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An Empirical Analysis

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Effect of IT Investments on Customer Satisfaction: An Empirical Analysis

Abstract

This study explores the relationship between firms' information-technology (IT) investments and customer-satisfaction performance. Although much of the prior work on the business value of IT at the firm level focused on financial and accounting measures, this paper explores the effect of IT investments on more qualitative outputs, such as improved customization, product variety and customer convenience, as reflected in the overall customer satisfaction for a firm. Our analysis of data collected from more than 50 firms for multiple years indicates a positive association between investment in IT labor and overall customer satisfaction. Our results also indicate that the effect of IT investments on customer satisfaction may differ across manufacturing and service companies.

Keywords: Information-technology Investments, IT Labor, IT Capital, Customer Satisfaction, Business Value of IT.

1. INTRODUCTION

The pervasive use of computing in all aspects of business life and the scale and nature of investments in information technology in the last decade have made it imperative to understand the role of information-technology (IT) investments in improving company performance. The quest to uncover the effect of IT investments sparked an intense debate characterized as the "productivity paradox" in economics and information-systems literature. Productivity paradox, first highlighted by Roach in 1987, referred to the stagnant white-collar labor productivity in the services sector of the economy despite heavy investments in IT. In due course, productivity paradox became shorthand for perceived lack of benefits from IT investments in general (Solow 1987, Brynjolfsson 1998). The often cited comment by Nobel laureate Robert Solow that “we see the computer age everywhere except in productivity statistics” seemed to capture the growing disillusionment with IT-led productivity gains.

The focus on productivity as the sole measure of economic performance came under closer scrutiny in subsequent years. Researchers argued that conventional output or quantitative measures of economic performance such as productivity may not be sufficient in a differentiated marketplace (Fornell 1995, Fornell et al. 1996). Some saw the need to study other intangible customer-oriented measures of firm performance, such as greater responsiveness to customers, more variety and overall customer experience, which may have enhanced customer satisfaction. (Brynjolfsson and Hitt 1998).

Researchers and practitioners also have argued that the locus of power in shaping an industry or business has shifted toward customers (Prahalad and Ramaswamy 2000;

Financial Times 2002). As a consequence, customer franchise has emerged as one of the crucial assets for firms. It has been argued that companies need to be "customer centric" to sense and meet customer demands for changes in pricing structure, distribution channels and the specific features of products and services. In order to improve customer loyalty and "word of mouth" opinions about their products and services, companies have begun to focus on the total customer experience and customer satisfaction. Significant investments in CRM (Customer Relationship Management) systems in the last several years indicate the industry belief that IT applications can streamline both internal and customer-interfacing business processes. Given that customer satisfaction has been identified as a leading indicator of the market value of firms, it is important to understand what role IT investments play in enhancing customer satisfaction (Ittner and Larcker 1996a). To our knowledge, no prior research has examined the role of IT investments in enhancing customer satisfaction.

The lack of empirical studies linking IT investments to customer-based performance measures may be due in part to the difficulty of collecting firm-specific IT investment and customer-satisfaction data. Although IT investments by firms are now tracked by multiple third-party sources and are available for research, obtaining customer-satisfaction data has been a challenge. Even when available, collecting this data directly from firms can present problems from a research viewpoint. For example, firms may use diverse methodologies to track customer satisfaction, and their satisfaction measures may be biased. In this study, we rely on IT investment and customer-satisfaction data collected by reputable third-party organizations that follow a well-defined, standardized approach to collecting such data. We combine these standardized IT investments and

customer-satisfaction measures for a broad range of manufacturing and services firms to examine if the proactive management of IT resources has helped companies achieve higher levels of customer satisfaction.

In addition to looking at the effect of investing in IT resources in aggregate, we also explore the individual effects of *IT labor* and *IT capital* on the customer-satisfaction performance of the firm. Disaggregating IT investments is particularly relevant because the so-called "IT productivity paradox" initially referred to the stagnant, or even declining, productivity of white-collar information workers in the services sector of the economy (Roach 1987). Although subsequent studies have reported a positive contribution of *IT labor* to productivity measures, very few studies have included firms from service industries in their sample. In this research, we study the effect of *IT labor* on the customer-satisfaction performance of firms in both manufacturing and service industries.

This study makes several important contributions. First, by focusing on customer satisfaction, our research complements the findings of the extant research linking IT investments to productivity. To our knowledge, this is the first empirical study that examines the business value of IT investments in terms of customer satisfaction. Unlike previous studies, which have used accounting and financial measures, our study highlights the business value of IT using a measure (i.e., customer satisfaction) that is based on direct inputs from customers and is insulated from potential managerial manipulations to achieve short-term results. Studying these non-financial measures of performance promises to augment our understanding of IT business value.

Second, our study examines the independent effects of investments in *IT capital* and *IT labor* and provides managerial insights from these results. Finally, the panel nature of our dataset allows us to examine the effect of IT investments on customer satisfaction over a period from 1994 to 2000. Our analysis enables us to raise questions about potential structural shifts in the relationship between IT investments and customer satisfaction in recent times across manufacturing and service industries.

