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Business Value of Information Technology in the Internet Economy

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To my parents, Jinpei Yin and Rongdi Zhou

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This dissertation consists of three essays that address the issue of the business value of Information Technology (IT) in the context of the Internet economy.

The first essay studies the productivity of IT in the context of pure Internet based companies or dot coms. Various dot coms are divided into two groups: "digital" dot coms whose product and service can be distributed in digital form, and "physical" dot coms whose product needs to be physically shipped to customers. Compared to digital dot coms, physical dot coms have lower extent of digitization due to the restriction of the physical nature of their product. Therefore, it is hypothesized that IT capital contributes more to the performance of digital dot coms than to that of physical dot coms. This hypothesis is supported

by a production economics based analysis based on data from publicly traded dot coms.

The second essay studies the transformation of the traditional companies toward the Internet-enabled electronic business. A holistic, process-oriented theoretical model is proposed to link IT applications and complementary factors to firm performance. The model postulates that only when Internet-based IT applications are associated with synergistic changes in complementary aspects such as inter- and intra-organizational processes as well as customer and supplier readiness can a firm experience improvement in its performance. The model is empirically validated with data from more than a thousand companies and reveals some interesting results.

The third essay applies the model developed in the second essay to study the difference in the adoption and pay-off of the Internet among firms of different sizes. The small business literature has established that small firms are facing very different opportunities and barriers from those faced by large firms. It is found that small firms are more likely to embrace the Internet on the customer side IT applications and processes while large firms are more likely to focus on supplier related IT applications and business processes.

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1.1 INTRODUCTION

The dramatic rise and fall of "dot coms" or pure Internet based companies have received unprecedented attention in the business press. In the aftermath of the dot com crash that began in early 2000, an important and interesting research issue facing researchers and practitioners alike involves the productivity and financial performance of Internet based organizations. While numerous practitioner-oriented articles have focused on factors leading to the crash (e.g., irrational investor expectations, uncontrolled growth, wasteful spending, etc.), the academic literature on the performance analysis of dot coms is sparse at best. Yet an analysis of the performance of various types of dot coms can provide valuable insights into the phenomenon of leveraging the Internet for business activities. For example, it can suggest whether all types or certain groups of dot coms were unproductive in taking advantage of the opportunities created by the Internet. It can also indicate the efficiency of resource allocation by these firms. Subramani and Walden (2001) note that high profile dot coms such as Amazon.com spend between 9 and 16 percent of their revenues on Information Technology (IT), while traditional retail and distribution industries spend only about 1 percent of revenues on IT. Do these relatively large IT investments pay off for the dot coms? Given that many dot coms (both publicly traded and privately held) are still in business but struggling for survival (Helft 2001), an investigation of past dot com

performance can suggest potential pitfalls as well as avenues of untapped opportunities. For example, according to an Industry Standard survey, as of October 2001, "34 percent of the online retailers studied have perished or been purchased" (Helft 2001). What lessons can the surviving dot coms learn in order to conduct successful business operations? Further, as traditional organizations migrate many of their business activities to the Internet, can they also benefit from insights regarding productive and unproductive activities in an online world?

In the late nineties, online traffic and the total amount of business conducted through the Internet were growing rapidly (e.g. Subramani and Walden 1999; Subramani and Walden 2001), creating unprecedented opportunities. However, while there has been a dramatic growth of business on the Internet, "big is not necessarily better" (Barua et al. 2000b). Generating all revenues online does not necessarily imply productive operations and better financial performance such as increased profitability. During the height of the dot com boom, the conventional wisdom was that the Internet would enable sellers to reach large markets without the usual costs associated with retailing operations. However, the failure of many early and high-profile dot coms raises questions about the accuracy of the above assumption, and provides the motivation to study dot com performance for insights into drivers of productivity.

Yet another reason makes it interesting to analyze the productivity of dot coms. Research in Information Technology (IT) productivity has often implicitly assumed that positive IT impacts exist, but that they may have remained elusive due to measurement and methodological limitations (e.g. Barua et al. 1995;

Brynjolfsson and Hitt 1993). However, the dramatic proliferation of the Internet in the business world since 1995 necessitates a reexamination of this point of view. The Internet and its related technologies and applications are widely available to all types of organizations across the globe. Prior to the Internet revolution, organizations often invested in vendor or technology specific applications that were not open or ubiquitous in nature. For instance, Electronic Data Interchange (EDI) has been around for over twenty years, and has yet failed to capture a significant volume of business transactions owing to the difficulties and cost of adoption. However, organizations adopting EDI technologies have enjoyed significant benefits. By contrast, the Internet provides a "level playing field" in terms of a low cost, globally accessible network infrastructure, open standards and applications that are based on the user-friendly universal Web browser. Given this technology equalizing effect of the Internet, does investing more in Internet related IT still lead to better firm performance?

To address these research issues, this study distinguishes between two types of dot coms: Digital and physical. Digital dot coms are Internet based companies such as Yahoo, eBay and America Online, whose products and services are digital in nature, and which are delivered to consumers directly over the Internet. The physical dot coms are also based entirely on the Internet in that they do not use physical retail channels, but sell physical products (e.g., books, CDs, jewelry, toys) that are shipped to consumers. They are referred to as electronic retailers (e-tailers) by the business press, and include electronic commerce pioneers such as Amazon.com, peapod.com and ashford.com. This

distinction enables investigating whether Internet based IT investments have similar impacts on physical and digital dot coms.

Based on the economic characteristics of information products and services, it is hypothesized that IT investments contribute more to various output measures (e.g., sales, sales per employee, gross income and gross income per employee) for digital dot coms than for physical dot coms. The rationale is that the current level of digitization of business processes is currently higher in digital products companies than in Internet based firms selling physical goods. While the Internet and electronic commerce applications are equally accessible to both types of companies, electronic retailers of physical products often build warehouses, handle inventory, and are subject to many of the physical constraints of bricks-and-mortar companies. By contrast, due to the very nature of their business, most of the processes and delivery mechanisms of digital dot coms are implemented online. Further, the ability of a digital dot com to differentiate itself from its competitors directly depends on being able to translate innovative business strategies into online capabilities.

Electronic retailers also suffer from the lack of complementary digitization in their value chain. While they may have digitized their interactions with customers, their value chain partners such as suppliers and channel partners may not have yet embraced the Internet for their operations. However, the true benefits of electronic commerce will not be harvested until all value chain partners adopt digital technologies and processes.

This study analyzes publicly traded digital and physical dot coms, and shows that IT capital (computer hardware, software and networking equipment) does not have any significant contribution to the four output measures. While this result may seem reminiscent of the familiar "IT productivity paradox" from the physical world, introducing the dichotomy involving digital and physical dot coms leads to a set of interesting results and insights. Specifically, IT is shown as contributing significantly to all four output measures for digital dot coms, while not contributing at all to the performance of physical dot coms. This result is found to be consistent across model specification and measurement methods. The sharp difference in the contribution of IT to firm productivity raises serious issues regarding the way the e-tailers have conducted their business on the Internet.

This study also finds that the digital dot coms should be investing the marginal dollar in IT, while the physical products companies are better off by investing it in labor. This reflects a relatively high level of manual processes, especially in the fulfillment and logistics areas of e-tailing, and calls for rapid digitization of all business processes both within and outside the firm. Further, physical dot coms must rely more on alliances and partnerships with organizations that specialize in the areas of order fulfillment, and use electronic linkages for coordination and collaboration with such partners. The potential of the Internet economy cannot be realized by only digitizing the front end (customer side) of a business and by relying on physical means to complete order fulfillment.

Recent anecdotal evidence suggests that surviving e-tailers have been shifting their business strategies rapidly, focusing on alliances with suppliers, manufacturers and established distribution channels to handle logistics and fulfillment. While the level of digitization may be intrinsically somewhat higher for digital dot coms, e-tailers should be able to increase the productivity of their operations through holistic digitization of their value chain processes.

The balance of this chapter is organized as follows: Section 1.2 discusses the sparse but emerging literature on dot com performance. This section also briefly reviews the IT productivity paradox and relates it to issues in electronic commerce. Section 1.3 develops the hypotheses to be empirically tested based on the characteristics of digital and physical products companies on the Internet. Modeling details based on production economics are outlined in section 1.4, while data and measurement issues are discussed in section 1.5. Analysis and results are presented in section 1.6, followed by a discussion of the findings in section 1.7. Future research and concluding remarks are provided in section 1.8.

