MICHIGAN
ROSS SCHOOL OF BUSINESS

Working Paper

Effect of Information Technology Investments on Customer Satisfaction: An Empirical Analysis

Sunil Mithas
Stephen M. Ross School of Business
at the University of Michigan

M. S. Krishnan
Stephen M. Ross School of Business
at the University of Michigan

Claes Fornell
Stephen M. Ross School of Business
at the University of Michigan

Ross School of Business Working Paper Series
Working Paper No. 893
March 2004

15 March 2004 Version

Effect of Information Technology Investments on Customer Satisfaction: An Empirical Analysis

Sunil Mithas (smithas@umich.edu)
University of Michigan Business School
701 Tappan Street
Ann Arbor, MI 48109-1234
Phone: 734 763-8290
Fax: 734 936-0279

M. S. Krishnan (mskrish@umich.edu)**
Michael R. and Mary Kay Hallman e-Business Fellow
Associate Professor and Area Chair
Computer and Information Systems Department
University of Michigan Business School
701 Tappan Street
Ann Arbor, MI 48109-1234
Phone: 734 763-6749
Fax: 734 936-0279

Claes Fornell (cfornell@umich.edu)
Donald C. Cook Professor of Business Administration
Director of the National Quality Research Center
University of Michigan Business School
Ann Arbor, MI 48109
Tel 734 763-5937
Fax 734 647-2343

**Contact author for this paper

University of Michigan Business School Working Paper #02-012

Acknowledgements: We thank Department Editor, Associate Editor, anonymous referees of Management Science and seminar participants at WISE 2002 and WISE 2003 for their comments and suggestions that helped us in improving this paper. We are grateful to InformationWeek for providing the necessary IT-investments data for this research. In particular, we would like to thank Rusty Weston, Lisa Smith, Stephanie Stahl and Brian Gillooly for their encouragement and support. We thank the National Quality Research Center at the University of Michigan Business School for providing the customer-satisfaction data used in this study. We also thank Stefan Dragolov and Eli Dragolov for their excellent research assistance. Financial support for this study was provided in part by the Michael R. and Mary Kay Hallman fellowship at the University of Michigan Business School.

Effect of Information Technology Investments on Customer Satisfaction: An Empirical Analysis

Abstract

In this paper, we study the effect of information-technology (IT) investments on firms' 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 125 panel observations on fifty firms for multiple years indicates a positive association between *aggregate IT investments* and customer satisfaction. Our results also indicate that the effect of IT investments on customer satisfaction may differ across manufacturing and service companies. Besides studying the effect of *aggregate* IT investments, we also study the effect of *customer interfacing IT applications* such as customer relationship management systems on customer satisfaction. Our analysis of archival data collected for a broad cross section of firms in the US shows a positive effect of customer interfacing CRM systems on customer knowledge and customer satisfaction. Our results suggest that CRM systems help firms in improving their customer knowledge that in turn leads to more targeted customer experiences thus improving customer satisfaction.

Keywords*: Information Technology, Customer Satisfaction, Customer Relationship Management, Firm Performance.*

1.0 INTRODUCTION

Customer franchise has emerged as one of the critical assets for firms because locus of power across industries and businesses is increasingly shifting towards customers. It has been argued that companies need to move from a product centric culture to a customer centric model to sense and meet customer demands for changes in specific features of products and services, distribution channels, and pricing structure (Financial Times 2002; Prahalad and Ramaswamy 2004; Seybold, Marshak and Lewis 2001). Customer satisfaction and customer retention have emerged as key metrics for measuring competitive success and long-term economic performance of firms (Chen and Hitt 2002; Fornell and Wernerfelt 1988). Research shows that higher levels of customer satisfaction have the potential to double or triple firm profits (Reichheld and Sasser 1990; Rose 1990). These research findings are consistent with perception among senior managers about critical importance of customer satisfaction for sustainable firm performance. Industry surveys

also report that senior executives and CEOs rank customer satisfaction and retention as their topmost challenge (Rosenbleeth et al. 2002).

In order to improve their customer satisfaction, firms are making greater use of IT tools in their internal and customer facing business processes. Managers consistently rank 'improvement in customer satisfaction' as one of the prime motivations for making IT investments and CRM (Customer Relationship Management) implementation is one of the top priorities of IT managers (Brynjolfsson and Hitt 1998; Rosenbleeth et al. 2002). Significant investments in IT applications in general and CRM systems in particular in recent years indicate the industry belief that IT applications can streamline both internal and customer-interfacing business processes. Forrester predicts that investments in CRM (including applications, services and infrastructure) will grow from $ 42.8 billion in 2002 to 73.8 billion in 2007.

Since customer satisfaction is a leading indicator of firm performance (Ittner and Larcker 1998), it is important to understand the role of IT investments in enhancing customer satisfaction. Much of the empirical research in information systems focuses on the effect of generic IT investments and IT capabilities on financial or market value related measures of firm performance (Barua and Mukhopadhyay 2000; Bharadwaj 2000; Dewan and Kraemer 1998; Dewan and Min 1997; Santhanam and Hartono 2003; Subramani and Walden 2001). However, increasingly, researchers are calling for uncovering the effect of IT investments on intangible customer-oriented measures of firm performance, such as greater responsiveness to customers, more variety, and overall customer experience, which are reflected in customer satisfaction (Brynjolfsson 1993). For example, Brynjolfsson and Hitt (1996), in their influential paper documenting productivity gains due to IT, call for future research utilizing "more direct approaches…such as directly accounting for intangible outputs such as product quality or variety (p. 557)." Bharadwaj, Bharadwaj and Konsynski (1999) endorse this view by noting that "useful direction for future research would be to model IT's impact on intangible dimensions of [firm] performance such as …customer service, and customer relationships (p. 1020)." Against this

backdrop, this study seeks to understand the effect of investments in IT and customer relationship management systems on customer satisfaction. Following Devaraj and Kohli (2000) who recently documented the effect of IT systems on customer satisfaction in the health sector, this study extends their work to a much broader cross section of firms across diverse industry sectors.

In this study, we use archival IT investments and customer-satisfaction data collected by reputable third-party organizations that follow a well-defined, standardized approach for collecting such data. We combine these standardized IT investments and customer-satisfaction measures for a broad range of manufacturing and service firms to examine the relationship between IT investments and customer satisfaction. In addition to looking at the effect of aggregate IT investments (such as IT hardware and software expenditures), we also explore the effect of investments in specific customer related IT applications such as CRM systems on customer-satisfaction performance of firms.

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 empirical models while section 4 describes the results. Section 5 contains concluding remarks.

2.0 THEORY AND HYPOTHESES

Our goal in this study is to understand the effect of *aggregate IT investments* and *customer related IT applications* on customer satisfaction. In the next section, we briefly review prior literature on the business value of IT investments pertinent to this research. In section 2.2, we present the theory underlying our hypotheses linking *aggregate IT investments* to customer satisfaction by positing two causal mechanisms: *perceived quality* and *perceived value*. In section 2.3, we present the theoretical linkages between customer related *CRM investments* and customer satisfaction and argue that the effect of CRM systems on customer satisfaction is mediated through *customer knowledge*.

2.1 Prior Literature on the Business Value of IT Investments

The business value of IT investments continues to attract significant interest both in the business press and academic literature (Economist 2002b; Kohli and Devaraj 2002; Waters 2004). Beginning with in-depth, case-based studies of specific IT applications at the firm level (Banker, Kauffman and Morey 1990; Banker and Kauffman 1991), this stream of literature now encompasses large sample empirical studies linking IT investments with outcome measures at the economy, firm, and process levels (for recent reviews of this literature, see Barua and Mukhopadhyay 2000; Dedrick, Gurbaxani and Kraemer 2003).

In studying the effect of IT on firm performance, researchers have looked at the effect of *aggregate IT expenditures* as well as *specific IT applications*. Both sets of studies have their advantages. While studies examining the effect of aggregate IT expenditures answer managerial concerns about appropriate level of IT expenditures and their effects on firm level outcome measures such as productivity and shareholder value (Bharadwaj, Bharadwaj and Konsynski 1999; Brynjolfsson and Hitt 1996; Dewan and Kraemer 1998; Dewan and Min 1997; Menon, Lee and Eldenburg 2000); studies at the IT application level provide a better understanding of the causal mechanisms that underlie value creation from IT (Banker et al. 2003; Barua, Kriebel and Mukhopadhyay 1995; Kauffman and Kriebel 1988; Mukhopadhyay, Kekre and Kalathur 1995; Mukhopadhyay, Rajiv and Srinivasan 1997).