The remainder of the paper is structured as follows. Section 2 provides a description of the theoretical framework and research hypotheses. Section 3 describes the research design and methodology employed, and section 4 provides data analysis and results. Section 5 discusses our results, and section 6 contains concluding remarks.

2. THEORY AND HYPOTHESES

In this section, we discuss prior literature on the business value of IT investments and present the theory underlying our hypotheses linking IT investments to customer satisfaction.

2.1 Prior Literature on the Business Value of IT Investments

The business value of IT investments is a subject that continues to attract significant interest both in the business press and academic literature (The Economist 2002b, Kohli and Devaraj 2002, Kudyba and Diwan 2002). Researchers have studied the business value of IT investments at different levels, including the economy, firm, functional and process levels.

Research on the business value of IT started as in-depth, case-based studies of specific IT applications in a given business function in an effort to understand the changes in business-process outcomes (Banker, Kauffman and Morey 1990). These

studies established the effect of IT investments on operational efficiency in sectors as diverse as restaurants and banking (Banker and Kauffman 1991) and were followed by empirical studies based on large datasets that sought to understand the role of IT investments in determining productivity at the firm level. However, findings from these firm-level analyses have been mixed with respect to productivity and profitability. For example, studies by Brynjolfsson and Hitt (1996) and Brynjolfsson and Yang (1997) provided evidence that IT contributes to firm productivity. On the other hand, studies by Strassman (1997), Loveman (1994), Hitt and Brynjolfsson (1996) and Weill (1992) reported no significant relationship between IT investments and business-profitability measures. Brynjolfsson (1996) reviewed these findings and identified several reasons for inconsistency, including problems in measuring inputs and outputs related to IT, the re-distributive aspect of IT resulting in greater competition without any benefit to the firms, and the mismanagement of IT due to the misallocation and over-consumption of resources.

The mixed results from firm-level analyses of IT investments on productivity and profitability prompted further research. Researchers highlighted the problems inherent in measuring the influence of IT directly on aggregate firm performance, which depends on many factors other than IT (Barua et. al. 1995, Kauffman and Kriebel 1988, Mukhopadhyay and Copper 1993). They suggested an approach using intermediate-level variables (such as capacity utilization and inventory turnover) to measure the impact of IT on outputs in specific functional areas, such as marketing and manufacturing. Subsequent IT application-level studies (Mukhopadhyay et al. 1995) and process-level

work (Mukhopadhyay et al. 1997a, 1997b; Davamanirajan et al. 1999) focused on the outcomes of business processes directly affected by IT applications.

Although studies using different levels of analysis as discussed above have provided valuable insights into the relationship between IT investments and business value, none of these studies has directly accounted for the customers' perspective of the value from IT investments. Most of the prior studies have addressed managers' and investors' perspectives of business-value outputs. Focusing on customer satisfaction is particularly relevant because, as noted earlier, customer franchise has emerged as a critical asset for firms, and customer satisfaction has been reported as a leading indicator of market value. Also, managers consistently rank customer service as the prime motivation for making IT investments (Brynjolfsson and Hitt 1998). Hence, there is a need for better understanding of the payoffs from IT investments in terms of customer satisfaction from a managerial perspective.

2.2 Relating IT Investments to Customer Satisfaction

Customer satisfaction is a powerful measure of firm performance because of the negative influence of customer complaints and the positive influence of customer loyalty (Fornell 1992). Researchers in marketing have reported that increased customer loyalty may secure future revenues, reduce the cost of future transactions, decrease price elasticity and minimize the likelihood of customer defection in the event of poor quality (Rust et al. 1994, Reichheld and Sasser 1990, Anderson 1996, Anderson and Sullivan 1993). In addition to these advantages, customer satisfaction may also help to account for intangible outputs such as product quality or variety. The quantification of such intangible improvements in product quality, variety or consumption experience through a

customer-satisfaction index at the firm level has the potential to complement the productivity-based measurement of economic growth. Although information-systems researchers have studied the effect of IT investments on consumer surplus and consumer welfare at the economy level, to our knowledge, no systematic study has been undertaken to relate IT investments to customer satisfaction at the firm level (Brynjolfsson 1996; Hitt and Brynjolfsson 1996). Thus, our study aims to fill this major gap by focusing on the effect of IT investments on customer satisfaction.

In this study, we adopt the customer-satisfaction measurement model used for calculating the American Customer Satisfaction Index (ACSI), which is compiled and analyzed by the National Quality Research Center at the University of Michigan Business School. In this measurement model, an individual firm's ACSI score represents its customers' overall evaluation of their total purchase and consumption experience (refer Fornell et al. 1996 for details). The overall customer satisfaction of a firm has three determinants: *perceived quality, perceived value* and *customer expectations*. *Perceived quality*, which captures recent consumption experience, has two components: (a) customization, i.e., the degree to which the firm's offering is customized to meet heterogeneous customer needs, and (b) reliability, i.e., the degree to which a product or service is standardized and free from deficiencies. The second antecedent of overall satisfaction, *perceived value,* captures the perceived level of product quality vis-à-vis the price paid. The third determinant, *customer expectations,* captures customer perspectives on prior consumption experience as well as belief in the firm's ability to deliver quality in the future.

