
<th>Standard error</th>
<th>Chi square</th>
<th>Sig*</th>
</tr>
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<tbody>
<tr>
<td>Intercept</td>
<td>$b_0$</td>
<td>2.16</td>
<td>0.076</td>
<td>803.44</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>MNGMTRATE</td>
<td>$b_1$</td>
<td>H1: +</td>
<td>0.17</td>
<td>0.084</td>
<td>3.94</td>
<td>0.024</td>
</tr>
<tr>
<td>TECH FACTOR</td>
<td>$b_2$</td>
<td>H2: +</td>
<td>−0.02</td>
<td>0.020</td>
<td>0.89</td>
<td>0.382</td>
</tr>
<tr>
<td>INFRA FACTOR</td>
<td>$b_3$</td>
<td>H3: +</td>
<td>0.01</td>
<td>0.032</td>
<td>0.11</td>
<td>0.369</td>
</tr>
<tr>
<td>PEEREVAL</td>
<td>$b_4$</td>
<td>H4: −</td>
<td>−0.15</td>
<td>0.079</td>
<td>3.61</td>
<td>0.029</td>
</tr>
<tr>
<td>CEO RATE</td>
<td>$b_5$</td>
<td></td>
<td>−0.15</td>
<td>0.068</td>
<td>4.93</td>
<td>0.026</td>
</tr>
<tr>
<td>GROWDIFF</td>
<td>$b_6$</td>
<td></td>
<td>0.06</td>
<td>0.076</td>
<td>0.60</td>
<td>0.440</td>
</tr>
<tr>
<td>ROADIFF</td>
<td>$b_7$</td>
<td></td>
<td>0.17</td>
<td>0.108</td>
<td>2.55</td>
<td>0.110</td>
</tr>
</tbody>
</table>

* $p$-values reported are one-tailed where directional predictions were made, other $p$-values are for two-tailed tests.
initiatives and the number of retaliatory responses, and a negative relation between the number of retaliatory responses and financial performance. If high peer rating signifies high visibility, then our findings are a confirmation that highly visible strategic initiatives potentially have an adverse effect on financial performance.

One of the control variables in the model, CEO rating, was also significant. According to the results, companies with higher CEO rating are predicted to have a shorter duration of competitive advantage. Although we had no ex-ante predictions regarding CEO rating, this result can be interpreted in light of previous research that CEOs' beliefs cannot be private (Earl and Feeny, 2000), and therefore become known in the industry, thus having a similar effect as peer rating. This is probably in part due to the fact that company executives examine what the CEOs of their competitors say in order to anticipate their agendas (Earl and Feeny, 2000).

In conclusion, our empirical analysis supports the arguments that a widely recognized competitive advantage will have a shorter duration than a less widely recognized competitive advantage, and that managerial IT skills are positively related to the duration of competitive advantage.

4.1. Limitations

One of the limitations of this study is the use of the *ComputerWorld* Premier 100 dataset. Although this dataset has been used extensively in previous research (Brynjolfsson and Hitt, 1996; Hitt and Brynjolfsson, 1996; Lichtenberg, 1995; Mahmood et al., 1998; Sircar et al., 2000; Stratopoulos and Dehning, 2000), the CWP100 companies are not representative of the market as a whole. On average the *ComputerWorld* companies are among the largest of all publicly traded companies, and primarily from the manufacturing sector. Therefore, there may be some limit on the generalizeability of these results beyond this sample of companies.

One of the limitations of the dataset is how we measure IT infrastructure. IT infrastructure is built on the components used as a proxy in our study, but these components are the part of IT infrastructure that are the easiest to imitate by competitors. True IT infrastructure includes human knowledge, skills, and experience fused with these components. Our measure does not include measures of these capabilities.

There are other possible limitations with the dataset used in this study. The validity of the dataset is based on the ability of *ComputerWorld* to identify companies that have successfully implemented an IT-enabled strategy. If the CWP100 companies have successfully implemented an IT-enabled strategy better than the matched control group, then ceteris paribus, the conclusions reported are valid. If the CWP100 companies have not successfully implemented an IT-enabled strategy better than the matched control group, then there is a second, less obvious explanation for the results. However, with just a cursory examination of the CWP100, one observes that many of the ‘classic’ companies that are widely recognized for having successfully implemented an IT-enabled strategy such as Wal-Mart, Merck, 3M Co., etc. are on the CWP100 list.