1.2 MOTIVATION AND PRIOR LITERATURE

The academic literature on dot coms is in a nascent stage. The most comprehensive academic research on dot com performance to date involves the studies by Subramani and Walden (1999; 2001), who use the event study methodology to analyze returns to publicly traded dot coms as well as traditional organizations from investments in electronic commerce related IT, human capital and processes. They categorized firms based on whether they are purely Internet based, the type of goods sold (digital or tangible), and the type of electronic

commerce (business-to-business or business-to- consumer). Of special interest are the hypothesis and results involving firms selling digital and tangible goods. Subramani and Walden (1999; 2001) hypothesize that returns to firms offering digital products from electronic commerce initiatives will be higher than those accruing to firms selling tangible products. However, their analysis reveals that physical dot coms enjoyed weakly higher returns than digital goods sellers. They suggest that the findings may be attributable to the intense competitive pressures faced by digital goods sellers. Other authors such as Weill and Vitale (2001) have analyzed dot com business models and have found fulfillment and logistics to be one of the key hurdles for e-tailers. This is a critical issue in the current study, for it is conjectured that e-tailers have not been able to take advantage of the Internet in digitizing their back-office operations.

Since this study deals with the IT and labor productivity in Internet based companies, it is important to briefly discuss the body of literature in IT productivity assessment and to relate it to the issues brought about by the proliferation of the Internet and the emergence of dot coms. A detailed review of this literature can be found in Barua and Mukhopadhyay (2000), and is summarized below.

A series of early studies of IT productivity led to disappointing results. For instance, Roach (1987) found that the labor productivity of "information workers" had failed to keep up with that of "production workers". Baily and Chakrabarti (1988) found similar results and suggested several possible reasons including incorrect resource allocation, output measurement problems, and redistribution of

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output within industries. Morrison and Berndt (1990), Berndt and Morrison (1995), Roach (1991) and others found lackluster returns from investments in IT. One of the most widely cited IT productivity studies was that of Loveman (1994), who analyzed the impact of IT and non-IT capital as well as labor and inventory on the productivity of large firms primarily in the manufacturing sector during the 1978-1984 time period. Loveman found that the output elasticity of IT capital was negative, suggesting that the "marginal dollar would have been better spent on non-IT factors of production."

The lack of a positive relationship between IT spending and performance prompted Roach (1987; 1989) to develop the notion of "IT productivity paradox". This sentiment was also reflected in Solow's (1987) remarks regarding IT productivity: "You can see the computer age everywhere but in the productivity statistics." Since the early nineties, the IT productivity paradox has puzzled and challenged researchers, and has often been used to support negative viewpoints and skepticism regarding the role of IT investments (Lohr 1999).

An exception to the above stream of disappointing results is Bresnahan's (1986) study that found a sizable consumer surplus due to investments in computing technologies in the unregulated parts of the financial services sector. In the nineties, Brynjolfsson and Hitt (1993; 1996b) and Lichtenberg (1995) deployed a common data set from International Data Corporation (IDC), and found significant productivity gains from investments in computer capital. Following Bresnahan's (1986) approach, Brynjolfsson (1996) also found significant consumer surplus resulting from IT investments. These findings

ushered in a new era in IT productivity research, and was followed by a series of studies that also established the positive impact of IT investments. For instance, with the same data used by Loveman (1994) but with different input deflators and modeling techniques, Barua and Lee (1997b) and Lee and Barua (1999) found that the IT contributed significantly more to firm performance than either labor or non-IT capital. By the late nineties, the IT productivity paradox was considered solved.

How do the above studies relate to Internet based IT investments? Particularly noteworthy is the time span of the datasets used by the above studies, which ranges from late seventies to the early nineties. At that time, IT often consisted of expensive proprietary applications and hardware systems. Further, IT was used to make firms more efficient in their operations such as forecasting sales, managing inventory, controlling quality, accounting, etc. Since the mid nineties, we have witnessed a rapid proliferation of network technologies characterized by the Internet and the World Wide Web. As a result, there has been a dramatic change from centralized mainframe based computing to an open, Web based distributed computing environment. Today applications for Internet based commerce are widely available from a myriad of technology vendors, while Subramani and Walden (1999) also allude to the ease with which pure Internet based companies can deploy IT applications:

> "The technology components required in e-commerce initiatives are general purpose: networking equipment and general-purpose hardware such as web servers and communication servers. The software components are modular and comprehensive e-commerce packages, as well as toolkits to develop e-commerce software, and are offered by a variety of vendors

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… The technology component of e-commerce thus poses only a minimal hurdle …"

The above discussions lead to the following questions: Since Internet based IT is easily available to virtually every firm at a relatively low cost, can every firm obtain similar benefit from using IT? Further, can all types of firms leverage the Internet based technologies to the same extent? The objective is to enumerate decisive criteria or significant characteristics that can be used to distinguish between the ability of players to leverage the new Internet economy. The key criterion used in this study is the type of product or service a firm offers on the Internet. Even though the emerging academic literature on Internet based companies (e.g. Cooper et al. 2001) generally does not distinguish between different types of "dot coms", this study takes the position that these Internet based companies currently operate in very different ways depending on the nature of the products they sell. As elaborated in the next section, the dot coms offering digital products and services can be characterized by a much higher level of digitization than those selling physical products. As a result, IT investments are expected to have a significantly different set of impacts for the two categories of Internet players.

1.3 HYPOTHESES DEVELOPMENT

In order to develop empirically testable hypotheses regarding the IT productivity of digital and physical dot coms, it is important to compare and contrast the activities of the two types of businesses, and to assess the extent to which they are affected by the Internet. All dot coms generate nearly 100 percent of their revenues online, and mostly interact with customers directly over the

Internet. Thus, the customer facing features of a digital products business may be similar to that of a physical dot com. For example, both groups strive to create highly functional and customer friendly interfaces that can support rich interaction with online visitors.

The most important distinctions between a digital and a physical dot com, however, involve the degree to which business strategies, processes and relationships have been or can be digitized, and the type of inputs used by each company. The complete business model of a digital products company is often reflected in its IT applications. For instance, a strategy of customizing content is implemented through online content personalization engines. Ebay's successful strategy of creating a feedback and rating system for all buyers and sellers is accomplished through Web-database connectivity tools. Intermediary services that find the lowest price and/or a combination of specified criteria for a product on the Internet are based on powerful search and comparison tools. In other words, any business strategy in the digital products world is directly translated into systems capabilities. In many situations, these IT based strategies enable the digital dot coms to create network effects (Shapiro and Varian 1998). For example, significant network externalities are associated with AOL's messaging system, whereby current users benefit as more new users adopt the technology. Similarly customization of digital content or service also creates customer value, while offering different versions of a digital product enables a seller to engage in price discrimination strategies (Shapiro and Varian 1998).

The above line of reasoning does not imply that digital dot coms do not face a challenging business environment. In fact, as noted by Shapiro and Varian (1998) and Subramani and Walden (2001), digital dot coms face extremely strong competitive pressures and difficulties in being able to charge for online content. However, there is anecdotal evidence that digital dot coms with innovative business models and strategies have benefited from the deployment of IT applications. Overall IT is expected to play a positive role in the performance of digital dot coms, which leads to the following hypothesis:

H1.1: For digital products companies, IT capital has a significant positive impact on (i) sales, (ii) gross income, (iii) sales per employee and (iv) gross income per employee.

The differentiation strategies of a physical products company on the Internet (e.g., an e-tailer) have been mostly implemented offline, and may have had little to do with IT. For instance, to provide the "highest level" of customer service, Amazon.com has large warehouses around the world that hold books, CDs and other physical products in their inventory. The motivation behind dealing with warehouses and inventory is the ability to provide fast delivery of goods to customers. For instance, if Amazon.com sells thirty copies of a particular book on a given day, it cannot possibly rely on the publisher of the book to ship thirty copies within, say, twenty-four hours. Most publishers themselves have not yet adopted electronic business processes to the extent where they can print any number of copies of a book on demand. As a result, e-tailers often hold inventory to be more responsive to customers. In fact, nearly 75 percent of the physical dot

coms in the sample maintained merchandise inventory, and handled packaging and shipping processes by themselves, citing customer service excellence as the primary reason. In this regard, e-tailers are not significantly different from their bricks-and-mortar counterparts. By contrast, the digital products companies manage content inventory directly through their Web sites and related applications.

As another example of the processes involved in the operation of a physical dot com, consider an online grocery store which uses its Web store front to take customer orders, but which must rely heavily on people and manual processes to fulfill the order efficiently and to the satisfaction of the customer. Thus a differentiation strategy for the online grocery store may call for investment in a faster delivery network.