It is believed that investments in appropriate IT applications can enable firms to influence the three determinants of overall ACSI (*perceived quality, perceived value and customer expectations)* to improve the total customer experience. Past research in information-systems literature has shown that information technology can play three types of roles in organizational performance (Schein 1992, Armstrong and Sambamurthy 1999). First, IT may replace human labor through the automation of business processes leading to efficiency gains and cost reductions. Such efficiency gains and cost reductions, if passed on to the consumers, may enhance the *perceived value* of a firm's offerings. Second, IT may facilitate the efficient flow of information in an organization, leading to efficient allocation of resources, shorter response times and improved quality. These outcomes may enhance the *perceived quality* of a firm's customer service, leading to a favorable impact on customer satisfaction. Finally, IT may also help facilitate business-process innovation by redefining and redirecting business relationships and core processes through new channels leading to significant improvements in *customer expectations* and the total customer experience.

In practice, IT applications in sales automation and internal-marketing processes have enabled firms to enhance the effectiveness of marketing and advertising programs in shaping *customer expectations*. Firms also have made major investments in IT to meet the heterogeneous needs of customers and to improve *perceived value* and *perceived quality* in order to improve customer satisfaction. For instance, firms spent $8 billion on customer-relationship management (CRM) technologies in 1999, and this figure is projected to reach $24 billion by 2003 (Simpson 2002). These CRM technologies are aimed at improving the efficiency and effectiveness of business processes covering

various customer touch points. More important, firms have spent significant sums of money to transform their business processes and train employees to leverage their investments in IT. The possible role IT plays in affecting customer satisfaction also has attracted the attention of marketing researchers. In several studies, these researchers have acknowledged the potential impact of IT on the customer-satisfaction performance of firms (Parasuraman 1996, Parasuraman and Grewal 2000). This leads to our first hypothesis:

H1: Higher investments in information technology are associated with higher levels of customer satisfaction.

Prior research on business value of IT has shown that the effect of IT investments may differ across manufacturing and service industries, underscoring the need to understand these differences (Brynjolfsson and Hitt 1996, Kudyba and Diwan 2002). For example, in their study of the contribution of IT to firm output, Brynjolfsson and Hitt (1996) excluded all firms in the financial-services and telecommunications industries from their sample. They did so because their model "poorly predicted" the output for such industries, reflecting the differences in the effect of IT across manufacturing and service firms. Several other studies also have failed to find any significant IT impact in the service sector (Roach 1991, Quinn and Baily 1994).

The nature of customer interaction and experience with service encounters differs significantly across the manufacturing and service sectors. Prahalad and Krishnan (1999) have noted that the customer view of “quality” may differ across products and services. For example, customers who purchase a manufactured product may regard the conformance of the product features to specifications as important. However, in the

service business, such as hospitality or airlines, customers may consider the "adaptive view of quality" (i.e., the flexibility to respond to the specific needs of individual customers) as equally or more important. Based on similar reasoning, marketing researchers have argued that the drivers of customer equity may be different across industry sectors (Rust, Zeithaml and Lemon 2000).

Given customer heterogeneity and the adaptive expectation of quality, firms in the service sector face the challenging task of tailoring their offerings to individual customer tastes and making a profit at the same time. Compared to manufactured goods, it is also much more difficult to evaluate services using objective criteria because the consumption experience is very personal and subjective. Following this line of reasoning, Johnson and Fornell (1991) have argued that average customer satisfaction should be higher for *goods* than for *services*.

Since the service business is information intensive and must adapt to individual customer requirements, IT can play a greater role in enabling service-sector companies to improve their customer satisfaction significantly. This can be accomplished by leveraging IT capability to customize product delivery and consumption experience in real time. For example, the innovative use of IT has enabled firms such as Amazon.com (retailing services) and Charles Schwab (financial services) to record high levels of customer satisfaction. Marketing researchers also have argued that IT may have greater leverage for achieving customer satisfaction in service businesses that are more information intensive (Anderson et al. 1997). Therefore, we expect IT investments to have a greater effect on customer satisfaction for firms in the service sector compared to those in the manufacturing sector.

H2: Higher investments in information technology are associated with higher levels of customer satisfaction for firms in the service sector than for firms in the manufacturing sector.