Another issue with the data is that it is now almost 10 years old. However, any study that uses duration must use ‘old’ data because measuring duration implies a longitudinal study for numerous years after competitive advantage is identified. A study that tries to
measure the duration of competitive advantage must use old data or the duration measure would not accurately measure the true duration (the variable would be right censored). For example, Kettinger et al. (1994) use system implementations from 1971 to 1983, resulting in data eleven to thirty three years old when they published their work in 1994. A secondary effect of using an older dataset is that many of the companies are no longer available in the active file of the Compustat Research Insight database. We were unable to measure the duration of companies not in the active file, and this reduced our sample by 22 companies. If the competitive advantage of these 22 companies or the other 13 companies not in the study (see Table 3) is different than the competitive advantage held by the remaining 65 companies, then our results may not hold.

Another concern is the time period covered in the study, right at the beginning of an explosion in the Internet, distributed computing, corporate intranets, e-commerce, and many other changes in business due to IT. Replicating the study in a few years with more recent data would answer the question of whether these results are specific to a time period before the IT and telecommunications revolution of the mid to late 1990s. Another reason to use data that are more recent is to gauge the impact of competitive intelligence, which gained wide use and acceptance in the late 1990s (Kahaner, 2000). Although our results on peer ranking suggest that high visibility of a company’s competitive advantage decreases the sustainability of that advantage, this relation is probably stronger in the age where the Internet has made access to real-time company information less costly, and has been suggested to make competition fiercer (McCune, 1997).

4.2. Implications of results and suggestions for future research

Previous research in the area of IT and competitive advantage has provided ample theoretical support for how IT can lead to a sustained competitive advantage, but has not tested the theory directly (Mata et al., 1995; Hidding, 2001). Other research in this area has searched for a relation between IT use and productivity or performance, and once identified, attributed it to factors mentioned in the theoretical literature (Bharadwaj, 2000). Our test is a direct measure of what specific IT factors lead to a sustained competitive advantage due to an IT-enabled strategy.

This study builds upon the work of Kettinger et al. (1994). Kettinger et al. surveyed the popular press, academic literature, and case studies to find strategic deployments of IT that led to competitive advantage. Using Return on Sales and Market Share, the authors identified companies that were able to gain and sustain a competitive advantage due to their IT deployments for five and ten year periods after implementation. This classification allowed them to perform discriminant analysis to see what factors distinguished sustainers (15 companies) from non-sustainers (13 companies). They found that the strong discriminating factors were investment intensity, cash flow, and industry competitiveness. Moderate factors were R&D intensity, times interest earned, and cost efficiency. Asset base and working capital were weak but still significant discriminating factors.

Our work is different from theirs in two respects. The primary difference is that we examine IT related factors, where as Kettinger et al. examined industry and non-IT firm level characteristics. The second difference is that the Tobit model allows us to establish the IT factors that determine the duration of competitive advantage, in addition to
the existence of competitive advantage. The Kettinger et al. work used a binary dependent variable, whether a firm had obtained a sustained competitive advantage or not. We feel ours is a large contribution to understanding the link between IT and sustainable competitive advantage.

Our work also builds upon the work of Chen and Miller (1994) and Chen and MacMillan (1992). Chen and Miller state that one of the weaknesses of their study is the fact that it is based on a single industry (Chen and Miller, 1994, p. 97). We augment their work by considering companies from several industries. We also follow the suggestion of Chen and MacMillan in considering the importance of resources and capabilities as determinants of competitive response. By considering the impact of peer rating while controlling for IT resources and capabilities, we separate the effects of visibility, resources, and capabilities.

Although there is theoretical support for managerial IT skills, technical IT skills, and IT infrastructure having the non-imitable characteristics required to sustain a competitive advantage, we did not test these non-imitable characteristics directly. A direct test of these characteristics and how they relate to the IT factors would aid managers in making resource allocation decisions for maximum sustained competitive advantage.