While previous research has provided valuable insights into the relationship between IT investments and business value, other than the work done by Devaraj and Kohli in the health sector as noted earlier, very few studies have directly accounted for the customers' perspective of the value gained from IT investments. Most of the prior studies have addressed managers' and investors' perspectives of business-value measures such as productivity or market value. 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 the market value of firms (Ittner and Larcker 1998).

Customer satisfaction is an important measure of firm performance because of its positive influence on customer loyalty (Anderson, Fornell and Rust 1997; Fornell 1992; Fornell 2001). Previous research has documented that increased customer loyalty secures future revenues, reduces the cost of future transactions, decreases price elasticity and minimizes the likelihood of customer defection in the event of poor quality (Anderson 1996; Anderson and Sullivan 1993; Reichheld and Sasser 1990; Rust and Keiningham 1994). In addition to these advantages, customer satisfaction also helps in accounting for intangible outputs such as product quality or variety that are not captured in firm productivity measures (Quinn and Baily 1994). 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 (Waters 2004). Although information-systems researchers have studied the effect of IT investments on consumer surplus and consumer welfare at the economy level (Brynjolfsson 1996; Hitt and Brynjolfsson 1996), with some exceptions (Devaraj and Kohli 2000), very few studies have related IT investments to customer satisfaction at the firm level.

2.2 Relating *Aggregate IT Investments* to Customer Satisfaction

Previous research in marketing literature points to several theoretical constructs as determinants of customer satisfaction at the firm level: *perceived quality, perceived value* and *customer expectations* (Anderson, Fornell and Rust 1997; Fornell 2001; Fornell et al. 1996). *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. *Perceived value* refers to the perceived level of product quality vis-à-vis the price paid. Finally, C*ustomer expectations* refer to customer perspectives on prior consumption experiences as well as customers' belief in the firm's ability to deliver quality in the future. Empirical studies on the relative importance of these three determinants of customer

satisfaction show that *customer expectations* do not play a major role in affecting customer satisfaction and *perceived quality* has a significantly greater effect on customer satisfaction than *perceived value* (Fornell et al. 1996). We, therefore, concentrate on elaborating how IT influences *perceived quality* and *perceived value* of a firm's offerings.

We posit that IT applications have the potential to enable firms to influence the *perceived quality and perceived value* of goods and services leading to an increase in customer satisfaction. For example, IT can enable both the determinants of *perceived quality* (customization and consistency of consumption experience) by capturing customer information and using such customer information to customize firms' offerings and by providing a seamless service experience to customers. Bharadwaj, Bharadwaj and Konsynski (1999) have noted the importance of IT enabled customization and improved customer service in creating intangible value for firms. In addition, by facilitating seamless flow of information in an organization, IT facilitates efficient allocation of resources, shorter response times and improved quality. Furthermore, IT also facilitates business-process innovation by redefining and redirecting business relationships and core processes through new channels leading to significant improvements in total customer experience. These outcomes may enhance the *perceived quality* of a firm's customer service, with a favorable impact on customer satisfaction.

Besides its impact on *perceived quality*, IT may also affect *perceived value* of a firm's offering. For example, IT investments in supply chain and ERP systems with end-to-end integration have the potential to improve perceived value of a firm's offering from a customer viewpoint through quicker responses to customer enquiries and consistent order fulfillment processes. IT may also help in 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.

The role of IT in affecting customer satisfaction 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 and have pointed to the need for studying the relationship between IT investments and customer satisfaction (Anderson, Fornell and Rust 1997; Bitner, Brown and Meuter 2000; Parasuraman 1996; Parasuraman and Grewal 2000). The above discussion leads to our first set of hypotheses:

H1a: IT investments are positively associated with higher levels of perceived quality.

H1b: IT investments are positively associated with higher levels of perceived value.

H1c: IT investments are positively associated with higher levels of customer satisfaction.

In addition to considering the effect of IT investments on *perceived quality*, *perceived value* and *customer satisfaction,* there is a need to consider the moderating influence of industry sector in these relationships. 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 because their model 'poorly predicted (p.549)' 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 (Quinn and Baily 1994; Roach 1991).

In order to understand the effect of IT across industry sectors, it is important to examine the nature of customer interactions and experiences across the manufacturing and service sectors. Prahalad and Krishnan (1999) argue 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 also argued that the drivers of

customer equity may be different across industry sectors (Rust, Zeithaml and Lemon 2000). Additionally, 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 (Anderson, Fornell and Rust 1997). Following this line of reasoning, Johnson and Fornell (1991) have argued that average customer satisfaction should be higher for *goods* than for *services*.

Even though services may have lower *levels* of customer satisfaction, IT can play a greater role in enabling service-sector companies to improve their customer satisfaction because the service business is more information intensive. As Barua and Mukhopadhyay (2000) note: 'while the services sector possibly stands to gain more than the manufacturing sector from IT applications, the latter can benefit significantly from IT enabled supply chain and production management.' However, since supply chain and production management processes are largely at the back end in the manufacturing sector, IT enabled innovations in these processes may have a marginal impact on customer satisfaction. In contrast, services require adaptation to individual customer requirements and 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, Fornell and Rust 1997). Therefore, we expect IT investments to have a greater effect on perceived quality, perceived value and customer satisfaction for firms in the service sector compared to those in the manufacturing sector.

H2a: IT investments will have greater effect on <u>perceived quality</u> for firms in the service sector than for firms in the manufacturing sector.

H2a: IT investments will have greater effect on <u>perceived value</u> for firms in the service sector than for firms in the manufacturing sector.

H2a: IT investments will have greater effect on customer satisfaction for firms in the service sector than for firms in the manufacturing sector.

2.3 Relating Specific Customer Related IT Systems with Customer Satisfaction

While the previous section links *aggregate IT investments* with customer satisfaction following the conventional approach used in the business value of IT literature (Hitt and Brynjolfsson 1996), we also study the effect of more proximate IT investments (such as *CRM applications)* that encompass business processes involved in affecting customer experience (Bitner, Brown and Meuter 2000; Meuter et al. 2000). Studying the business value of IT at the application level (in our case at the CRM application level) also permits better explication of the causal mechanisms that underlie value creation through IT applications (Barua, Kriebel and Mukhopadhyay 1995; Kauffman and Kriebel 1988; Mukhopadhyay, Kekre and Kalathur 1995). As noted earlier, firms have made major investments in IT and CRM systems to meet the heterogeneous needs of their customers and to improve their customer satisfaction. CRM systems capture and manage customer information, help provide products or services to customers and enable efficient communication and information sharing with customers. The growing use of CRM technologies is aimed at improving the efficiency and effectiveness of business processes covering various customer touch points. Our analysis of literature points to *customer knowledge* as one of the key mechanisms that helps CRM systems in improving customer satisfaction. By gathering detailed customer data and converting that into customer knowledge, CRM systems enable firms to improve their ability to customize and deliver a reliable consumption experience leading to an improvement in customer satisfaction. In other words, we posit that CRM systems help firms in building customer knowledge and that in turn has a positive effect on customer satisfaction. We next discuss the theory linking CRM investments with customer knowledge and customer satisfaction.

2.3.1 Relating CRM systems with Customer Knowledge

Customer knowledge is an important component of the feedback loop that influences product innovation and customization. The notion of customer knowledge encompasses knowledge about customers as well as knowledge possessed by customers (Rowley 2002). One of the main motivations for implementing CRM systems is to track customer behavior to gain an insight into customer tastes and evolving needs and help organize this information to leverage customer knowledge in designing better products and services (Davenport, Harris and Kohli 2001). CRM systems facilitate organizational learning about customer tastes by enabling the capture and analysis of purchasing behavior across transactions through different channels and customer touch points. Glazer (1991) cites Federal Express and American Airlines as examples to illustrate how these firms used their investments in IT systems at the customer interface to gain valuable customer knowledge. More recently, firms have invested in integrated set of tools and functionalities offered by leading software vendors such as Siebel systems and Salesforce.com to gather and accumulate customer knowledge.