2.3 Role of IT capital and IT labor

Consistent with previous studies in economics and information systems, in this research we disaggregate IT investments into two constituent components: *IT capital* and *IT labor* (Barua and Lee 1997, Brynjolfsson 1996, Dewan and Min 1997, Hitt and Brynjolfsson 1996, Kudyba and Diwan 2002). *IT capital* here refers to the component of overall IT expenditure that leads to the creation of some tangible assets, such as hardware components, networks and IT equipment, which last several years. Whereas *IT labor* refers to the portion of a firm's IT expenditure that is used to pay the salaries and benefits of IT employees who develop, maintain and manage hardware and software applications in the IT infrastructure of the firm. Although previous research has explored the contributions of *IT labor* and *IT capital* vis-à-vis non-IT labor and non-IT capital to firm output (sales or value added), we explore the contribution of *IT labor* and *IT capital* in managing the overall customer-satisfaction performance of a firm.

Given that leveraging information technology in the context of a particular firm entails investments in firm-specific knowledge and routines, one may argue that having internal *IT labor* and *IT capital* may help firms better leverage their IT resources. Although investments in *IT capital* may lead to "machine power" in terms of the latest hardware technology and software platforms, investments in *IT labor* may help in tailoring applications to meet the unique requirements of the company and its customers, thus improving the total customer experience. This leads to our next set of hypotheses:

H3a: Higher investments in internal *IT labor* are associated with higher levels of customer satisfaction.

H3b: Higher investments in internal *IT capital* are associated with higher levels of customer satisfaction.

{Insert Figure 1 about here}

3. RESEARCH DESIGN AND METHODOLOGY

As depicted in Figure 1, this study explores the effect of IT investments on overall customer satisfaction with a firm's goods and services. We use linear regression and production-function approaches for analyzing the relationship between IT investments and customer satisfaction. We use regression analysis to examine the effect of IT investments on customer satisfaction across manufacturing and service sectors over the period from 1994 to 2000. A production-function model is used to disaggregate the effect of IT investments in terms of *IT labor* and *IT capital* and to study their individual effects on customer satisfaction.

3.1 Variable Definition

The variables used in the study are described below:

ACSI refers to the American Customer Satisfaction Index tracked by the National Quality Research Center (NQRC), University of Michigan Business School. Each year the NQRC surveys 65,000 customers who purchase products from about 190 companies and asks these consumers to score companies on a scale of 0-100 to determine overall customer satisfaction for a company. The ACSI is considered to be a reliable indicator of a firm's customer satisfaction, and the aggregate report of this index is tracked by leading business publications including The Wall Street Journal and Fortune magazine. This data

also has been used in a number of academic studies in the accounting and marketing literature (Fornell et al. 1996, Ittner and Larcker 1996a, 1996b, Anderson and Rego 2000).

ITINVPC refers to the level of IT investment made by a firm as a percentage of the sales revenue of the firm. We obtained detailed firm-level IT-investment data from Information Week annual surveys of top IT managers in North America. Information Week is considered to be a reliable source of information, and previous academic studies also have used data from Information Week surveys (Bharadwaj et al. 1999, Hitt 1999, Kudyba and Diwan 2002).

IT capital refers to IT investments in hardware measured in dollars. Since our IT-investment data is measured as a percentage of sales, we compute this amount in dollars by determining the proportion of the IT budget that was allotted to hardware and multiplying the appropriate percentage of IS budget with revenue of the firm.

Non-IT capital refers to the value of the net property plant and equipment after accounting for the IT capital computed above.

IT labor refers to the money spent by firms on their IT employees. Instead of converting IT labor to dollar figures, we used the number of IT employees in our production-function models since dollar figures will be a multiple of IT employees.

Non-IT labor refers to the number of non-IT employees. This was computed by subtracting the number of IT employees from the total number of employees.

SVCEMFG is an indicator variable representing whether the company offering is primarily goods or a service (0=services, 1=goods), depending on the type of product for which ACSI scores are available from the NQRC. All companies in the manufacturing sector (both durable and non-durable) were classified as offering primarily goods while service companies included firms from the hospitality, airline and financial-services sectors.

HHI (industry concentration): Arguably, the relative market concentration of a firm in a given industry may influence customer perceptions of its products and services and eventually affect customer satisfaction. Hence, in marketing literature, industry-concentration measures for firms are used as a control variable. Following this, we collected market-share data from databases such as Table Search and Market Share Guide to compute the Hirschman-Herfindahl Index (HHI), which is one of the widely accepted measures of market concentration (Anderson and Rego 2000, Curry and George 1983).

TA refers to the total assets of a firm for the corresponding year during the period of the study.

Year is an indicator variable (0=1994, 1995 and 1996; 1=1999 and 2000). Since firms were investing aggressively in information technology to open new Internet-based

channels for conducting business from 1994 to 2000 and this trend is believed to have peaked during the 1999-2000 period, it is important to look for any structural shifts in the role of IT investments over time. For example, Brynjolfsson and Hitt (1996) and Bharadwaj et al. (1999) observed that IT was showing a continually declining contribution to productivity and market value in their dataset. The use of this dummy indicator in our regression model allows us to control for any unobserved systematic effects during the two time periods (1994 to 1996 and 1999 to 2000). Table 1 provides a summary of the variables and the data sources used in the study. Table 2 provides co-relations among key variables.