Another avenue for future research is the relation between duration and competitive environments. Hidding (2001) developed a dynamic framework that assessed strategic advantage from a product standpoint to explain how firms gain and maintain competitive advantage due to IT. His framework is based on the following observations: first, product advantages come and go with different speeds in different environments (ecologies). A product advantage may range from 7 to 10 years in a long-cycle ecology, while in a short-cycle ecology it may last only 0.5–3 years. Second, different ecologies imply different strategy paradigms. Hidding argues that IT strategies will differ significantly depending on a particular ecology, and that development of strategic IT applications as well as core IS capabilities must focus on the particular ecology’s success factors. Future research could test these notions empirically by classifying firms by their respective ecologies. This would allow researchers to study how IT resources contribute to duration of competitive advantage within ecologies. If there are differences across ecologies, researchers could study the interaction between ecology and managerial IT skills, technical IT skills, and IT infrastructure.

4.3. Implications for managers

Empirical and anecdotal evidence have demonstrated that “Strong IS initiatives have a direct impact on competition” (ComputerWorld, 1993, p. 48). Competitors are faced with the dilemma of either responding to the IS initiative in order to maintain competitive parity or not respond and slide into a position of disadvantage. Most companies faced with a situation like this try to analyze and imitate their successful competitors’ practices. This is validated from the following quote on peer ratings in ComputerWorld (1993, p. 48), “They have been very innovative in past years. We usually use them as a guide as we try new
things”. When competitors replicate the leading company’s strategy and capabilities, the leader loses their competitive advantage.

It is important for managers to protect IT initiatives from competitive scrutiny through causal ambiguity and social complexity. This is achieved by using IT to integrate across activities or business units. In an interview in CIO magazine, Porter says that CIOs should integrate as many activities in their business as possible to achieve sustainable competitive advantage. This is because it is more difficult for competitors to replicate an entire system than individual components (Pastore, 1995). The role of managerial IT skills becomes more important when seen in the backdrop of the results of Peer rating and CEO rating. It is the responsibility of IT management to foresee the role that new IT can play in terms of supporting business activities ahead of the competition, while maintaining an element of secrecy regarding strategic initiatives.

The message of this study for CEOs is similar yet more challenging, because CEOs need to balance two opposing forces. On one hand, as suggested in previous research, they must signal continuously and positively the importance of IT (Earl and Feeny, 2000). On the other hand, they must be careful in terms of how much they are revealing to external sources. Given the visibility of their actions and statements, they are more likely to attract external attention and be scrutinized by their competitors. Such visibility seems to be detrimental to the duration of a company’s competitive advantage.

There are also implications for CIOs, given that the role of CIO is evolving and “the CIO potentially becomes a more proactive, business visionary. In this stage, the CIO begins to be one of the main drivers of strategy by recognizing the emerging capabilities and applications of IT and arguing their significance to the business” (Ross and Feeny, 2000, p. 400). This was demonstrated in 1996 when the management of Wal-Mart recognized the strategic importance of collaborative planning, forecasting, and inventory replenishment model (CPFR). CPFR lets trading partners realize increased efficiency in inventory management, it supports more sales, and improves customer service. In a study by the Gartner Group (Songini, 2001), it was estimated that companies using the CPFR model could improve their inventory accuracy by 5–15%, reduce their supply chain operations by 20–35%, and the cost of the software could be recovered in 4–6 months. Five years later Kmart joined the CPFR initiative.

Increasing integration is another CIO opportunity. Porter suggests that you need to integrate IT across activities or businesses units, making the process of imitation more difficult for competition (Pastore, 1995). “Even $670 million in technology and logistics investments this year won’t change the hard reality that Kmart Corp. is facing an uphill battle trying to catch rival Wal-Mart” (Sliwa, 2000).

5. Conclusion

We examined the role of several factors that previous work has posited contribute to the sustainability of an IT-enabled competitive advantage. Previous theoretical researchers have agreed that managerial IT skills are a source of sustainability, and our work validates this conclusion. We find no evidence that technical IT skills or IT infrastructure contribute
to the duration of competitive advantage, but this may be due to measurement error. Prior research has shown that the visibility of competitive advantage is linked to inferior performance. We find that successful users of IT whose accomplishments are widely recognized by their peers do indeed have a shorter duration of competitive advantage.

A vast body of work has concluded that successful use of IT can lead to a competitive advantage. We extend this work by examining the duration of competitive advantage rather than the creation of competitive advantage. We find that a competitive advantage due to an IT-enabled strategy is more likely to be sustainable if it is built on the managerial expertise of the organization, and protected from recognition by the competition.