An examination of the components of cost of sales of digital products companies and physical dot coms suggests some key differences in their operations. For the digital products companies, cost of sales consists of Internet connection, Web hosting, telecommunications, Web site infrastructure and development, networking, computer hardware, software development, payroll for Web site operation, and digital content provided by other companies. The cost of sales of most physical dot coms consists of the cost of merchandise sold and inbound/outbound shipping.

There are other important distinctions between these two categories. For instance, a digital products company can grow by creating more content alliances and by expanding and enhancing its Web presence. By contrast, an e-tailer has to

undertake an elaborate and often labor intensive expansion program to grow the volume of business. The above observations are summarized in Table 1.1 and lead to the following hypotheses:

H1.2: For physical dot coms, IT capital does not have a significant positive impact on (i) sales, (ii) gross income, (iii) sales per employee and (iv) gross income per employee.

H1.3: IT capital has a higher contribution to (i) sales, (ii) gross income, (iii) sales per employee and (iv) gross income per employee for digital product companies than for physical dot coms.

While H1.3 may seem to be redundant in the light of H1.1 and H1.2, it should be noted that the relative levels of significance of IT contribution in H1.1 and H1.2 will jointly determine if the difference in contribution of IT across the two groups is significant.

Note that the above discussion applies to the manner in which physical dot coms have conducted their business through predominantly physical processes. As the Internet economy matures, surviving e-tailers will undergo a major metamorphosis whereby they will also leverage the Internet in virtually every aspect of their business.

1.4 PRODUCTION FUNCTION BASED MODELING

IT productivity studies are generally based on the production economics literature (e.g. Barua and Lee 1997b; Brynjolfsson and Hitt 1993; Brynjolfsson and Hitt 1996b; Dewan and Min 1997; Lee and Barua 1999; Lichtenberg 1995). Following this tradition, to model the IT productivity for digital and physical dot

coms, this study chooses the Cobb-Douglas production function with a disembodied technological change rate λ:

$$q = Ae^{\lambda t} \prod_{i=1}^{N} x_i^{\alpha_i}$$

where

q is the output,

x_i is the level of input I,

α_i is the output elasticity of input I,

A is a constant,

and where N is the number of inputs.

The Cobb-Douglas production function is the most commonly chosen form for productivity analysis, although it has some restrictions such as perfect substitution among inputs. For this reason, a more general functional form, translog production function (Christensen et al. 1973), has been used as an alternative in several past research (e.g. Brynjolfsson and Hitt 1995). Section 1.6 also reports the results of an estimation using the translog production function with the same data. The finding is that although the translog function is a better approximation of reality for some of the data, the estimates of the output elasticities from both functional forms are not different from each other.

Returning to the Cobb-Douglas production function, this study use the form

$$OUTPUT = Ae^{\lambda t} IT\_CAP^{\alpha_1} NIT\_CAP^{\alpha_2} LABOR^{\alpha_3}$$

where IT_CAP is the IT capital (computer hardware, software and networking equipment), NIT_CAP is the non-IT capital, LABOR is a measure of

labor, and where t is the number of years in business. t is included in the model to control for the maturity of a company. Companies operating in the Internet space are expected to improve their conduct of business over time. Since the companies in the data set are almost all start-ups, it is expected to see a positive impact of time on output.

Two measures of output deployed in this study are sales and gross income (sales minus cost of sales). In the early days of electronic commerce, dot coms were solely focused on increasing consumer visits to their Web sites, and were focusing on metrics related to the volume of Web traffic and the time spent by visitors at various Web pages. However, once it became evident that increased online traffic does not necessarily translate into actual sales, the dot coms started concentrating on revenues. Financial analysts also started emphasizing gross income, even though dot coms may have primarily focused on revenues during the time frame of the study.

After a log transformation comes the following:
$$\log SALES = c_s + \lambda_s t + \alpha_{1s} \log IT\_CAP + \alpha_{2s} \log NIT\_CAP +$$
$$\alpha_{3s} \log LABOR + \varepsilon$$
$$\log GROSS\_INCOME = c_g + \lambda_g t + \alpha_{1g} \log IT\_CAP + \alpha_{2g} \log NIT\_CAP +$$
$$\alpha_{3g} \log LABOR + \varepsilon$$

Two additional output measures used in this study are sales per employee and gross income per employee. Assuming constant returns to scale[1], it follows:

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[1] For regression of sales and gross income on IT, non-IT, Labor and year, the null hypothesis $H_0 : \alpha_1 + \alpha_2 + \alpha_3 = 1$ is tested by conducting F-test. The results indicate that the null hypothesis of constant return to scale cannot be rejected for all four regressions. See the row labeled "H_0:CRTS" in Table 1.5.

$$\frac{OUTPUT}{LABOR} = Ae^{\lambda t}\left(\frac{IT}{LABOR}\right)^{\alpha_1}\left(\frac{nonIT}{LABOR}\right)^{\alpha_2}\left(\frac{LABOR}{LABOR}\right)^{\alpha_3}$$

Taking log on both sides and substituting *OUTPUT* with *SALES* and *GROSS INCOME* and using subscripts *se* and *ge* for sales per employee and gross income per employee respectively:

$$\log SALES\_EMP = c_{se} + \lambda_{se}t + \alpha_{1se}\log IT\_CAP\_EMP +$$
$$\alpha_{2se}\log NIT\_CAP\_EMP + \varepsilon$$
$$\log GROSS\_INCOME\_EMP = c_{ge} + \lambda_{ge}t + \alpha_{1ge}\log IT\_CAP\_EMP +$$
$$\alpha_{2ge}\log NIT\_CAP\_EMP + \varepsilon$$

where SALES_EMP is sales per employee, GROSS_INCOME_EMP is gross income per employee, IT_CAP_EMP is IT capital per employee, and where NIT_CAP_EMP is non-IT capital per employee.

Since labor cost is not available for most of the companies in the dataset, this study first uses the number of employees as a proxy for the labor input. The total labor cost can be thought of as a product of the number of employees and an average annual salary plus benefits. Then the log of the average yearly salary and benefits becomes a part of the regression constant. Thus, with the exception of the constant term, the coefficient estimates will not be affected by using the number of employees instead of the total labor cost. However, to test the robustness of the estimates obtained with the number of employees, this study also uses a derived labor cost, which is calculated from data on industry averages. The result shows that the elasticity estimates with two different measures of labor input are very similar to each other despite the fact that the average labor cost are different across physical and digital dot coms.

In order to test hypotheses 3, dummy variables are used (using standardized values without the constant term):

$$\log SALES = \gamma_{1s} D + \gamma_{2s} D * t + \gamma_{3s} D * \log IT\_CAP + \gamma_{4s} D * \log NIT\_CAP +$$
$$\gamma_{5s} D * \log LABOR + \lambda_s t + \alpha_{1s} \log IT\_CAP +$$
$$\alpha_{2s} \log NIT\_CAP + \alpha_{3s} \log LABOR + \varepsilon$$

$$\log GROSS\_INCOME = \gamma_{1g} D + \gamma_{2g} D * t + \gamma_{3g} D * \log IT\_CAP +$$
$$\gamma_{4g} D * \log NIT\_CAP + \gamma_{5g} D * \log LABOR + \lambda_g t +$$
$$\alpha_{1g} \log IT\_CAP + \alpha_{2g} \log NIT\_CAP + \alpha_{3g} \log LABOR + \varepsilon$$

$$\log SALES\_EMP = \gamma_{1se} D + \gamma_{2se} D * t + \gamma_{3se} D * \log IT\_CAP\_EMP +$$
$$\gamma_{4se} D * \log NIT\_CAP\_EMP + \lambda_{se} t + \alpha_{1se} \log IT\_CAP\_EMP +$$
$$\alpha_{2se} \log NIT\_CAP\_EMP + \varepsilon$$

$$\log GROSS\_INCOME\_EMP = \gamma_{1ge} D + \gamma_{ge} D * t + \gamma_{3ge} D * \log IT\_CAP\_EMP +$$
$$\gamma_{4ge} D * \log NIT\_CAP\_EMP + \lambda_{ge} t + \alpha_{1ge} \log IT\_CAP\_EMP +$$
$$\alpha_{2ge} \log NIT\_CAP\_EMP + \varepsilon$$

where D represents a dummy variable, which has a value of 1 for digital products companies and 0 for physical dot coms. Further, the α's and the corresponding levels of inputs in the last four formulations involving the dummy variable apply only to the physical dot coms.