{Insert Table 1 and 2 about here}

3.2 IT Investment and Customer-satisfaction Model

We use a linear model estimation approach to relate IT investments to customer-satisfaction levels. Based on findings in past research, we control for other variables that may influence the relationship between IT investments and customer-satisfaction performance. Accordingly, we use market concentration (Conner 1991, Anderson and Rego 2000), industry sector and firm size (Atiase 1985; Bharadwaj et al., 1999) as control variables in our study. Our empirical model is shown below:

$$ACSI = \alpha_0 + \alpha_1 HHI + \alpha_2 SVCMFG + \alpha_3 ITINVPC + \alpha_4 SVCMFG*ITINVPC + \alpha_5 TA + \alpha_6 YEAR + \alpha_7 YEAR*ITINVPC + \varepsilon \quad (1)$$

3.3 Production-function Approach

We also use a production-function approach, similar to the ones used by Barua and Lee (1997), Brynjolfsson and Hitt (1996a, 1996b), Dewan and Min (1997) and Kudyba and Diwan (2002), to analyze the effect of *IT labor* and *IT capital* on customer

satisfaction. We use the following form of Cobb-Douglas production function to estimate the elasticity of production inputs such as labor and capital with respect to customer satisfaction:

$$ACSI = (IL^{\beta 1}, L^{\beta 2}, IK^{\beta 3}, K^{\beta 4})$$

Note that the ACSI score (the customer-satisfaction rating of the firm) is treated as an output variable in the above production function. IL and IK are *IT labor* and IT capital while L and K represent non-IT labor and non-IT capital used by a firm.

Linearization of the above equation yields the following form:

$$\ln(ACSI) = \beta_1 \ln(IL) + \beta_2 \ln(L) + \beta_3 \ln(IK) + \beta_4 \ln(IK) + \varepsilon \qquad (2)$$

The data used in this study comprises an unbalanced panel of more than 50 firms over the period of 1994 to 2000, for which customer-satisfaction data is available. We utilized the customer-satisfaction data tracked by the National Quality Research Center (NQRC) at the University of Michigan Business School. IT-spending data comes from several annual surveys of top IT managers of Fortune 500 companies in North America. These data are matched to a Compustat database to obtain values for sales, value added, number of employees, labor expenses, total capital and other financial information. Table 3 provides a summary profile of the firms in our sample.

{Insert Table 3 about here}

4. ANALYSIS AND RESULTS

The results of empirical estimation of models in equations (1) and (2) are shown in Tables 4 and 5. For both models shown in equations (1) and (2), we tested for the standard assumptions of linear regression. We tested for multi-collinearity by computing the condition numbers (Belsley et al., 1980). The highest condition index in both models

was 13.5. This value is lower than the threshold specified in the literature, indicating that multi-collinearity is not a serious concern in our analysis (Belsley et al. 1980). We also tested for heteroskedasticity using White's test for both models. This test rejected the null hypothesis of homoskedasticity for the model specified in equation (1). Hence, we corrected for heteroskedastcity by estimating the Huber-White standard errors. The parameter estimates with corrected standard errors are shown in column four of Table 4.

In order to capture any potential firm-level heterogeneity, we also estimated the model in equation (1), allowing for the intercept to vary across individual firms and with one period autocorrelation in the error terms using a Toeplitz (2) covariance structure. The estimates of this random-effects model are shown in column five of Table 4. We tested for the significance of random effects using the Breusch and Pagan (1980) Lagrange Multiplier test. This test statistic exceeded the critical value of chi-square with one degree of freedom rejecting the null hypothesis in favor of the random-effects model. The Hausman test using Wald criterion for random effects also rejected the null in favor of the random-effects model (Hausman, 1978). As shown in Tables 4 and 5, the explanatory power of these models is reasonable in comparison to similar models used in previous studies (for example, see Brynjolfsson and Hitt 1996, Kudyba and Diwan 2002). We also tested for outliers and influential observations in our sample and did not detect any significant problems. Next, we discuss the results of the customer-satisfaction model based on the estimates of the random-effects model shown in column five of Table 4 and the results of production-function specifications shown in columns three to five shown of Table 5.

{Insert Table 4 and 5 about here}

5. DISCUSSION

Hypothesis 1 predicted a positive association between IT investments and customer satisfaction. We find from Table 4 (column five) that the coefficient of the variable ITINVPC (IT investments) is positive and highly significant (α_3=0.667, p<0.008). Since our IT investment is measured as a percentage of sales, this indicates that an increase of one percentage point in IT investments in the service sector is associated with an increase of 0.667 (a 0.91% increase at the mean level) in the customer-satisfaction index for the period 1994 to 1996. However, this effect of IT investments needs to be understood along with the coefficient of interaction terms with IT investments in our model.