There are two ways in which CRM systems help firms in gathering and making use of customer knowledge. First, CRM systems enable customer contact employees to record relevant information about each customer transaction. Once captured, such information can be processed to convert into customer knowledge based on information processing rules and organizational policies. This knowledge captured about customers across service encounters can then be made available to all the relevant customer support employees for all future transactions to respond to any customer need in a contextual fashion. Firms can also use such customer knowledge to profile their customers and identify their latent needs based on similarity with purchasing behavior of other customers. Second, firms can also share their accumulated customer knowledge with customers to let customers serve themselves by defining the service and its delivery to suit their own needs (Bitner, Brown and Meuter 2000). The process of self-selection of service

features by customers provides further opportunities to firms to learn about the evolving needs of their customers and deepen their customer knowledge. Thus,

H3: Use of CRM systems has a positive effect on customer knowledge gained by firms.

2.3.2 Relating CRM Systems with Customer Satisfaction

Investments in CRM systems are predicated on the belief that such systems help firms in improving customer satisfaction. In contrast with *generic* IT systems that are often implemented to reduce costs and process variability, CRM systems are typically justified on the basis of their potential effect in improving customer satisfaction.

There are two reasons why CRM systems are likely to have an effect on customer satisfaction. First, CRM systems allow firms to customize their offering for each customer. By accumulating information across customer interactions and by processing such information to discover hidden patterns, CRM systems help firms in customizing their offerings to suit individual tastes of customers. Such *customized offerings* have the effect of enhancing the *perceived quality* of products and services from a customer viewpoint. Second, in addition to enhancing the *customization* induced increase in *perceived quality* of the offering, CRM systems also allow firms to improve the *reliability* of the consumption experiences by providing a consistent experience every time a customer interacts with the firm. Improvement in the ability to customize and deliver a consistent consumption experience enhances perceived quality of a firm's offering that in turn has a positive effect on customer satisfaction. Thus,

H4: Use of CRM systems has a positive effect on customer satisfaction of firms.

Although customer knowledge and customer satisfaction by themselves are important metrics for tracking the success of CRM systems, from a theoretical perspective it is important to consider if the effect of CRM systems on customer satisfaction is *mediated* by an improvement in customer knowledge. From a managerial perspective too, an understanding of causal mechanisms will shed light on facilitating conditions for CRM success. We posit that the real value of CRM systems lies in collecting and disseminating customer knowledge gained through repeated

interactions. It is this customer knowledge that subsequently drives customer satisfaction because a firm can now tailor its offering to suit customer requirements. Previous conceptual work in Information Systems and Marketing provides support for this view. For example, Bharadwaj (2000) notes the advantages of gathering customer knowledge from customer encounters and disseminating such knowledge to employees for cross-selling and better forecasting of product demand. Bolton, Kannan and Bramlett (2000) provide empirical evidence for how IT enabled loyalty programs allow firms to gain valuable customer knowledge about customers' purchasing behavior. Deeper knowledge of customer behavior enables firms to manage and target customers based on evolving service experiences instead of stable demographic criteria leading to an increase in the perceived value of the firm offering and less chance of loyal customers defecting to competition. Firms also derive a competitive advantage by making such cumulative customer knowledge available to customers to help customers manage their operations better (Glazer 1991). We, therefore posit that the effect of CRM systems on customer satisfaction is mediated through customer knowledge.

Figures 1 and 2 show the research models used in this study. While Figure 1 depicts the research model linking aggregate IT investments with customer satisfaction (H1 and H2), Figure 2 depicts the research model linking CRM investments with customer knowledge and customer satisfaction (H3-H4).

---Insert Figures 1 and 2 about here---

3.0 RESEARCH DESIGN AND METHODOLOGY

We constructed two datasets to test the research models shown in Figure 1 and 2. While we were able to obtain *aggregate IT investment* data for a panel of firms from 1994 to 2000, the data for customer facing IT investments including *CRM systems* was available only for one year for a larger cross section of firms.

Panel Data for Studying Effect of Aggregate IT Investments on Customer Satisfaction

The panel data used in this study comprises an unbalanced panel of 50 firms over the period of 1994 to 2000, for which both IT investments and customer-satisfaction data are available. IT investments data comes from several InformationWeek annual surveys of top IT managers of Fortune 500 companies in North America. Customer-satisfaction data comes from the National Quality Research Center (NQRC) at the University of Michigan Business School. NQRC tracks about 150 U.S. firms on their customer satisfaction performance through its American Customer Satisfaction Index (ACSI). These IT and customer satisfaction data for firms in our panel are matched to the Compustat database to obtain values for sales and other financial information.

Table 2 provides a summary profile of the firms in our sample. Out of 50 firms in our panel, 10 appear only once, 15 appear in twice, 15 appear thrice and the remaining 10 appear four times during a period of five years covered by 1994-1996 and 1999-2000. InformationWeek data for the period 1997 and 1998 is not available for any of the firms. Out of 50 firms in our sample, 28 firms in our panel belong to manufacturing sector and 22 belong to services sector.

Cross-sectional Data for Studying Effect of CRM Investments on Customer Satisfaction

For exploring the effect of CRM applications and IT investments on customer knowledge and customer satisfaction, we obtained detailed data on investments made by a large cross-section of U.S. firms in customer related IT systems. CRM investments being a recent phenomenon, InformationWeek collected this data during the year 2000. In this dataset, *customer satisfaction* and *customer knowledge* variables relate to managerial perceptions of benefits obtained from deployment of customer related IT systems. To check the robustness of our findings, we matched a subset of these firms to the NQRC database to validate the managerial assessment of improvement in customer satisfaction with changes in archival ACSI scores during this period.

3.1 Variable Definition

Since this study uses two datasets with some common variables, we first describe the variables in the panel dataset followed by a description of additional variables collected for a cross-section of U.S. firms for the CRM study.

ACSI: ACSI refers to the American Customer Satisfaction Index tracked by the National Quality Research Center (NQRC) at the University of Michigan Business School. 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 of ACSI measurement, pattern and range across industries). Each year, the NQRC surveys about 65,000 customers who purchase products from about 150 companies and asks these consumers to score companies on a scale 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. This data also has been used in a number of widely cited academic studies in the accounting and marketing literature (Fornell et al. 1996; Ittner and Larcker 1996; Ittner and Larcker 1998). It is important to note that ACSI measures customer satisfaction for only those products and services that are consumed by a firm's end customers i.e. ACSI primarily covers satisfaction with consumer transactions.

ITINVPC: This variable refers to the level of IT investment as a percentage of the sales revenue of a firm. We obtained 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, Bharadwaj and Konsynski 1999; Kudyba and Diwan 2002; Santhanam and Hartono 2003).

MFG (Industry Sector): This is an indicator variable representing whether the company's offering is primarily goods or service (0=services, 1=goods). 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 (Curry and George 1983).

YEAR: Year is an indicator variable (0=1994-1996; 1=1999-2000). 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. Findings of the previous studies also suggest a consideration of such structural shifts. 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 respectively in their sample of firms. The use of this dummy indicator in our regression model allows us to control for any unobserved systematic effects during the two time periods (1994-1996 and 1999-2000).

In addition to the above variables that were available for the period 1994-2000 for fifty firms, we collected data on the following additional variables for a larger cross-section of firms for the year 2000 to validate the research model shown by Figure 2.

CUSTSAT (Perceptual Measure of Customer Satisfaction): In order to study the effect of CRM on customer satisfaction, we measure customer satisfaction by a binary perceptual measure where 1 represents that a firm perceives a significant gain in customer satisfaction because of its customer related IT systems while 0 represents that a firm has not realized any significant gain in customer satisfaction following implementation of its customer related IT systems.

CUSTKNOW (Customer Knowledge): Customer knowledge is measured as a binary variable where 1 signifies that a firm has gained significant knowledge about its customers from its customer related IT systems while 0 signifies that firm does not perceive any gains in customer knowledge from its customer related systems.

***CRM (Customer Relationship Management Systems)*:** CRM is a binary variable where zero refers to the absence of CRM systems in a firm while 1 refers to use of CRM systems by a firm to manage its customer relationships.

***CUSTIT (Customer Facing IT Systems)*:** This is a thirteen items scale indicating deployment of IT systems to support various business processes involved in supporting customers' acquisition and disposal of products and services offered by firms. The specific IT systems covered by this scale relate to product marketing information, multilingual communication, personalized marketing offerings, dealer locater, product configuration, price negotiation, personalization, transaction system, online distribution and fulfillment system, customer service and customer satisfaction tracking. These items broadly correspond with the stages in the Customer Resource Life-cycle (CRLC) model proposed by Ives and Learmonth (1984).

Table 1 provides a summary of the variables and the data sources used in the study. Table 2 provides summary statistics for the variables used in the study. Table 3 and 4 provide co-relations among variables. As would be expected, customer satisfaction is highly correlated with perceived quality and perceived value of a firm's offerings (see Table 3).