1.5 DATA AND MEASUREMENT

1.5.1 Data collection

The primary source of the data used in this study is the 10K form of the companies selected through Hoover's Online, Inc. (http://www.hoovers.com). The company's Web site offers information on over 14,000 public and private

companies (and access to 37,000 additional companies). Users can view free information on the companies covered by Hoover's; subscribers can view additional in-depth coverage of 8,000 of these companies. This study is interested in publicly traded companies that generate all of their sales online. From the search page of Hoover's Online, it is possible to search by company type (e.g., public, private, country, industry, etc.). There are nearly 300 industry types. The data collection begins with search for public U.S. companies in every industry that can possibly contain companies generating all of their revenue online. Then the "capsule" of each company in the search results is examined to determine if it should be included in the sample. For example, a search for public U.S. companies in "Accounting, Bookkeeping, Collection & Credit Reporting" results in a list of 11 companies. By analyzing the capsules of these 11 companies, it is decided that only Claimsnet.com Inc. should be included in the sample. This process is repeated for all industry categories. Some industries such as airlines, auto manufacturers, etc. are skipped since they will not contain companies meeting the criteria of generating all sales through the Internet. All companies in the Hoover's Online IPO Central are also examined and those based purely on the Internet are selected.

These searches provide a list of about 300 companies. Then the actual data are collected from these companies' SEC filings. During the data collection process, some companies are discarded from the list due to one or more of the following reasons:

- They may not generate all of their revenue online (as assessed from the description of the revenue in their 10K forms)

- Some critical data such as IT capital were not available.

- The financial data is not for the entire financial year (12 months). Although some kind of projection might be used to get a whole-year figure, it might at the same time generate bias. Also the exclusion of partial-year data may help alleviate heteroskedasticity problems.

This study does not include companies selling in both physical and digital worlds. For example, the Wall Street Journal sells both print and online edition to its subscribers, and Charles Schwab offers brokerage services both online and in the traditional way. This approach of exclusion increases comparability and simplifies the measurement process.

At the end of this exercise, a sample of 149 online companies is compiled. These companies are divided into two groups according to whether they sell physical or digital products. There are 116 and 33 digital and physical products companies respectively. In most cases, this dichotomy coincides with distinction made among different industries. And at the time of data collection, no company in the sample is found dealing with digital and physical products at the same time. For example, most companies in "Internet & Online Content Providers" deal exclusively with digital products while most companies in various retailing industries deal exclusively with physical products.

There are a few exception cases that deserve special mention. For example, Emusic.com Inc., which is in "Music, Video, Book & Entertainment

Software Retailing & Distribution", sells downloadable music through Internet instead of physical CD[2]. Thus it is classified as a digital products business. On the other hand, even though Alloy Online Inc. is in the "Internet & online content providers" category, it generates almost all of revenue from selling physical items such as CDs and clothing to young people.

All the data are for the 1998 financial year (ending on June 30, 1999). The total sales of these 149 companies is $9.2 billion. The total number of employee is 44,156. The summary statistics can be found in Table 1.2 and Table 1.3.

1.5.2 Measurement issues

1.5.2.1 Output

As mentioned above, sales is one of the output measures used in this study. During the time frame of the study, dot coms were beginning to shift focus from Web traffic and attention metrics to increasing sales and market share. It is reasonable to expect that these dot coms were maximizing sales and customer base instead of net profit. Although value-added type of measures is more appropriate for mature industries, sales is an appropriate measure of output in this specific context. All sales are converted to constant 1996 dollars using the chain-type price indices for gross domestic product by industry from BEA (Lum and Moyer 2000) according to the two-digit SIC code.

Another output measure used is gross income, which is calculated as sales minus cost of sales, and then is converted to constant 1996 dollars. For digital dot

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[2] Emusic.com is eventually excluded from the sample because it does not provide full year financial information for 1998.

coms, the cost of sales primarily consists of costs related to web content, network connectivity, web hosting and maintenance, etc., while for physical dot coms, the cost of sales consists primarily of the cost of goods sold to customer plus inbound and outbound shipping and handling costs. Gross profit is a value-added type of measure. Given the rapidly expanding online markets during the time period covered by the study, gross income maximization may not have been a major objective of the dot coms. However, given that financial analysts have called for gross income as an important metric for dot coms, this study has chosen to include it as one of the output metrics. In fact, 30% of the dot com companies in the sample do not have a positive gross profit, which excludes them from the regression using gross profit as the dependent variable.

1.5.2.2 IT capital

The book values of computer hardware, software and network equipments are used as the base for the IT capital measure. These data are available in the 10K reports of the publicly traded companies. Almost all the companies list the beginning and ending book values of all hardware, software and networking equipment separately as a component of the "Property and equipment" item in the balance sheet. These numbers are likely to be more accurate than those obtained through other methods like industry surveys, since these financial statements are audited by public accounting firms.

Both the beginning and ending book values are converted to constant 1996 dollars using the chain-type price indices for "Information processing equipment

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and software" from the Bureau of Economic Analysis (BEA). Then the average of the beginning and ending values is used as the IT capital value for that year.

1.5.2.3 Non-IT capital

Non-IT capital is calculated by subtracting the book value of computer hardware, software and network equipment from the total property and equipment, and then converting to constant 1996 dollars using chain-type price indices for "Non-residential private fixed investment" from BEA. The average of beginning and ending values is used.

1.5.2.4 Labor measures

One measure of the labor input of the production function could be the number of employees. As long as the unit labor cost is considered as a constant, using the number of employees as a proxy for the labor input does not affect the estimation of labor output elasticity when estimating the production functions for digital and physical dot coms separately. Only the estimate of the intercept is affected. However, if the unit labor costs are different across digital and physical dot coms, using the number of employees becomes problematic when the production function is estimated using the pooled data. In that case, it is desirable to consider the actual labor cost.

Since no labor expense data are available from the financial statements, industry average labor cost is used to calculate the labor input of the production function. According to the SIC code of the firms obtained from Hoover's Online, industry hourly labor cost is obtained from the Bureau of Labor Statistics' Employer Cost for Employee Compensation (ECEC) data. ECEC measures the

average hourly cost that employers pay for wages and salaries plus benefits including paid leave, supplemental pay, insurance, retirement, social security, etc. The data used are from March 1999 release, which is displayed in Table 1.4 along with the number of firms in each major industry group:

The average labor cost is also calculated using the number of employees as the weight for digital and physical dot coms. The results are as follows:

Digital: $21.23 ($44,158 per year*)

Physical: $15.38 ($31,990 per year*)

*52x40 hours per year

As expected, digital dot coms have a higher unit labor cost than physical dot coms. One weakness of the above method of calculating labor cost is that it might under-estimate the actual labor cost, given the fact that Internet startups may have offered more than industry averages to attract new employees. However it is reasonable to expect this effect to be in the same magnitude for both physical and digital dot com categories.

Most of the digital dot coms are in services sector (7) while most of the physical dot coms are in wholesale (50-51) and retail (52-59) sector. Some firms seem to appear in an industry group that does not match the definitions of digital and physical dot coms. This is due to the SIC code provided by Hoover's Online. For example, Neoforma.com, Inc. operates as an online intermediary of medical equipment, products and supplies for suppliers and distributors, which should be categorized as a digital dot com. However, the SIC code for this company is 5047 (medical and hospital equipment wholesale). Another example is uBid, Inc.,

which has a SIC code of 7389 (business services); uBid is in fact categorized as a physical dot com since it actually handled inventory and the delivery of the products during the 1998-1999 time period.

The correlation between the two labor measures is calculated. The log values of these two measures are highly correlated with a Pearson correlation coefficient of 0.989. Therefore, it is expected that the estimation results of the production function using either the number of employees or the derived labor cost will be quite similar even though the average labor costs are different between digital and physical dot coms.

1.6 EMPIRICAL ANALYSIS AND RESULTS

The production functions are estimated using the Ordinary Least Squares (OLS) method. Multicollinearity is a well-known problem in production function estimation using the Cobb-Douglas form (e.g., see Greene (2000) for a general discussion and Prasad and Harker (1997) for multicollinearity issues specific to IT contribution assessment). To test for multicollinearity, this study follows the approach of Belsley, Kuh, and Welsch (1980) and reports conditional indices for all regressions (see the row labeled "Con. Index" in Table 1.5). All conditional indices for regressions using the number of employees as the labor measure are well below the threshold level of 30, which is considered benign and acceptable for production function estimates. However, the regressions using calculated labor cost as labor measure show some mild multicollinearity problems. While the problem is not serious, given the closeness of the estimates with two different

labor measures, later part of this chapter uses the estimates from regressions using the number of employees as the basis of discussion of the results.

When conducting cross-sectional analysis, heteroskedasticity is often an issue to be addressed. Statistics suggested by White (1980) is used to test for heteroskedasticity and the results are shown in also shown in Table 1.5. None of the regressions shows any heteroskedasticity problem.