The coefficient of the interaction term involving IT investments and industry sector (manufacturing or service) in our model is negative and significant (α_4=-0.955, p<0.010) The interaction coefficient indicates that higher IT investments in manufacturing firms are associated with lower customer-satisfaction scores. Each percentage increase in IT investment is associated with a decline of 0.288 in the customer-satisfaction level index (a 0.35% decline at the mean level) during 1994 to 1996. We used the Wald statistic to test the hypothesis of joint significance for the terms involving IT investments and its interaction with the industry sector. This test rejected the null hypotheses (α_3=0 and α_4=0) at $p < 0.05$, providing evidence in support of the argument that IT investments have a significant influence on customer satisfaction in both the service and manufacturing sector.

Table 4 (column five) also shows a positive and significant coefficient for the variable SVCEMFG (α_2=11.379, p<0.000), indicating that the mean level of customer-satisfaction index is higher for manufacturing firms in comparison to service firms. This

result is consistent with previous research in marketing (Fornell et al. 1996). The joint test of significance for the coefficients of industry sector and interaction term involving industry sector and IT investments (α_2=0 and α_4=0) is significant in our model at $p<0.05$. This result provides evidence in support of our hypothesis 2 that firms in the service sector perform significantly better than firms in the manufacturing sector in leveraging IT to improve customer-satisfaction levels. As noted earlier, one reason for this result may be that IT applications are enabling firms in the service industries to better understand customer needs and to provide flexibility in business processes for adapting to the specific requirements of each customer. In addition, the nature of the service business is such that consumers may experience more directly the IT-enabled flexibility and convenience in business processes, which enhance the consumption experience. For example, IT applications can be used in the hospitality industry to track the preferences of each customer based on past experiences and to tailor new service features that will delight these customers on their next business encounter. Such use of IT applications in the service industry may be one of the reasons for the positive association between IT investments and customer satisfaction. Whereas in the case of manufacturing firms, a larger proportion of IT investments may be deployed to streamline backend business processes, such as production planning and supply-chain management, which are not visible to customers.

The positive association between overall IT investments and customer satisfaction for service firms applies only for the period of 1994 to 1996. This effect is reversed in the subsequent time period of 1999 to 2000, as indicated by the negative and significant coefficients involving the interaction term between IT investments and the dummy for the

years 1999 and 2000 (α_7=-1.138, p value <0.000). One possible reason for this structural shift may be the over-investment in IT by firms during the 1999-2000 period. It was during this period that firms aggressively invested in IT assets and adopted a plethora of hardware and software standards and platforms as part of their e-business strategy. Our data show that firms significantly increased their IT investment as a percentage of sales from 1994 to 2000. For example, in our dataset, mean IT investments as a percentage of sales increased from 2.65% during 1994-1996 to 4.18% during 1999-2000, an increase of more than 57% during a five-year period.

The negative effect of this over-investment in IT on customer satisfaction is intriguing. One rationale for this effect is that although firms were aggressive in acquiring the latest IT technologies in 1998-2000, they may have failed to see the true customer needs and expectations while deploying these applications. Although IT applications have the potential to enhance the customer experience when implemented correctly, an overemphasis on IT in automating customer touch points without specific knowledge of individual customer needs may have adverse effects on customer satisfaction. This explanation is supported by trends in the customer-satisfaction index as well as views expressed by several prominent industry observers (Financial Times 2002, Forrester 2002). For example, although firms have invested heavily in call centers in the recent past, their approach often has not reflected customer needs. It is common for customers to experience long delays in getting a response to their unique requirements. Our results provide empirical evidence in support of these observations regarding the potential negative effect of IT investments on customer satisfaction.

As noted earlier, our hypothesis 3 examines the role of *IT labor* and *IT capital* in improving overall customer satisfaction. Our production-function model results in Table 5 show that *IT labor* contributes positively to greater overall customer satisfaction (see Model 1, β_1= 0.265, p value <0.01). This emphasizes the importance of investing in *IT labor* and building an IT skill base with an understanding of the firm's business needs and customer requirements. However, *IT capital* is negatively associated with customer satisfaction (β_3= -0.188, p value <0.01). There may be several explanations for these results. First, negative returns to *IT capital* may be due to the complexity arising from the use of multiple IT platforms. Managing such complexity requires skilled *IT labor* with an understanding of the company's business processes and customer scenarios. Our empirical results showing a positive contribution of *IT labor* to customer satisfaction support this explanation. Second, much of the capital investments made during the 1998-2000 period went toward enterprise resource planning (ERP) implementation on a massive scale. ERP systems, if not managed properly, make it difficult to adapt to changing customer requirements due to their inherent rigidity.

6. CONCLUSION

In this study, we examined the relationship between IT investments and customer satisfaction. Our dataset comprising an unbalanced panel of more than 50 large firms covering the period of 1994 to 2000 enabled us to study the effect of *IT labor* and *IT capital* on customer satisfaction over time. The study period encompasses one of the periods in which firms made significant investments in IT, particularly Internet-based and customer-relationship management systems. By using a dataset that has both IT

investments and customer satisfaction at the firm level, this study fills a major gap in our understanding of the effect of IT on customer satisfaction.