---Insert Tables 1-4 about here---

3.2 Empirical Models and Econometric Issues

3.2.1 Model Linking *Aggregate* IT Investments with Customer-Satisfaction

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 such as market concentration, industry sector, and time period. Our empirical model is shown below:

$$PERQUAL = \alpha_{10} + \alpha_{11} MFG + \alpha_{12} ITINVPC + \alpha_{13} MFG*ITINVPC + \alpha_{14} HHI + + \alpha_{15} YEAR + \alpha_{16} YEAR*ITINVPC + \varepsilon_{1a} \quad (1A)$$

$$PERVAL = \alpha_{20} + \alpha_{21} MFG + \alpha_{22} ITINVPC + \alpha_{23} MFG*ITINVPC + \alpha_{24} HHI + + \alpha_{25} YEAR + \alpha_{26} YEAR*ITINVPC + \varepsilon_{1b} \quad (1B)$$

$$ACSI = \alpha_{30} + \alpha_{31} MFG + \alpha_{32} ITINVPC + \alpha_{33} MFG*ITINVPC + \alpha_{34} HHI + + \alpha_{35} YEAR + \alpha_{36} YEAR*ITINVPC + \varepsilon_{1c} \quad (1C)$$

Because of the panel nature of our dataset, the OLS approach for estimating equations (1A) –(1C) may not be appropriate because the residuals across time for the same firms may be correlated. Since firms in our sample may be considered as a draw from a larger population of firms, an alternative and preferred way to estimate the parameters more efficiently is through random effects models which not only allow correlations among residuals of firms across time periods but also control for unobservable firm specific effects (Baltagi 2001)[1]. We estimated the models in equations (1A)-(1C) allowing the intercept to vary across individual firms (Greene 2000; Wooldridge 2002). 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.

Since use of the random effects model provides consistent estimates only if firm-specific effects are uncorrelated with other explanatory variables, we used the Hausman specification test (1978) to evaluate the validity of this independence assumption. Our failure to reject the null under this test provided further justification for the appropriateness of the random-effects model used in this research[2].

As shown in Table 5, the explanatory power of our models is reasonable as reflected by the overall R square values. For all the models shown in equations (1A)-(1C), we performed several diagnostic checks to ascertain the stability of our results. We tested for multi-collinearity by computing the condition numbers (Belsley, Kuh and Welsch 1980). The highest condition

[1] Although random effects models typically use exchangeable covariance structure, we also specified AR(1) covariance structure as a robustness check and obtained essentially similar results.

[2] We also estimated fixed effects model that handles unobserved heterogeneity by computing within-firm estimates of coefficients. This approach uses only the variation within a firm across time to estimate regression coefficients without using between-firm variation hence is relatively less efficient compared to random effects model but relaxes the independence assumption used in the

index (13.75) was lower than the threshold specified in the literature, indicating that multi-collinearity is not a serious concern in our analysis. We also calculated Hat values to check for leverage and studentized residuals to detect outlying cases. Our analysis of measures of influence (DFbetas and Cook's distance) did not suggest presence of influential observations in our sample.

3.2.2 Models Linking CRM Investments with Customer Knowledge and Customer Satisfaction

Since dependent variables such as customer knowledge and customer satisfaction are coded as binary choices in our CRM dataset, the ordinary least squares approach to modeling this choice will result in heteroskedastic error distribution and the models may lead to predicted probabilities being below zero or above one. In order to overcome these estimation problems inherent in ordinary least squares approach, we carried out analysis for these models using probit approach that overcomes the limitations of the linear model (Long 1997). Since this study seeks to study the effect of CRM applications on customer satisfaction, we control for aggregate IT investments, other customer related IT systems, and industry sector in our study.

The functional form of the models is as follows:

$$Probability\ (Customer\ Knowledge=1) = \Phi\ [\beta_{10} + \beta_{11} CRM + \beta_{12}\ Customer\ Facing\ IT\ Systems + \beta_{13} IT\ Investments + \beta_{14}\ Services + \varepsilon_1] \quad (2)$$

$$Probability\ (Customer\ Satisfaction=1) = \Phi\ [\beta_{20} + \beta_{21}\ CRM + \beta_{22} Customer\ Facing\ IT\ Systems + \beta_{23} IT\ Investments + \beta_{24}\ Services + \varepsilon_2] \quad (3)$$

$$Probability\ (Customer\ Satisfaction=1) = \Phi\ [\beta_{30} + \beta_{31}\ CRM + \beta_{32}\ Customer\ Facing\ IT\ Systems + \beta_{33}\ IT\ Investments + \beta_{34}\ Services + \beta_{35}\ \underline{Customer\ Knowledge} + \varepsilon_3] \quad (4)$$

Where βs are the parameters for the respective variables and Φ denotes the normal cumulative distribution function (the area under the normal curve).

The results of estimation of equations (1) to (4) are shown in Tables 5 and 6.

---Insert Tables 5 and 6 about here---

random effects models. We obtained essentially similar coefficients in our fixed effects models providing greater confidence in our random effects model results.

4.0 RESULTS AND DISCUSSION

We first discuss the results for the effect of aggregate IT investments on customer satisfaction followed by a discussion of the effect of CRM applications on customer satisfaction.

4.1 Effect of Aggregate IT Investments on Customer Satisfaction

Hypothesis 1 predicted positive effect of IT investments on perceived quality, perceived value and customer satisfaction. This hypothesis is fully supported for firms in the services sector. We find from Table 5 that the coefficients of the variable ITINVPC ($\alpha_{12,}$ α_{22} and α_{32}) are positive and highly significant in perceived quality, perceived value and customer satisfaction models. As Table 5 shows, an increase of one percentage point in IT investments (as a percentage of sales revenues) in the service sector during 1994-96 is associated with an increase of 0.939 (α_{12}) in perceived quality, 0.598 (α_{22}) in perceived value and 1.050 (α_{32}) in ACSI scores. All these coefficients (α_{12}, α_{22} and α_{32}) are statistically significant at $p<0.05$. Although Table 5 shows marginally negative effects of IT investments in the manufacturing sector during 1994-96 period ($\alpha_{12} +\alpha_{13} =-0.036$ for perceived quality, $\alpha_{22} +\alpha_{23} =-0.136$ for perceived value and $\alpha_{32} +\alpha_{33} =-0.080$ for customer-satisfaction); none of these effects are statistically significant at $p=0.05$ in the Wald tests of the joint significance.

Our results show partial support for Hypothesis 2. We find that firms in the service sector perform significantly better than firms in the manufacturing sector in leveraging IT to improve *perceived quality* and *customer-satisfaction*. The negative and statistically significant interaction term involving IT investments and industry sector (manufacturing or service) in perceived quality ($\alpha_{13}= -0.975$, $p<0.012$) and ACSI models ($\alpha_{33}=-1.130$, $p<0.009$) indicates that higher IT investments in manufacturing firms are associated with lower perceived quality and customer-satisfaction scores than for services firms. However, the non-significant interaction term involving IT investments and industry sector in the *perceived value* model ($\alpha_{23}=-0.734$, $p=0.130$)

suggests that the effect of IT investments on perceived value during 1994-96 did not differ significantly across industry sectors.

These results provide evidence in support of our hypotheses that firms in the service sector perform significantly better than firms in the manufacturing sector in leveraging IT to improve *perceived quality* and *customer satisfaction*. 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, as noted earlier, the nature of the service business is such that consumers may experience the IT-enabled flexibility and convenience more directly in business processes that 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. Piccoli and Applegate (2003) lend support to this explanation and describe how Wyndham Hotels used IT to improve its customer satisfaction. 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 may not have a visible impact on customer service and consumption experience.

We also tested for the effect of aggregate IT investments on customer satisfaction being mediated through perceived quality and perceived value (results not shown). Since the effect of aggregate IT investments on customer satisfaction becomes insignificant when perceived quality and perceived value are controlled for, our results provide support to the research model proposed in section 2.2.