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Appendix A. Censored regression models

The general formulation of the censored regression model is

\[ y^*_i = \beta' x_i + \varepsilon_i, \]  

(A1)

where \( y^*_i \) stands for the number of consecutive years a company sustains its competitive advantage. The latent variable, \( y^*_i \) is observed for values greater than zero, i.e. when the company enjoys a competitive advantage, and censored for values less or equal to zero, i.e. when the company does not enjoy a competitive advantage. On the other hand \( x \)'s, the vector of explanatory and control variables, are observed for all cases, and \( \varepsilon_i \ iid \sim N(0, \sigma^2) \).

To analyze the distribution, we define a new random variable \( y_i \) transformed from the original one \( y^*_i \), by Eq. (A2), the selection equation, which determines whether a company makes it into the sample of companies with a competitive advantage.

\[
\begin{aligned}
    y_i &= \begin{cases} 
        y^*_i & \text{if } y^*_i > 0 \\
        0 & \text{if } y^*_i \leq 0
    \end{cases} \\
    \text{or } y_i &= \begin{cases} 
        y^*_i = x_i \beta + \varepsilon_i & \text{if } y^*_i > 0 \\
        0 & \text{if } y^*_i \leq 0
    \end{cases}
\end{aligned}
\]

(A2)

The distribution that applies if \( y^* \sim N[x; \beta, \sigma^2] \) is

\[
\text{Prob}(y = 0) = \text{Prob}(y^* \leq 0) = \Phi\left( -\frac{x_i \beta}{\sigma} \right) = 1 - \Phi\left( \frac{x_i \beta}{\sigma} \right). \]

(A3)
and if \( y^* > 0 \), \( y \) has the density of \( y^* \). \( \Phi(\cdot) \) is the standard normal cumulative density function.

The estimation is done using the Maximum Likelihood method. The log-likelihood for the censored regression model is

\[
\ln L = \sum_{y_i > 0} -\frac{1}{2} \left[ \ln(2\pi) + \ln \sigma^2 + \frac{(y_i - \beta^T x_i)^2}{\sigma^2} \right] + \sum_{y_i = 0} \ln \left[ 1 - \Phi \left( \frac{B^T x_i}{\sigma} \right) \right] \quad (A4)
\]

The two parts correspond to the classical regression for the non-limit observations (companies with a competitive advantage) and the relevant probabilities for the limit observations, respectively (companies without a competitive advantage).

\[
L = \prod_{y_i > 0} \frac{1}{\sqrt{2\pi} \sigma} e^{-\frac{1}{2} \left[ \frac{(y_i - \beta^T x_i)^2}{\sigma^2} \right]} \cdot \prod_{y_i = 0} \left[ 1 - \Phi \left( \frac{B^T x_i}{\sigma} \right) \right] \quad (A5)
\]

The likelihood consists of the product of expressions for the ‘probability’ of obtaining each observation. For each non-limit observation, this expression is just the height of the appropriate density function representing the probability of getting the particular observation. For each limit observation, however, all we know is that the actual observation is below zero. The probability for a limit observation therefore must be the probability of getting an observation for a company without a competitive advantage, which would be the integral below zero of the appropriate density function.

For an observation randomly drawn from the population, which may or may not be censored,

\[
E[y_i | x_i] = \Phi \left( \frac{B^T x_i}{\sigma} \right) (\beta^T x_i + \sigma \lambda_i), \text{ where } \lambda_i = \frac{\phi(B^T x_i/\sigma)}{\Phi(B^T x_i/\sigma)} \quad (A6)
\]

For \( y_i \), given the censoring, the marginal effect is only

\[
\frac{\partial E[y_i | x_i]}{\partial x_i} = \beta \Phi \left( \frac{B^T x_i}{\sigma} \right) \quad (A7)
\]

The slope vector can be further decomposed into

\[
\frac{\partial E[y_i | x_i]}{\partial x_i} = \text{Prob}[y_i > 0] \frac{\partial E[y_i | x_i, y_i > 0]}{\partial x_i} + E[y_i | x_i, y_i > 0] \frac{\partial \text{Prob}[y_i > 0]}{\partial x_i} \quad (A8)
\]

Thus, the change in \( x_i \) has two effects. It affects the conditional mean of \( y^*_i \) in the positive part of the distribution, and it affects the probability that the observations will fall in that part of the distribution.

References