1.6.1 Cobb-Douglas production function

First a Cobb-Douglas production function is estimated using both employee number and labor cost. The production function is estimated separately for digital and physical dot coms using either sales or gross profit as dependent variables. The same regressions are also run on pooled data to test whether the digital and physical dot coms have different sets of production function parameters. The regression results are shown in Table 1.5.

The estimates confirm the previous conjecture that the results using different labor input measures are quite similar to each other, although the regressions using labor cost show some collinearity problem (as suggested by the conditional indices). However, the multicollinearity with labor cost is still within an acceptable range.

A series of tests are conducted to test the structural difference in the production function coefficients between digital and physical dot coms. These tests are often called Chow test in reference to Chow (1960). Basically these tests are a series of F-tests of a group of linear restrictions that some of or all the

regression coefficients are the same between two subsets of the data. The F-statistics and the p-value are shown by the row marked "Chow test" in Table 1.5.

The Chow-test results show that the structural difference in the production function parameters can be established between digital and physical dot coms when sales is used as the dependent variable. However, the same is not true when gross profit is used as the dependent variable. This can be justified by the fact that most of the dot coms in the data set are new companies who have been in business for just a couple of years (The mean of the time in business is 2 years for the entire sample). Most of these dot coms are concentrating on how to gain customer base, grab market share, and reach the critical mass instead of how to make profit. It is more reasonable to assume that these specific firms are trying to maximize their sales instead of the traditional assumption of profit maximization. Therefore, sales is a more relevant measure of output than gross profit in this specific circumstance.

The results in Table 1.5 show that IT capital has significantly positive elasticity in all four regressions for digital dot com but insignificant and somewhat negative elasticity for physical dot com. Therefore, both hypothesis 1 and 2 are supported. When sales is used as output measure, the overall impact of IT capital on the pooled sample is insignificant. In contrast, non-IT capital has significantly positive impacts in all four regressions for physical dot com but no significant impact digital dot com. Both labor measures are significant only for digital dot com when using sales as dependent variable but insignificant for both physical and digital dot coms when using gross profit as dependent variable. The

effect of time is significant for digital dot com but insignificant for physical dot coms.

1.6.2 Translog production function

A more general functional form of production function is the translog production function that includes the square and cross product of all inputs. For the three inputs used in this study, the translog production function is as follows:

$$\log OUTPUT = \text{intercept} + \beta_1 \log IT + \beta_2 \log nonIT + \beta_3 \log LABOR + \beta_4 YEAR +$$

$$\frac{1}{2}\beta_{11}(\log IT)^2 + \frac{1}{2}\beta_{22}(\log nonIT)^2 + \frac{1}{2}\beta_{33}(\log LABOR)^2 + \frac{1}{2}\beta_{44}YEAR^2 +$$

$$\beta_{12}\log IT * \log nonIT + \beta_{13}\log IT * \log LABOR + \beta_{14}\log IT * YEAR +$$

$$\beta_{23}\log nonIT * \log LABOR + \beta_{24}\log nonIT * YEAR + \beta_{34}\log LABOR * YEAR + \varepsilon$$

The null hypothesis of Cobb-Douglas functional form is equivalent to all the coefficients of square and cross-production terms equal to zero in the above and therefore can be tested. Various output elasticity can be calculated in the translog functional form to be compared with the Cobb-Douglas output elasticity.

$$e_{IT} = \beta_1 + \beta_{11}\overline{\log IT} + \beta_{12}\overline{\log nonIT} + \beta_{13}\overline{\log LABOR} + \beta_{14}\overline{YEAR}$$

$$e_{nonIT} = \beta_2 + \beta_{12}\overline{\log IT} + \beta_{22}\overline{\log nonIT} + \beta_{23}\overline{\log LABOR} + \beta_{24}\overline{YEAR}$$

$$e_{LABOR} = \beta_3 + \beta_{13}\overline{\log IT} + \beta_{23}\overline{\log nonIT} + \beta_{33}\overline{\log LABOR} + \beta_{34}\overline{YEAR}$$

$$e_{YEAR} = \beta_4 + \beta_{14}\overline{\log IT} + \beta_{24}\overline{\log nonIT} + \beta_{34}\overline{\log LABOR} + \beta_{44}\overline{YEAR}$$

The Chow-tests on translog regression yields the same result that the structural differences are supported for regressions using sales as output measure but not for regressions using gross profit as output measure.

The results of regressions show that the null hypothesis of Cobb-Douglas functional form cannot be rejected for physical dot coms (F-test of the null hypothesis yields a p-value of .2888 and .3372 for the two labor measures

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respectively). However, the same hypothesis can be rejected for digital dot coms at 5% level. Therefore the output elasticity is calculated using the translog regression estimates for digital dot coms as shown in Table 1.6.

From Table 1.6 it can be seen that although the Cobb-Douglas function form is rejected for digital dot coms, the IT elasticity estimates for translog function form are quite comparable to the Cobb-Douglas estimates. IT capital, labor and time have significantly positive impacts while non-IT capital is insignificant. The magnitudes of the elasticity are quite close to those of Cobb-Douglas production function. Therefore, later analysis can continue to use the estimates from the Cobb-Douglas function.

1.6.3 Cobb-Douglas function using per employee input and output

Given the facts that constant returns to scale cannot be rejected and that the number of employees can be used as a measure of labor input without causing bias in the estimation, one can also estimate the Cobb-Douglas production function using per employee output and inputs, for which the results are shown in Table 1.7.

Again the structural differences are supported when sales is used as the output measure. As in the previous Cobb-Douglas function estimates, IT capital is significant and positive for digital dot coms but insignificant and even slightly negative for physical dot coms. Non-IT capital is shown to have a significant (insignificant) impact on the outputs of physical (digital) dot coms. Therefore hypotheses 1 and 2 are again supported.

1.6.4 Pooled Cobb-Douglas regression including a dummy variable

The hypothesis 3, the difference in the impacts of IT between digital and physical dot coms can be tested with regressions using the Cobb-Douglas function on pooled data with a dummy variable. The dummy equals to 1 for digital dot com and 0 for physical dot com. The interaction terms between dummy and various inputs are also included in the regression. The focus will be on the interaction term between the dummy and IT input. Since the regressions are subject to collinearity problem due to the inclusion of the interaction terms, standardized variables are used in the regression to alleviate the collinearity problem (Belsley et al. 1980).

The results in Table 1.8 show that the interaction terms between the dummy and IT capital is significantly positive when sales are used as dependent variable, which means that IT capital's impact on sales for digital dot coms is significantly higher than for physical dot com. However, the same significance cannot be established when gross profit is used as dependent variable. Therefore, hypothesis 3 is partially supported.

1.6.5 Test for endogeneity of inputs

It is possible that the various inputs in the production function are endogenous, which means they are correlated with the disturbance term. Previous research has found mixed evidence regarding the endogeneity of production function inputs. For example, while Lee and Barua (1999) found IT and non-IT inputs to be endogeneous, in the analysis of more recent data by Brynjolfsson and Hitt (1996b), such inputs were of exogeneous nature. The instrumental variables

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approach and Hausman's specification test are adopted to investigate the potential endogeneity of IT and non-IT inputs. The beginning values of both inputs are used as the instruments to obtain a set of instrumental variable (IV) estimators following Greene (2000, pp. 370-375). Under the null hypothesis of exogeneity, both the least squares (LS) and IV estimators are consistent and LS estimators are efficient relative to IV estimators. Under the alternative hypothesis of endogeneity of inputs, the IV estimators remain consistent but the LS estimators are inconsistent. Therefore a Hausman's specification test can be used to test the null hypothesis of exogeneity. The details of the above IV estimation and test are listed in the Appendix. The IV estimators and the test results are shown in Table 1.9.

From Table 1.9, it is evident that the null hypothesis of input exogeneity cannot be rejected by the test statistics. Lee and Barua (1999) assumed that firms are profit maximizers, and choose the levels of IT and non-IT inputs based on input prices. However, it is unlikely that dot coms engaged in such calculated behavior of selecting levels of various inputs based on their unit prices, and may have chosen IT and non-IT inputs based on industry averages, available capital, and actions of competitors.

1.7 DISCUSSION OF RESULTS

It is interesting to note that for the pooled dataset, IT shows no contribution to any of the four output measures. If dot coms are considered as a single group (as they often are in business press articles), then the above result would raise the "IT productivity paradox" issue for pure Internet based

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companies. The dichotomy between digital and physical dot coms enabled us to study the productivity issue in more detail and to uncover that only a subgroup of dot coms failed to benefit from their Internet based IT initiatives.