Although aggregate IT investments show a positive effect on perceived quality, perceived value and customer satisfaction for service firms for the 1994-1996 period, these result do not

hold in the subsequent time period of 1999-2000 as indicated by the negative interaction term between IT investments and the YEAR dummy (α_{16}=-1.011 for perceived quality, α_{26}=-0.884 for perceived value and α_{36}=-1.234 for ACSI; all coefficients significant at $p<0.01$). More specifically, aggregate IT investments do not seem to have a significant effect on perceived quality, perceived value and customer satisfaction during 1999-2000 for service firms. However, IT investments show a statistically significant (although economically marginal) but negative effect for manufacturing firms during 1999-2000. These results in Table 5 showing declining returns to IT in terms of customer satisfaction over the years 1994-2000 are consistent with previous studies that found declining returns to IT in terms of productivity and market value (Bharadwaj, Bharadwaj and Konsynski 1999; Brynjolfsson and Hitt 1996).

While there may be several alternative explanations for declining returns from aggregate IT investments in terms of consumption experience over 1994-2000 period, we discuss two plausible reasons here. One possible reason relates to over-investment in aggregate IT systems by firms during the 1999-2000 period that did not directly improve consumption experience and in fact, may have distracted firms from focusing on customers. Our data show that firms significantly increased their IT investment as a percentage of sales from 2.65% during 1994-1996 to 4.18% during 1999-2000, an increase of more than 57% during a five-year period. It was during 1999-2000 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. Besides investing in IT to support their e-business strategy, firms also made significant investments in Y2K related activities by upgrading their back-end IT infrastructure significantly to alleviate widely prevailing investor and customer concerns (Anderson, Banker and Ravindran 2003). Preoccupation with e-business transformation, Y2K compliance, ERP implementation and associated organizational disruption are likely to have shifted attention away from customers resulting in the observed

insignificant or negative relationship between aggregate IT investments and customer satisfaction during 1999-2000. There is a need for further research to validate this reasoning empirically.

Second, and a complementary rationale for the negative effect of aggregate IT investments on customer satisfaction may be that although firms were aggressive in acquiring the latest information technologies in 1999-2000, many of these applications did not directly impact the business processes touching customer experience. In comparison to aggregate and internally focused applications, we would expect that customer facing IT applications particularly CRM systems will have a positive effect on customer satisfaction. We next discuss the effect of CRM applications on customer satisfaction to test the support for this explanation.

4.2 Effect of CRM Investments on Customer Satisfaction

The results of empirical estimation of models in equations (2) through (4) are shown in columns (1) to (3) of Table 6. Besides indicating the coefficients of the probit models, we have also shown the marginal effect of each variable in columns (1) through (3). Marginal effects represent the effect of a unit change in the independent variable on the probability of increase in customer satisfaction. Since the probit model is inherently non-linear, the effect of each individual variable is interpreted holding all other variables at their mean value.

Consistent with hypotheses 3 and 4, we find that investments in CRM systems are positively associated with both customer knowledge and customer satisfaction (refer Columns 1 and 2 in Table 6). In order to assess if CRM systems first improve customer knowledge and this in turn leads to an improvement in customer satisfaction, we added customer knowledge as an explanatory variable in the customer satisfaction equation (refer Column 3 in Table 6). We compared two models of customer satisfaction- one with customer knowledge (Column 3 in Table 6) and one without it (Column 2 in Table 6) to test for the hypothesis that CRM systems help firms to gain customer knowledge and in turn, this improved customer knowledge leads to improved customer satisfaction. We found support for this mediation effect because the coefficient of the CUSTKNOW (customer knowledge) in the customer satisfaction equation is

significant and there is a decrease in the coefficients of other variables due to inclusion of the customer knowledge term in the model (Sobel 1982). Figure 3 provides a visual representation of the effect of CRM systems on customer satisfaction and the important role of customer knowledge to realize the significant gains from CRM implementation.

---Insert Figure 3 about here---

It is important to note that the effect of *aggregate IT investments* as a percentage of sales is statistically non-significant in columns (1) through (3) in Table 6 once we control for presence of CRM systems. This result suggests that *'focused'* customer facing IT applications (such as CRM) are more effective at influencing customer experience than *'generic'* IT systems. In other words, our results lend support to the process based view in business value of IT that advocates examining the effect of specific IT applications in functional areas that are relatively uncoupled with other confounding business processes (Barua, Kriebel and Mukhopadhyay 1995; Barua and Mukhopadhyay 2000).

Since the dependent variable in the columns (2) and (3) in Table 6 is a perceptual measure of customer satisfaction, as a robustness check we also estimated the customer satisfaction model using archival measure of customer satisfaction tracked by the University of Michigan (refer column 4 in Table 6). This model serves as a robustness check because the ACSI based customer satisfaction data is collected by NQRC independently from consumers of firms implementing CRM and is available for a subset of firms in the InformationWeek 2000 survey. This empirical model is shown below:

$$\textit{Improvement in ACSI due to customer related IT systems} = \beta_{41} + \beta_{41}\ CRM + \beta_{42}\textit{Customer Facing IT Systems} + \beta_{43}\textit{IT Investments} + \beta_{44}\textit{Manufacturing} + \beta_{45}\ \underline{\textit{Customer Knowledge}} + \varepsilon_4 \quad (5)$$

Note that the sample size for the ACSI model (column 4 in Table 6) is 23 compared to a sample size of 479 for the customer satisfaction model using perceptual measure in the InformationWeek survey. Despite a relatively small sample size for the ACSI based model,

broadly similar results for changes in customer satisfaction using perceptual and archival measures provide confidence in the results presented above showing positive effect of CRM applications in improving customer knowledge and customer satisfaction.

5.0 CONCLUSION

To conclude, this paper empirically tested the effect of *aggregate IT investments* and *customer related IT applications* on customer satisfaction. Our analysis of an unbalanced panel of 50 firms indicates that *aggregate IT investments* had a positive effect on customer satisfaction for service firms during the 1994-96 period. We also find that service firms were significantly better at leveraging aggregate IT investments in improving their customer satisfaction compared to manufacturing firms. Our results are consistent with previous findings that suggest declining returns to IT over the years because we observe a declining effect of aggregate IT investments on customer satisfaction from 1994-96 to 1999-2000. These results must be viewed with caution because most IT applications covered under the *aggregate IT investments* category do not directly affect business processes impacting customer experience.

We extended our research to understand the effect of *customer related IT applications* on customer satisfaction controlling for *aggregate IT investments* made by firms. Based on archival data covering a broad cross section of firms in the U.S., we found evidence for a positive effect of *CRM systems* on customer knowledge and customer satisfaction during the 1999-2000 period. Our analysis suggests that *CRM systems* have a positive effect on customer satisfaction because these systems allow organizations to gain customer knowledge facilitating a deeper understanding of customers' needs and requirements.

This study makes several important contributions. First, unlike previous studies, which have used accounting and financial measures, this study highlights the business value of IT using customer perspective in terms of customer knowledge and customer satisfaction to provide a more complete view of judging returns from IT considering non-tangible aspects. Customer knowledge and customer satisfaction being external and customer-based measures of

organizational performance assume increasing importance in increasingly competitive markets. Second, from a theoretical perspective, this study explicates the causal mechanisms that relate IT applications to improved customer satisfaction. Our results suggest that IT applications affect perceived quality and perceived value of a firm's offerings and these in turn have a positive effect on customer satisfaction. Our analysis of IT investments specific to customer engagement processes brought out the importance of IT applications in building customer knowledge. We found that CRM-enabled customer knowledge has a positive effect on perceived quality of firm offerings and therefore on its customer satisfaction by helping firms in improving their ability to customize and deliver a reliable experience. These findings extend previous research in information systems that provided justification for the effect of IT investments and IT capabilities on market value (Bharadwaj 2000; Bharadwaj, Bharadwaj and Konsynski 1999). Finally, given the paucity of academic research on value from CRM investments and conflicting claims in the business press, this study provides a rigorous assessment of business value of CRM systems to inform managerial decision-making on the benefits of CRM systems.

Though our study provides evidence of a linkage between IT investments and the customer-satisfaction performance of the firm, there are several opportunities for extending this work. First, although our sample size is a reasonable representation of large firms, 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. Such studies will enhance our understanding of the situational and contextual factors that are difficult to control in large-scale archival research. 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 how IT is being used to influence the

consumption experience in these industries. Finally, there is a need to further validate our findings showing the effect of CRM applications on customer based measures of firm performance by collecting archival data on customer retention and success of cross-selling efforts through improved customer knowledge enabled by IT systems.