Consistent with our expectations, we find that IT investments played a significant role in affecting the overall customer-satisfaction performance of the full sample of firms. We find evidence showing that IT investments may help service firms improve their customer-satisfaction performance. This may be due to the more information-intensive nature of the service sector, making it more amenable to IT-facilitated interventions. Our results also show that the customer-satisfaction levels in the manufacturing sector are negatively associated with IT investments. Further, we find evidence suggesting that returns to IT may have been declining over the years due to possible over-investments in IT or a lack of complementary investments in understanding specific customer needs and streamlining business processes. Clearly, there is a need for further research to analyze the nature of the relationship between IT investments and customer satisfaction, taking into account the intermediate process level variables.

Our results also provide implications for managing IT strategy and IT investments. For example, we find that investing in *IT labor* allows firms to achieve greater customer satisfaction. We also find that marginal returns to *IT capital* are negative in terms of customer-satisfaction outcomes, holding *IT labor* constant. In summary, these results indicate that the key to increasing customer satisfaction may lie in the effective management of IS staff. Regarding the management of *IT capital*, our results seem to show that it may be prudent for managers to selectively outsource a part of IT capital assets. In contrast with *IT labor*, IT capital assets are relatively generic in nature, so firms may benefit from outsourcing arrangements in IT capital.

Though our study provides evidence of a linkage between IT investments and the customer-satisfaction performance of the firm, there are several opportunities for improving and extending this work. First, although our sample size is a reasonable representation of large firms that comprise the Fortune 500, there is a need for validating these results for mid-sized and small firms. Second, case-based research within a firm along the lines of Banker, Kauffman and Morey (1990) is needed to help us better understand how specific IT investments in various industries may affect customer satisfaction. Third, we have classified all firms as offering either goods or services for examining how the nature of goods or services affects overall customer satisfaction as it relates to IT investments. Future research may benefit from a more rigorous classification scheme that looks closely at the nature of the consumption experience in specific industries such as automotive, airline or hospitality and examines the role of IT. A promising line of enquiry may be to find out whether customer-relationship management (CRM) investments in the service sector have yielded desired outcomes in terms of greater customer satisfaction, loyalty and retention, and reduced cost or time to service customers. Finally, our study explores the link between IT investments and overall customer-satisfaction levels in the context of B2C (business to consumer) consumption experience. A useful extension of our research will be to study the effect of IT investments in CRM systems in the B2B (business to business) context.