Given the output elasticity of various inputs, it is important to analyze the marginal benefits of additional investments in various input factors. This provides insights into the current allocation of resources and provides guidance for investing additional resources.

1.7.1 Investing the marginal dollar

The marginal output obtained by increasing input i is given by:

$\frac{\partial y}{\partial x_i} = \frac{y}{x_i} \alpha_i$, where α_i is the output elasticity of input i. The means of y and

x_i are generally used when calculating the impact of increasing the input levels.

Since non-IT capital's impacts are insignificant for digital dot coms, the following analysis focuses on IT capital and labor for this group of companies. On an average, a digital dot com in the sample can increase its sales by $1,400 by investing $1,000 more in IT capital. It should be noted, however, that an additional investment of $1000 in IT returns $1400 in sales in the same year. However, the investment continues to generate additional sales beyond the first year.

The digital dot coms can also increase sales by $700 by investing $1,000 more in labor. Unlike IT capital, the increased return in sales from increasing the labor input occurs only once. Thus it is evident that the digital dot coms should invest the marginal dollar in IT capital. If the employee number is used as the labor measure, the additional sales from one more employee is $30,000, which is

equivalent to $700 more in sales from an $1,000 of labor (because the average labor cost is $43,000 per year, as calculated from figures in Table 1.2).

Since IT capital has an insignificant impact on all four output measures for physical dot coms, investing the marginal dollar in IT will not lead to increased benefits with any degree of certainty. On an average, a physical dot com in the current sample can increase its sales by $29,000 (or $27,000 if employee number is used in the regression instead of labor cost) by investing $1,000 more in non-IT capital. Thus it appears that the physical dot coms in current study should invest their marginal dollar in non-IT capital. However, it should be noted that the above numbers are based on sensitivity analysis around the status quo. As discussed below, the production function approach is incapable of suggesting radical changes in the way firms operate. The lackluster IT contribution estimates for physical dot coms call for large scale changes in their business processes and strategies.

1.7.2 Business process digitization and production functions

In the early phase of the dot com revolution, most electronic retailers focused on customer acquisition, and perhaps grossly underestimated the challenges of logistics and fulfillment. Weill and Vitale (2001) have noted the importance of efficient logistics in the electronic commerce context:

> "One of the major challenges for the direct-to-customer firm selling a physical product is getting the right product to the right address reliably and economically. Many Internet entrepreneurs have conceived of attractive Web sites, but they do not have a clear understanding of the complex logistics."

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It is evident that during the early days of electronic commerce, most publicly traded e-tailers were busy building warehouses and managing their own logistics operations. In the absence of high levels of digitization in the fulfillment processes of the physical products companies as well as in the supply chains of their trading partners, it is not surprising that non-IT capital was a more productive input than IT capital for this group. The production function approach can show the contribution of a given set of inputs toward one or more measures of output; however, it cannot suggest "radical" changes. The implication that the marginal dollar would be better spent on labor than on IT capital for physical dot coms only applies to the status quo – an environment marked by a high level of digitization only at the customer end of the business, but by manual and labor intensive processes on the "back office" side. In the long run, as digitization of business processes becomes more widespread throughout the value web, there should be a change in the role of IT capital in the production process even for the physical dot coms.

1.7.3 Should the physical dot coms abandon ship?

The above results do not suggest that physical products firms on the Internet should abandon their current business and start dealing with digital products. Instead the results suggest that the e-tailers failed to capitalize on the informational advantages of a digital world. They need to either develop their own logistics and fulfillment capabilities like Amazon.com, or coordinate with logistics and fulfillment partners for efficient back office operations. They also need to develop stronger digital relationships with manufacturers and suppliers or

distributors. The lackluster results for e-tailers call for digitization of the entire business to be able to fully leverage the Internet. This digitization involves processes and strategies both inside and outside the organization. These firms and their trading partners must deploy new business models, redesign the entire set of business processes including interaction with customers, order taking, coordination in fulfillment and delivery, and quality control. Every aspect of the business other than the actual physical production and delivery must be digitized. Even the product itself may be digitized whenever possible, as witnessed in the online music and entertainment industry.

In addition, organizations need to form new alliances and partnerships to facilitate this move towards digitization. This may suggest outsourcing the delivery to other partners and concentrating on digitally controlling and coordinating the fulfillment and delivery processes. A good example may be the business model of Cisco Systems, even though Cisco cannot be classified as a dot com company. Since 1995, Cisco has reengineered its business process using Web technologies. It books over 90 percent of its orders over the Internet and operates 80% of its customer service through the company's Web site. On the manufacturing side, the company outsources most of its production to other manufacturers. Half of the orders placed on its Web site are shipped to customers directly from contractors, while Cisco monitors the entire fulfillment process through the Internet. This type of digitization results in a revenue per employee figure that is 64% higher than the S&P 500 average (Reinhardt 1999).

1.8 CONCLUSIONS

Given that Internet related technologies and applications are equally available to all businesses today, IT alone cannot make a difference in the performance of the firm. The nature of the business, the ability to implement strategies and processes and manage relationships digitally across the value chain would be important determinants of how much IT can contribute to a firm's business performance. This study found that when considered as a group, dot coms did not benefit from their IT investments, even though such investments constituted a significant percentage of their revenues. However, when the dot coms were divided into digital and physical types based on whether they sell and actually handle physical goods, a significant difference in the impact of IT on dot com performance is observed. Contrary to the currently popular wisdom that all dot coms were unproductive businesses, at least in the early phases of electronic commerce, Internet based companies offering digital products enjoyed significant productivity from their IT investments. Unfortunately those offering physical products online did not benefit at all from IT,

The difference in IT impacts across the two groups is not attributable to different IT, since the new generation of electronic commerce oriented IT is easily available to all players. The source of higher IT contribution for digital dot coms may be explained by the nature of digital products. Digital products and services can be delivered digitally through the Internet at virtually zero cost. Further, once the content of a digital product has been developed, the marginal cost for making an additional copy or an automated modification of the product is basically zero.

Therefore, unlike an e-tailer, the seller of digital goods and services does not have to invest in physical resources such as warehouses to increase the scale of operation; instead, it can invest in more productive IT infrastructure and applications.

Future research in this area should include focus on traditional organizations that are undergoing the digitization metamorphosis. It will be important to study how the level of digitization of the business model enables a company to better exploit its IT investments.

For bricks-and-mortar firms, the existing technology infrastructure as well as business processes and channel relationships determine how rapidly and successfully they can switch to an electronic business mode. The relationship between IT investments and firm performance is unlikely to be a straightforward one due to the need to integrate electronic commerce applications and electronic business initiatives with existing systems, processes and strategies. It will be important and interesting to compare the contributions of IT to the performance of pure dot coms and traditional businesses that are also operating in an online environment.

Chapter 2 Electronic Business Transformation of the Traditional Firms

2.1 INTRODUCTION

Despite well-publicized anecdotal evidence that Internet-enabled transformation to electronic business has led to significant financial performance in a few large organizations, there is increasing pressure on managers to justify such major technology investments and to assess the value created through such initiatives. Such demand is not unreasonable given the recent evidence that firms involved in large information technology (IT) investments derived no benefits (McKinsey 2001; Nolan 1994; Strassman 1997). Managers often lack a holistic view of how IT investments and complementary factors (e.g., organizational processes, customer/supplier readiness) create new value. Research in business process reengineering (BPR), resource-based view (RBV), IT business value, and supply-chain management has addressed different aspects of this holistic view (e.g. Bharadwaj 2000; Henderson and Venkatraman 1993; Jarvenpaa and Leidner 1998; Venkatraman 1994) and emphasize the need for better theoretical models (e.g. Mooney et al. 1995; Sambamurthy et al. 1994; Soh and Markus 1995). Building on various research streams, this research proposes and empirically validates an electronic business transformation model that explicate how Internet-based IT investments in the presence of complementary organizational changes create value for firms.

Research linking IT investments and firm performance is extensive and diverse. Studies aimed at understanding the effect of IT at the macro level addresses the issue whether IT investments have lead to better productivity using the production function method (Brynjolfsson and Hitt 1996a; Hitt and Brynjolfsson 1996; Lee and Barua 1999; Lichtenberg 1995; Loveman 1994). While such a macro-level analysis is critical, the production function method does not explain why some firms can better utilize IT than other firms. That is, the managerially relevant question of "How can I better use IT" is not addressed by this method.