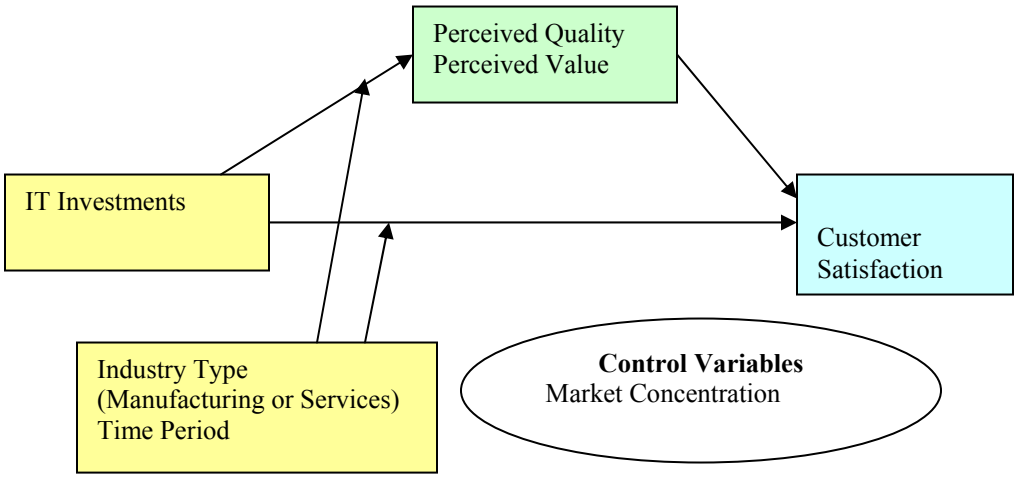

Figure 1: IT-Customer Satisfaction Research Model

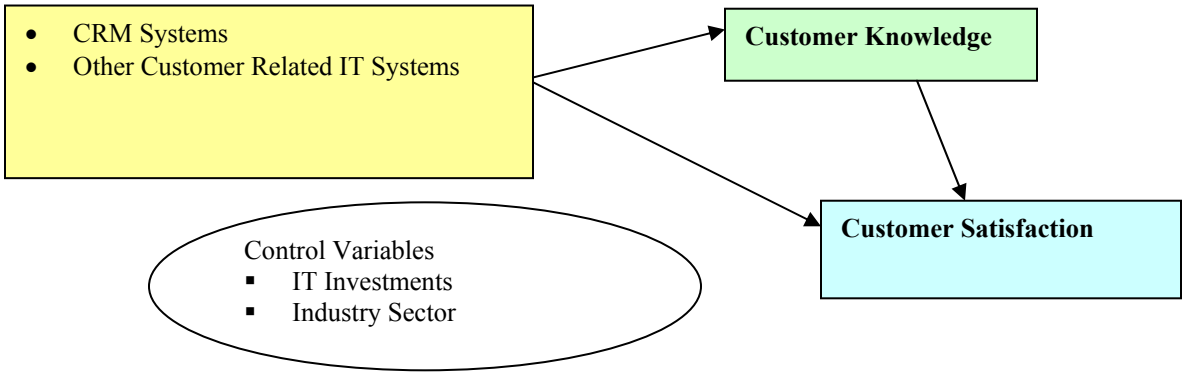

Figure 2: CRM-Customer Satisfaction Research Model

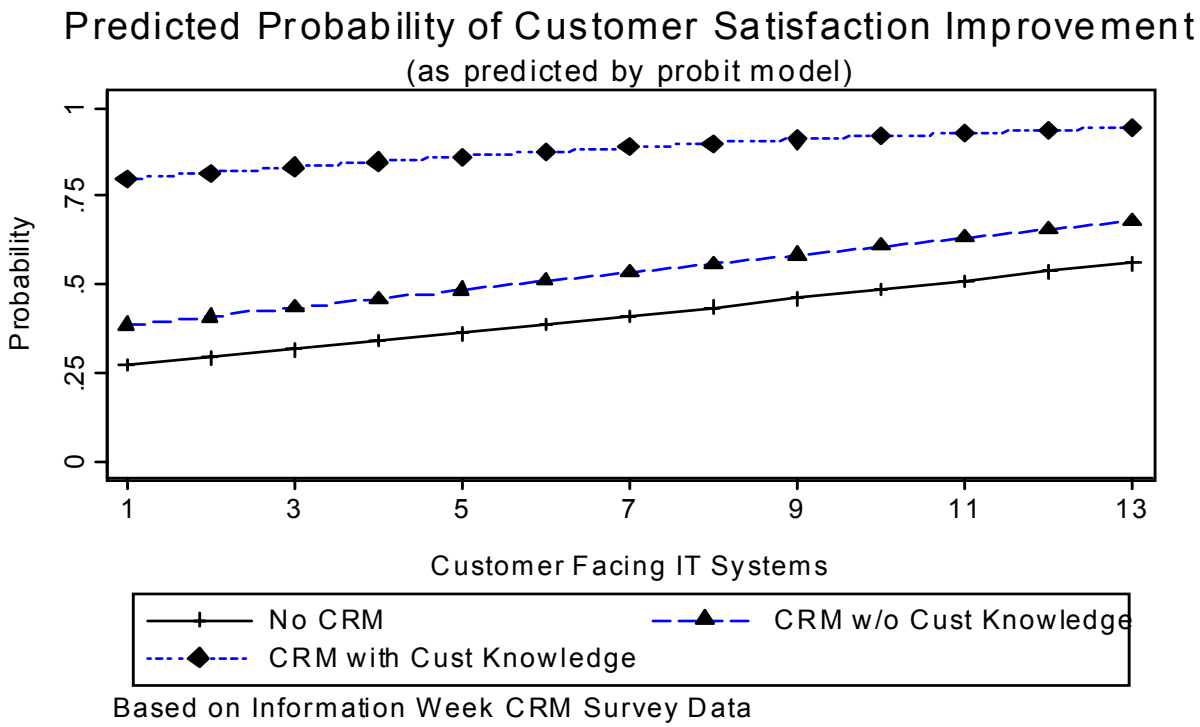

Figure 3: CRM Systems, Customer Knowledge and Customer Satisfaction

Table 1. Variable Definition, Construction and Data Sources

Variable Name	Definition	Source
ACSI (Overall Customer Satisfaction Level)	American Customer satisfaction index is an archival measure of customer satisfaction for a firm tracked by National Quality Research Center at the University of Michigan Business School	National Quality Research Center (NQRC)
Perceived Quality	Measures perceived quality of a firm's offering as a function of customization and reliability of consumption experience	NQRC
Perceived Value	Perceived value measures perceived quality for a given price.	NQRC
Customer Satisfaction	Perceptual measure of firm's assessment that its customer related IT systems improved customer satisfaction. Coded as one or zero.	Information Week
Customer Knowledge	Perceptual measure of a firm's assessment that its customer related IT systems improved customer knowledge. Coded as one or zero.	Information Week
CRM	Use of CRM systems by a firm (1=CRM Systems deployed, 0=CRM Systems not deployed)	Information Week
Customer Facing IT Systems	Thirteen items summative scale covering deployment of IT systems in areas such as product marketing information, multilingual communication, personalized marketing offerings, dealer locater, product configuration, price negotiation, personalization, transaction system, online distribution and fulfillment system, customer service and customer satisfaction tracking.	Information Week
ITINVPC (IT Investments)	IT Investments as a percent of sales revenues	Information Week
Firm size	Sales revenues of firms	Compustat
Industry Sector (Mfg=1)	Whether firm belongs to Manufacturing or Services sector (Services =0, Manufacturing=1)	SIC based Classification
Market Concentration (HHI)	Measures the extent of dominance by fewer firms in a given industry	Table Base, Media Guide and Compustat

Table 2. Descriptive Statistics for Key Variables

	Services			Manufacturing		
	N	Mean	SD	N	Mean	SD
Panel Dataset						
ACSI	53	72.49	7.31	72	81.70***	4.12
PERQUAL	53	78.26	7.00	72	87.07***	3.84
PERVAL	53	72.96	6.40	72	81.53***	3.67
HHI	53	1665	1319	72	1740	1471
ITINVPC	53	5.49***	4.24	72	1.95	1.11
CRM Dataset						
Customer Satisfaction	288	0.79	0.41	191	0.79	0.41
Customer Knowledge	288	0.83	0.38	191	0.81	0.40
CRM	288	0.63***	0.48	191	0.51	0.50
Customer facing IT systems	288	7.44	2.76	191	7.81	2.95
IT Investments	288	3.82***	3.60	191	2.69	2.23
Improvement in ACSI	15	0.17	3.03	8	-1.90	1.48

[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 3. Correlations Among Variables in the Panel Dataset