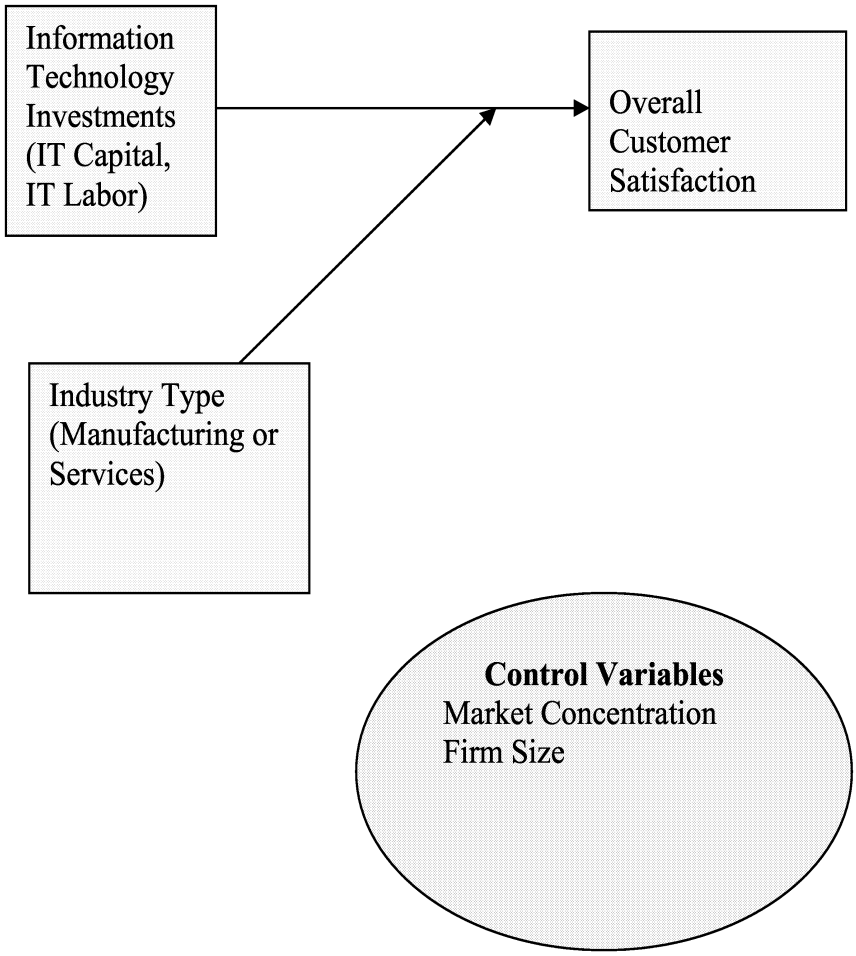

Figure 1: Research Model

Table 1. Variables and Data Sources

Variable	Source
Overall Customer Satisfaction Level (ACSI)	American Customer Satisfaction Index
IT Investment (ITINVPC)	Information Week Annual Surveys
IT Capital	Information Week Annual Surveys
IT Labor	Information Week Annual Surveys
Non-IT Capital	Information Week, Compustat
Non-IT Labor	Information Week, Compustat
Firm Size (Revenues, Assets, Number of employees)	Compustat, Hoovers
Industry Sector (Manufacturing or Services)- SVCEMFG	ACSI Classification
Market Concentration (HHI)	Table Base, Media Guide and Compustat

Table 2. Correlations Among Variables (N=145)

	1	2	3	4	5	6	7	8
ACSI (1)	1.0000							
hhi (2)	0.4237	1.0000						
svcemfg (3)	0.6022	0.0148	1.0000					
itinvpc (4)	-0.3817	0.0440	-0.5007	1.0000				
Svcemfg*itpc (5)	0.3334	-0.0433	0.7592	-0.2094	1.0000			
ta (6)	-0.1665	-0.3052	-0.1165	0.0692	-0.0818	1.0000		
Year (7)	-0.2706	-0.0481	-0.0335	0.2013	0.0169	0.0810	1.0000	
Itpc* Year (8)	-0.3998	0.0194	-0.2735	0.7930	-0.1301	0.0309	0.6045	1.0000

Table 3. Summary Statistics for Key Variables

	Manufacturing[a]			**Services**		
Variable	Mean	SD	N	Mean	SD	N
Customer Satisfaction Levels (ACSI)	81.78***	4.17	81	73.19	7.18	64
IT Investments as percentage of revenue (ITINVPC)	1.98	1.13	81	5.21***	4.01	64
Firm Size (Total Assets, bn $)	32.07	66.51	81	47.08*	60.65	64
Firm Revenues (bn $)	25.82***	31.48	81	15.64	14.91	64
Number of Employees	95600	118695	81	96947***	83622	64
Market Concentration (HHI)	1689	1438	81	1648	1295	64
IT Employees	4241	6268	29	3614	5338	42
IT Capital (million $)	182	282	29	143	165	42

[a] Differences in means were tested using t-tests for all continuous variables. Significance levels are indicated on the larger of the two numbers.

*p < .10 ** p < .05 ***p < .01

Table 4. Parameter Estimates of The Regression Models *(p values are in parentheses)*

Model	Parameter	1 OLS	2 OLS with Consistent Std Errors	3 Random Intercept Model
Dependent Variable		ACSI	ACSI	ACSI
N		145	145	145
Year		94-96, 99-00	94-96, 99-00	94-96, 99-00
Intercept	α_0	67.840*** (0.000)	67.840*** (0.000)	68.242*** (0.000)
Market Concentration	α_1	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)
Svcemfg (Mfg=1, Svces=0)	α_2	12.667*** (0.000)	12.667*** (0.000)	11.379*** (0.000)
Firm IT Investments (ITINVPC)	α_3	0.896*** (0.002)	0.896*** (0.005)	0.667*** (0.008)
SVCEMFG*ITINVPC (Interaction term)	α_4	-1.689*** (0.000)	-1.689*** (0.000)	-0.955*** (0.010)
Firm Size (total assets)	α_5	V Small (0.720)	V Small (0.720)	V Small** (0.049)
Year (0=1994-96, 1=1999-2000)	α_6	0.435 (0.715)	0.435 (0.717)	-0.464 (0.488)
Year* ITINVPC (Interaction term)	α_7	-1.138*** (0.000)	-1.138*** (0.000)	-0.922*** (0.000)
R Sq		65.19	65.19	
F Statistic		36.65*** (0.000)	22.54*** (0.000)	
AIC				756.1
ChiSquare				92.35*** (0.000)

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

Table 5. Production Function Models For Customer Satisfaction Performance
(p values are in parentheses)

Model	Parameter	1	2	3
Dependent Variable		lnacsi	lnacsi	lnacsi
N		71	29	42
Firm Type		Mfg and Services	Mfg and Services	Mfg and Services
Year		99-00	1999	2000
ln itlabor	β_1	0.265*** (0.000)	0.131* (0.072)	0.375*** (0.000)
ln non it labor	β_2	0.162*** (0.000)	0.152** (0.011)	0.165*** (0.001)
ln it capital	β_3	-0.188*** (0.000)	-0.128* (0.053)	-0.257*** (0.000)
ln non it capital	β_4	0.123*** (0.015)	0.216*** (0.001)	0.061 (0.230)
Industry Sector Dummy (Svcemfg)	β_5	0.304*** (0.008)	0.544*** (0.007)	0.194* (0.068)
R Sq		99.29	99.23	99.47
F Statistic		1552*** (0.000)	806*** (0.000)	1776*** (0.000)

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

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