In contrast, process-oriented approaches explain the process through which IT investments lead to operational and financial performance (e.g. Barua et al. 1995; Kauffman and Kriebel 1988a; Kauffman and Kriebel 1988b). This research stream specifies multi-stage models where IT investments influence intermediate performance measures critical to a firm's success, which in turn relates to higher levels of performance measures such as revenues, return on assets, and market share. These IT business value models have been refined and extended by various researchers (Davamanirajan et al. 1999; Mukhopadhyay et al. 1997; Ragowsky et al. 2000).

The above economics-oriented research focuses only on IT to create business value with an implicit assumption that IT will have the same impact on all organizations irrespective of organizational dynamics such as processes, and relationships with customers and suppliers. The BPR literature (e.g. Davenport 1993; Hammer and Champy 1993) has argued the need for better processes that

take into consideration the organizational culture and incentives when adopting IT (e.g., enterprise resource planning – ERP systems). Organization researchers have studied IT and its relationship with organizational attributes such as readiness, structure and processes (e.g. Desanctis and Poole 1994; Orlikowski 1992; Orlikowski and Robey 1991). Organizational readiness is shown to be a key determinant of successful adoption of IT (e.g., EDI) (e.g. Iacovou et al. 1995; Swatman and Swatman 1992) where readiness is the needed expertise, support, and understanding of IT, and the financial resources.

The RBV literature argues that firm's performance is linked to organizational resources and capabilities that are valuable, rare, difficult-to-imitate and non-substitutable (Barney 1991; Conner 1991; Penrose 1958). Building on this school of thought, IS researchers have argued IT capabilities (e.g., IT infrastructure, human IT resources, IT flexibility, customer orientation of IT) as a distinct source of advantage that links IT investments to a firm's performance (e.g. Bharadwaj 2000; Jarvenpaa and Leidner 1998; Mata et al. 1995).

From the perspective of economic theory, the incorporation of organization processes and readiness into the study of business value of IT can be justified using the theory of complementarities (Milgrom and Roberts 1990). The notion of complementarities reflect the idea that increasing one input will increase the marginal benefit of increasing its complementary inputs. Milgrom and Roberts (1990) studied the notion of complementarities in the transformation of mass production to modern manufacturing (i.e., flexible manufacturing) enabled by

advanced technology. They argue that to maximize benefits, a firm must make coordinated changes involving all decision variables in marketing, manufacturing, engineering, design and organizational structure. Therefore, it is not mere coincidence that various changes in a whole range of the firm's activities are taking place together, but a necessary result driven by the interconnection between various activities across the firm. Barua, Lee, and Whinston (1996) applied complementarity theory to the field of BPR. They argued that IT is complementary with organizational characteristics and processes, and that investment in IT and reengineering cannot succeed if done in isolation.

Given the above stream of research it is imperative to consider Internet-related IT investments along with a complementary set of investments in organizational processes and readiness. The internal IT infrastructure and those facing customers and suppliers must be aligned with organizational processes to create a synergy and to exploit emerging opportunities rapidly. Such synergy can occur only when the organization and trading partners have necessary readiness in terms of IT acceptance, resources and sophistication. Thus, this research takes a view that in order to maximize organizational payoff, complementary decision variables such as IT, processes, and readiness must all be changed in a coordinated manner in the right direction by the right magnitude. Each of the decision variables must be focused internally and externally (i.e., customer and supplier focused). However, this research does not intend to test the nature or extent of complementary relationship among technology and various

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organizational structures and processes, but to demonstrate the necessity of coordinated changes.

This chapter proposes and tests an exploratory model of electronic business transformation, which can ultimately be a reference framework for business strategies. This chapter proposes a holistic, process-oriented, theoretical model to link IT investments and complementary factors to firm performance. The study empirically validates the business value model highlighting linkages between electronic business decision variables and performance measures. The model elucidates interesting relationships between firm performance and supplier and customer-side performance measures, and between internal system integration and supplier and customer orientation of IT applications. The constructs developed in this model can serve as a foundation for future investigation of different facets of electronic business impacts.

The balance of this chapter is organized as follows. The next section describes the research model, provides theoretical justification and enumerates hypotheses. Section 2.3 discusses the details of operationalization of the constructs, survey instrument, and data collection. This is followed by data analysis, discussion of the results, limitations, and concluding comments.

2.2 RESEARCH MODEL

The theoretical model for Internet-enabled (electronic) business transformation and value assessment is shown in Figure 2. 1. The model suggests that Internet enabled business performance is ultimately judged by often-used traditional financial performance measures such as revenue per employee, gross

profit margin, return on assets and return on invested capital. Further it is posited that the improved financial performance is a result of improved digitization levels in interactions with customers and suppliers. This digitization is the extent to which activities across the entire value chain (e.g., information sharing with customers, suppliers and internal units) are conducted electronically. As discussed below, the levels of digitization of a firm's interaction with its customers and suppliers are crucial in enabling efficient operations, and are conceptually similar to *critical success factors* (Rockart 1979) or *beneficial strategic necessities* (Clemons and Kimbrough 1987). The strength of the relationship between digitization levels and financial performance may depend on factors such as industry outlook, firm size, firm history, channel conflict, competitive response, and general economic conditions that are beyond the scope of this study. Note that these exogenous variables have a moderating impact on the relationship between digitization level and financial performance measures, but not on the antecedents of digitization levels as a firm is likely to have control on the antecedents. The model specifies that the supplier-side and customer-side digitization levels depend on the readiness, processes, and IT applications focused on suppliers and customers, respectively. However, the extent of supplier and customer facing IT application depends on the extent of organizational (internal) systems integration. The theoretical considerations for each construct are given below.

2.2.1 Financial Performance

Measuring Internet-enabled business initiatives have been much debated in the business press. Practitioners have developed new performance metrics

based on web site usage. However, such metrics must translate into financial performance to understand the true implications. Research in measuring IS success have used diverse metrics. DeLone and McLean (1992) in their literature survey on IS success identify six categories of IS success: system quality, information quality, use, user satisfaction, individual impact and organizational impact. They argue that these categories are interrelated and interdependent, leading to an IS success model "*which recognizes success as a process construct which must include both temporal and causal influences in determining IS success.*" In this IS success model, organizational impact, which mainly involves the effect of IS on financial performance, is considered to be the definitive category of IS success. Information technology productivity and business value literature (e.g. Barua et al. 1995; Bharadwaj 2000; Hitt and Brynjolfsson 1996; Strassman 1990; Weill 1992) have widely used return on assets, profit margin, return on invested capital and other related metrics to measure firm performance. Consistent with the above research, the proposed model assumes that the conclusive evidence of the success of Internet-enabled business initiatives will involve improvements in various financial measures.

2.2.2 Digitization Level

The digitization level related to customer and supplier relationships refers to the effect of Internet-enabled business initiatives on the level of electronic activities in the day-to-day operations of the firm. That is, it reflects the extent to which various activities in the extended value chain of a firm that includes its customers and suppliers are conducted electronically. The digitization levels refer

to measures unique to electronic transformation such as online sales, online customer service, and online procurement. The levels of customer and supplier-side digitization have direct impacts on the firm's financial performance, which can be justified from the transaction cost economics framework (Williamson 1989), the value chain framework (Lee et al. 1997b; Porter 1985; Porter and Millar 1985), the Schumpeterian theory of innovation (Schumpeter 1942), and the resource-based view of the firm (e.g. Barney 1991).

Increased digitization levels across the value chain activities including those with customers and suppliers improve coordination, lower search costs, reduce information asymmetry, and improve operational efficiency (e.g., reduce delays, and improve quality). Digitization implies better use of IS that impacts information quality and usage (DeLone and McLean 1992; Garrity and Sanders 1998). Past literature on successful adoption of IT such as EDI has demonstrated that firms improve data quality (i.e., reduce errors), lower administrative costs, reduce communication delays, and support transformative business practices such as just-in-time inventory, continuous replenishment, and quick response (Barua and Lee 1997a; Chwelos et al. 2001; Mukhopadhyay 1993; Mukhopadhyay et al. 1995; Premkumar and Ramamurthy 1995; Saunders and Clark 1992; Wang and Seidmann 1995). Further, the research conducted by (Mukhopadhyay 1993; Mukhopadhyay et al. 1995; Wang and Seidmann 1995) has demonstrated the relationship between EDI adoption and financial benefits. The digitization of the value chain not only boosts the efficiency of the current operation and financial performance, but also triggers innovation in products and services, production

processes, distribution channels and market reach. Milgrom and Roberts (1990) argued in a similar context on how transformation of mass production to flexible manufacturing leads to a series of changes in complementary organizational activities.