		1	2	3	4	5	6	7	8	9
1	ACSI	1.00								
2	PERQUAL	0.97	1.00							
3	PERVAL	0.89	0.87	1.00						
4	HHI	0.42	0.43	0.31	1.00					
5	MFG	0.63	0.63	0.65	0.03	1.00				
6	ITINVPC	-0.41	-0.40	-0.37	0.02	-0.52	1.00			
7	Interaction Term (ITINVPC*MFG)	0.36	0.37	0.48	-0.01	0.75	-0.23	1.00		
8	YEAR	-0.28	-0.30	-0.13	-0.08	-0.07	0.21	0.01	1.00	
9	Interaction Term (ITINVPC*YEAR)	-0.41	-0.42	-0.32	0.01	-0.32	0.82	-0.15	0.59	1.00

Table 4. Pair-wise Correlations Among Variables in the CRM Dataset

		1	2	3	4	5	6	7	8
1	Customer Satisfaction	1.00							
2	Customer Knowledge	0.40	1.00						
3	Improvement in ACSI	-0.37	0.34	1.00					
4	CRM	0.22	0.26	0.27	1.00				
5	Customer facing IT systems	0.18	0.15	-0.10	0.28	1.00			
6	IT Investments	0.03	0.04	-0.14	0.11	0.13	1.00		
8	Manufacturing	0.00	-0.03	-0.37	-0.12	0.06	-0.17	1.00	1.00

Table 5. Parameter Estimates for Effect of Aggregate IT Investments

(p values are in parentheses)

		(1)		(2)		(3)
		Perceived Quality		Perceived Value		ACSI
MFG (0=Services, 1=Manufacturing)	$\alpha_{11=}$	11.906*** (0.000)	$\alpha_{21=}$	10.136*** (0.000)	$\alpha_{31=}$	12.370*** (0.000)
ITINVPC	$\alpha_{12=}$	0.939*** (0.000)	$\alpha_{22=}$	0.598** (0.014)	$\alpha_{32=}$	1.050*** (0.000)
MFG*ITINVPC (INTERACTION TERM)	$\alpha_{13=}$	-0.975** (0.012)	$\alpha_{23=}$	-0.734 (0.130)	$\alpha_{33=}$	-1.130*** (0.009)
HHI	$\alpha_{14=}$	0.002*** (0.000)	$\alpha_{24=}$	0.001** (0.013)	$\alpha_{34=}$	0.002*** (0.000)
YEAR (0=1994-96, 1=1999-2000)	$\alpha_{15=}$	0.492 (0.453)	$\alpha_{25=}$	1.266 (0.133)	$\alpha_{35=}$	0.864 (0.244)
ITPINVC*YEAR (INTERACTION TERM)	$\alpha_{16=}$	-1.011*** (0.000)	$\alpha_{26=}$	-0.884*** (0.000)	$\alpha_{36=}$	-1.234*** (0.000)
CONSTANT	$\alpha_{10=}$	72.780*** (0.000)	$\alpha_{20=}$	69.845*** (0.000)	$\alpha_{30=}$	66.917*** (0.000)
N		125		125		125
Overall R square		0.665		0.521		0.656
Chi Square		160.30***		82.61***		169.61***

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6. Parameter Estimates for Effect of CRM Investments on Customer Knowledge and Customer Satisfaction

		1		2		3		4
		Customer Knowledge		Customer Satisfaction		Customer Satisfaction		Improvement in ACSI
CRM	β_{11}=	0.712***	β_{21}=	0.523***	β_{31}=	0.310**	β_{41}=	0.924
		[0.173]		[0.144]		[0.081]		
		(0.000)		(0.000)		(0.037)		(0.338)
Customer Facing IT Systems	β_{12}=	0.050*	β_{22}=	0.069***	β_{32}=	0.063**	β_{42}=	-0.121
		[0.012]		[0.019]		[0.016]		
		(0.060)		(0.005)		(0.016)		(0.490)
IT Investments (as percentage of Revenue)	β_{13}=	-0.001	β_{23}=	-0.001	β_{33}=	-0.002	β_{43}=	-0.153
		[-0.0002]		[-0.0003]		[-0.0005]		
		(0.971)		(0.962)		(0.936)		(0.225)
MFG (0=Services, 1=Manufacturing)	β_{14}=	-0.025	β_{24}=	0.025	β_{34}=	0.043	β_{44}=	-2.725**
		[-0.006]		[0.007]		[0.011]		
		(0.865)		(0.858)		(0.771)		(0.024)
Customer Knowledge					β_{35}=	1.133***	β_{45}=	4.468*
						[0.295]		
						(0.000)		(0.090)
Constant	β_{10}=	0.220	β_{20}=	0.029	β_{30}=	-0.676***	β_{40}=	-2.625
		(0.297)		(0.886)		(0.003)		(0.333)
N		479		479		479		23
Log Likelihood		-207.335		-230.196		-205.673		
Chi Square		36.26***		30.41***		79.46***		
R Squared								0.428

Note: Marginal effects are shown in square brackets and p values are shown in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

References

Anderson, E.W. "Customer Satisfaction and Price Tolerance," *Marketing Letters* (7:3) 1996, pp 19-30.
Anderson, E.W., Fornell, C., and Rust, R.T. "Customer Satisfaction, Productivity, and Profitability: Differences between Goods and Services," *Marketing Science* (16:2) 1997, pp 129-145.
Anderson, E.W., and Sullivan, M.W. "The Antecedents and Consequences of Customer Satisfaction for Firms," *Marketing Science* (12:2) 1993, pp 125-143.
Anderson, M.C., Banker, R.D., and Ravindran, S. "The New Productivity Paradox," *Communications of the ACM* (46:3), March 2003, pp 91-94.
Baltagi, B.H. *Econoteric Analysis of Panel Data*, (Second ed.) John Wiley & Sons, Chichester, 2001.
Banker, R., Kauffman, R., and Morey, R. "Measuring Gains in Operational Efficiency from Information Technology: A Case Study of the Positran Deployment at Hardee's Inc.," *Journal of Management Information Systems* (Fall) 1990, pp 29-54.
Banker, R.D., Bardhan, I.R., Chang, H., and Lin, S. "Plant Information Systems, Manufacturing Practices and Plant Performance," in: *University of Texas at Dallas Working Paper*, 2003, pp. 1-36.
Banker, R.D., and Kauffman, R.J. "Case Study of Electronic Banking at Meridian Bancorp," *Information And Software Technology* (33:3) 1991.
Barua, A., Kriebel, C.H., and Mukhopadhyay, T. "Information Technologies and Business Value - an Analytic and Empirical Investigation," *Information Systems Research* (6:1) 1995, pp 3-23.
Barua, A., and Mukhopadhyay, T. "Information Technology and Business Performance: Past, Present, and Future," in: *Framing the Domains of Information Technology Management: Projecting the Future... Through the Past,* R.W.Zmud (ed.), Pinnaflex Press, Cincinnati, OH, 2000, pp. 65-84.
Belsley, D.A., Kuh, E., and Welsch, R.E. *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity* John Wiley & Sons, New York, 1980.
Bharadwaj, A. "A Resource Based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation," *MIS Quarterly* (24:1) 2000, pp 169-196.
Bharadwaj, A.S., Bharadwaj, S.G., and Konsynski, B.R. "Information Technology Effects on Firm Performance as Measured by Tobin's Q," *Management Science* (45:7) 1999, pp 1008-1024.
Bitner, M.J., Brown, S.W., and Meuter, M.L. "Technology Infusion in Service Encounters," *Academy of Marketing Science Journal* (28:1) 2000, pp 138-149.
Bolton, R.N., Kannan, P.K., and Bramlett, M.D. "Implications of Loyalty Program Membership and Service Experiences for Customer Retention and Value," *Journal of the Academy of Marketing Science* (28:1) 2000, pp 95-108.
Breusch, T.S., and Pagan, A.R. "The Langrange Multiplier Test and Its Application to Model Specification in Econometrics," *Review of Economic Studies* (47) 1980, pp 239-253.
Brynjolfsson, E. "The Productivity Paradox of Information Technology," *Communications of the Acm* (36:12) 1993, pp 67-77.
Brynjolfsson, E. "The Contribution of Information Technology to Consumer Welfare," *Information Systems Research* (7:3) 1996, pp 281-300.
Brynjolfsson, E., and Hitt, L. "Paradox Lost? Firm-Level Evidence on the Returns to Information Systems Spending," *Management Science* (42:4) 1996, pp 541-558.
Brynjolfsson, E., and Hitt, L.M. "Beyond the Productivity Paradox," *Communications of the ACM* (41:8) 1998, pp 49-55.
Chen, P.Y.S., and Hitt, L.M. "Measuring Switching Costs and the Determinants of Customer Retention in Internet-Enabled Businesses: A Study of the Online Brokerage Industry," *Information Systems Research* (13:3) 2002, pp 255-274.
Curry, B., and George, K.D. "Industrial Concentration: A Survey," *The Journal of Industrial Economics* (31:3), Mar 1983 1983, p 203.
Davenport, T.H., Harris, J.G., and Kohli, A.K. "How Do They Know Their Customers So Well?," *MIT Sloan Management Review* (Winter) 2001, pp 63-73.
Dedrick, J., Gurbaxani, V., and Kraemer, K.L. "Information Technology and Economic Performance: A Critical Review of Empirical Evidence," *ACM Computing Surveys* (35:1) 2003, pp 1-28.
Devaraj, S., and Kohli, R. "It Payoff in the Healthcare Industry: A Longitudinal Study," *Journal of Management Information Systems* (16:4) 2000, pp 41-67.

Dewan, S., and Kraemer, K.L. "International Dimensions of the Productivity Paradox," *Communications of the ACM* (41:8) 1998, pp 56-62.
Dewan, S., and Min, C.K. "The Substitution of Information Technology for Other Factors of Production: A Firm Level Analysis," *Management Science* (43:12) 1997, pp 1660-1675.
Economist, T. "American Productivity: A Profitless Recovery?," (362:8259) 2002b.
Financial Times "A Guru of Old-Fashioned Customer Satisfaction," in: *Financial Times*, 2002.
Fornell, C. "A National Customer Satisfaction Barometer: The Swedish Experience," *Journal of Marketing* (56:1) 1992, pp 6-22.
Fornell, C. "The Science of Satisfaction," *Harvard Business Review* (March) 2001.
Fornell, C., Johnson, M.D., Anderson, E.W., Cha, J., and Bryant, B.E. "The American Customer Satisfaction Index: Nature, Purpose, and Findings," *Journal of Marketing* (60:4) 1996, pp 7-18.
Fornell, C., and Wernerfelt, B. "A Model for Customer Complaint Management," *Marketing Science* (7:Summer) 1988, pp 271-286.
Forrester "My View: Naked Technology," in: *Available at http://www.forrester.com/Info/0,1503,287,FF.html*, Forrester Research, 2002.
Glazer, R. "Marketing in an Information Intensive Environment: Strategic Implications of Knowledge as an Asset," *Journal of Marketing* (55:4), Oct 1991, pp 1-19.
Greene, W.H. *Econometric Analysis*, (4th ed.) Prentice Hall Professional Technical Reference, New Jersey, 2000.
Hausman, J.A. "Specification Tests in Econometrics," *Econometrica* (46:6) 1978, pp 1251-1271.
Hitt, L.M., and Brynjolfsson, E. "Productivity, Business Profitability, and Consumer Surplus: Three Different Measures of Information Technology Value," *MIS Quarterly* (20:2) 1996, pp 121-142.
Ittner, C.D., and Larcker, D.F. (eds.) *Measuring the Impact of Quality Initiatives on Firm Financial Performance*. JAI Press, Greenwich, 1996.
Ittner, C.D., and Larcker, D.F. "Are Nonfinancial Measures Leading Indicators of Financial Performance? An Analysis of Customer Satisfaction," *Journal of Accounting Research* (36:Supplement) 1998, pp 1-35.
Ives, B., and Learmonth, G.P. "The Information System as a Competitive Weapon," *Communications of the ACM* (27:12) 1984, pp 1193-1201.
Johnson, M.D., and Fornell, C. "A Framework for Comparing Customer Satisfaction across Individuals and Product Categories," *Journal of Economic Psychology* (12:2) 1991, pp 267-286.
Kauffman, R.J., and Kriebel, C.H. (eds.) *Modeling and Measuring the Business Value of Information Technologies*. ICIT Press, Washington D.C, 1988.
Kohli, R., and Devaraj, S. "Measuring Information Technology Payoff: A Meta Analysis of Structural Variables in Firm-Level Empirical Research," *Information Systems Research* (Forthcoming) 2002.
Kudyba, S., and Diwan, R. "Research Report: Increasing Returns to Information Technology," *Information Systems Research* (13:1) 2002, p 104.
Long, J.S. *Regression Models for Categorical and Limited Dependent Variables* Sage Publications Inc., Thousand Oaks, 1997.
Menon, N.M., Lee, B., and Eldenburg, L. "Productivity of Information Systems in the Healthcare Industry," *Information Systems Research* (11:1) 2000, pp 83-92.
Meuter, M.L., Ostrom, A.L., I., R.R., and Bitner, M.J. "Self-Service Technologies: Understanding Customer Satisfaction with Technology-Based Service Encounters," *Journal of Marketing* (64:3) 2000, pp 50-64.
Mukhopadhyay, T., Kekre, S., and Kalathur, S. "Business Value of Information Technology - a Study of Electronic Data Interchange," *MIS Quarterly* (19:2) 1995, pp 137-156.
Mukhopadhyay, T., Rajiv, S., and Srinivasan, K. "Information Technology Impact on Process Output and Quality," *Management Science* (43:12) 1997, pp 1645-1659.
Parasuraman, A. "Understanding and Leveraging the Role of Customer Service in External, Interactive and Internal Marketing," Frontiers in Services Conference, Nashville, TN, 1996.
Parasuraman, A., and Grewal, D. "The Impact of Technology on the Quality-Value-Loyalty Chain: A Research Agenda," *Journal of the Academy of Marketing Science* (28:1) 2000, pp 168-174.
Piccoli, G., and Applegate, L. "Wyndham International: Fostering High-Touch with High-Tech," in: *Harvard Business School Case Study*, 2003, pp. 1-42.
Prahalad, C.K., and Krishnan, M.S. "The New Meaning of Quality in the Information Age," *Harvard Business Review* (77:5), Sep-Oct 1999, pp 109-+.

Prahalad, C.K., and Ramaswamy, V. *The Future of Competition: Co-Creating Unique Value with Customers* Harvard Business School Press, Boston, MA, 2004.
Quinn, J.B., and Baily, M.N. "Information Technology: Increasing Productivity in Services," *Academy of Management Executive* (8:3) 1994, pp 28-51.
Reichheld, F.F., and Sasser, W.E., Jr. "Zero Defections: Quality Comes to Services," *Harvard Business Review* (68:5) 1990, pp 105-111.
Roach, S.S. "Services under Siege-the Restructuring Inperative," *Harvard Business Review*), Sept-Oct 1991 1991, pp 82-92.
Rose, S. "The Coming Revolution in Credit Cards," *Journal of Retail Banking* (12:Summer) 1990, pp 17-19.
Rosenbleeth, M., Dallas-Feeney, C., Simmerman, S.S., and Casey, T. "Capturing Value through Customer Strategy," 20010140/2/02 (2002), Booz, Allen and Hamilton.
Rowley, J.E. "Reflections on Customer Knowledge Management in E-Business," *Quantative Market Research* (5:4) 2002, pp 268-280.
Rust, R.T., and Keiningham, T.L. *Returns on Quality: Measuring the Financial Impact of Your Company's Quest for Quality* Probus, Chicago, IL, 1994.
Rust, R.T., Zeithaml, V.A., and Lemon, K.N. *Driving Customer Equity* Free Press, New York, 2000.
Santhanam, R., and Hartono, E. "Issues in Linking Information Technology Capability to Firm Performance," *MIS Quarterly* (27:1), March 2003, pp 125-153.
Seybold, P.B., Marshak, R.T., and Lewis, J.M. *The Customer Revolution* Crown Business, New York, 2001.
Sobel, M.E. "Asymptotic Confidence Intervals for Indirect Effects in Structural Equations Models," in: *Sociological Methodology,* S. Leinhart (ed.), Jossey-Bass, San Francisco, 1982, pp. 290-312.
Subramani, M., and Walden, E. "The Impact of E-Commerce Announcements on the Market Value of Firms," *Information Systems Research* (12:2) 2001, pp 135-154.
Waters, R. "The Enigma within the Knowledge Economy: Productivity," in: *Financial Times*, London (UK), 2004, p. 9.
Wooldridge, J.M. *Econometric Analysis of Cross Section and Panel Data* The MIT Press, Cambridge, Mass, 2002.