Customer-side digitization such as increased online revenue may lead to a smaller sales force, less paperwork, fewer data errors, and improved operational efficiencies relative to traditional channels. Online sales also shift the responsibility of product information search, order entry and tracking to the customer, while delivering speedy and cost-efficient informational, transactional and service needs of the customers (Johnston and Vitale 1988). Further, an online presence allows a firm to expand its markets by reaching out to new customer base or segment without geographical and time barriers (Evans and Wurster 1997).

On the supplier side, online procurement has been argued to be more efficient than the traditional procurement processes by reducing stock-out situations, smaller lead times, fewer order fulfillment errors, and higher inventory turnover rates. This bears some resemblance to the EDI adoption discussed earlier, that has been shown to reduce cycle times and costs by improving speed, quality and business value (Massetti and Zmud 1996; Mukhopadhyay et al. 1995). In addition, researchers have argued that increased use of IT in procurement can lower coordination cost without increasing the associated transaction risks, leading to more outsourcing and less vertical integration (Clemons et al. 1993; Malone et al. 1987). The web-based supply chain management applications

provide a way for firms to exchange rich and real-time information about demand forecast, quality and inventory, which innovates the way of organizing the entire production process. All these innovations form the major driving force of economic development in Schumpeter's model of "creative destruction"(Schumpeter 1942), which also supports the positive relationship between the levels of digitization and the improvement in financial performance. Hence:

H2.1: The higher the level of customer-side digitization, the higher the financial performance attributable to electronic business.

H2.2: The higher the level of supplier-side digitization, the higher the financial performance attributable to electronic business.

While the IT business value literature implicitly assumes that intermediate measures are not related to each other, the model here posits that supplier-side digitization is a prerequisite for improved customer related digitization. The argument is that a firm can provide with relative ease customization capabilities through an online interface. However, customization of products requires a firm to have the necessary infrastructure to be able to procure items on demand from suppliers, and to have better relationships with suppliers to communicate order, and seek inventory status and quality information. In the absence of a strong supplier digitization a firm risks not meeting delivery schedules, and affecting customer satisfaction, which in the long run will affect a firm's ability to increase online sales. In the absence of supplier-side digitization, the firm risks holding excess inventory or incur high costs to satisfy diverse demand that will affect its

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financial performance. Some of this phenomenon was observable in many online retailers, who developed sophisticated customer facing applications and cultivated valuable online customer relationships, but failed to integrate customer systems and processes with the supplier side of the value chain (Barua et al. 2000a). Hence,

H2.3: The higher the level of supplier-side digitization, the higher the level of customer-side digitization.

2.2.3 Electronic Business Enablers

IT investments in isolation without a consideration of other organizational dynamics (e.g., business processes, incentives, customer orientation, and organizational design) do not yield desired performance impacts (Barua et al. 1996; Bharadwaj 2000; Bresnahan et al. 2002; Brynjolfsson et al. 1997; Davenport 1993; El Sawy et al. 1999; Henderson and Venkatraman 1999; Mata et al. 1995; Venkatraman 1994). The proponents of the resource-based view (RBV) of IT impacts also argue that firm-specific competencies and resources (e.g., intangibles such as organizational knowledge, customer orientation) that are difficult to replicate determine how firms leverage IT for sustained advantages (Bharadwaj 2000; Clemons and Row 1991; Jarvenpaa and Leidner 1998; Mata et al. 1995).

Given a set of organizational competencies, the current model argues that all firms must commit certain resources and make complementary changes with sustained efforts in certain areas in its transition to Internet-based electronic business. These complementary changes are the decision variables that are

termed "enablers." Based on the past literature in diverse areas of research, this study identifies three distinct but complementary changes critical for transformation to electronic business: business processes, IT applications and the readiness of partners to engage in electronic business. These three areas are consistent with the technology-organization-environment paradigm that has been used to study the adoption of IT (Chau and Tam 1997; Iacovou et al. 1995; Kuan and Chau 2001). The enablers in these three areas can also be thought of as a set of business strategies focused on suppliers, internal operations and customers and corresponding IT strategies (Henderson and Venkatraman 1999; Konsynski 1993; Palmer and Markus 2000; Reich and Benbasat 1996). That is, these enablers are a result of the strategic alignment between IT strategy and corporate strategy to maximize business value that has been long proposed in management and MIS literature (Prahalad and Hamel 1990; Venkatraman 1989b).

2.2.3.1 Customer-oriented IT applications

Customer-oriented IT applications refer to customer-related informational and transactional capabilities of a firm that results from the adoption of the Internet and related technologies. Customer orientation of a firm, in general, has a positive impact on firm's performance (e.g. Jaworski and Kohli 1993). Bharadwaj (2000) notes that IT is an *indispensable factor* in achieving a high level of customer orientation. Internet technologies allow wider reach and richer interactions with customers (Evans and Wurster 1997), which were severely limited in the past due to more expensive, limited functionality, and proprietary technologies. Customers can now search/seek product information on demand,

customize products, and manage orders online (Johnston and Vitale 1988). Such capabilities are widely cited as some of the reasons for improved performance of successful Internet enabled businesses. The extent to which a firm provides each of these capabilities online has an impact on customer-side level of digitization. When such capabilities are limited, customers may incur substantial costs searching for the right information online and then resort to traditional methods of expensive face-to-face or telephone interactions that add substantial costs to the firm, while possibly diminishing customer satisfaction.

H2.4: The higher the level of customer-oriented IT applications, the higher the level of customer-side digitization.

2.2.3.2 Supplier-oriented IT applications

Supplier-oriented IT applications involve a firm's capability to enhance supplier relationships with transactional and on-demand information sharing (e.g., quality, supply continuity, and relationship management) capabilities through the Internet technologies. The adoption and benefits of supplier-oriented IT applications include those studied in inter-organizational information systems such as EDI (e.g. Barua and Lee 1997a; Clark and Stoddard 1996; Drury and Farhoomand 1996; Hart and Saunders 1998; Iacovou et al. 1995; Massetti and Zmud 1996; Mukhopadhyay et al. 1995; Premkumar and Ramamurthy 1995; Riggins and Mukhopadhyay 1994; Srinivasan et al. 1994; Zaheer and Venkatraman 1994). However, Internet-based supplier-orientation entails higher levels of coordination and collaboration that potentially has higher benefits relative to EDI, which has limitations on the types of information exchanged

(Johnston and Mak 2000; Mishra et al. 2001; Senn 1998; Threlkel and Kavan 1999). Internet-based systems let firms share strategic and tactical information including product roadmaps, demand forecast, product availability, quality, innovation, and real-time monitoring and feedback (e.g., line rejection rates, cost curves). However, sharing of strategic information with supplier requires appropriate processes and incentive compatible incentives as discussed in the supplier-related processes construct.

The supply chain management literature has often discussed the role of information sharing to reduce inefficiencies in the extended value chain (e.g. Lee and Billington 1992; Lee et al. 1997b; Lovejoy 1990; Lovejoy 1995; Milgrom and Roberts 1988) using the concept of information substituting inventory and bullwhip effect. The uncertainty with product demand, quality, delivery, and availability often leads firms to hold inventory. However, when firms along the extended value chain share strategic information, such uncertainty is reduced, resulting in lower inventory holding, and reduced amplification (distortion) of demand information along the value chain referred to as bullwhip effect (Lee et al. 1997b). In general, the supply chain management literature identifies three types of information to be shared to reduce inefficiencies: quality, resource planning/availability (e.g., product roadmap, demand forecast), and supplier relationship management (e.g., contact information, FAQ).

Quality related information from suppliers involves manufacturing process related data such as defect and yield rates that allow buyers to monitor quality at the source in real time. Buyers provide information about field incidences,

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customer feedback and wrong and defective parts to suppliers that help the latter make continuous improvements and incorporate quality changes. Buyers also provide engineering change orders on a real time basis to help suppliers make modifications to their products dynamically.

Some supply chain management applications help buyers and suppliers maintain the availability of materials in the right quantity, at the right place and at the right time (Konsynski and McFarlan 1990). Through these applications buyers provide demand forecasts based on region and item. This information is highly sensitive, and requires significant trust between buyers and suppliers (Hart and Saunders 1997; Zaheer and Venkatraman 1994). The extent of trust may decide the level of precision (i.e., aggregated versus detailed data) of the information exchanged. The level of precision also depends on buyer's design input, component criticality, number of suppliers in the market, and the relationship of the suppliers with competitors (Mishra et al. 2001). Suppliers provide information on the inventory levels, work-in-progress, machine constraints, if any, and lead-time. This information allows buyers to maintain the continuity of its operations.

Some IT applications are oriented towards information exchange related to relationship management that helps buyers build and maintain a closer relationship with suppliers (Bensaou 1997). These capabilities enable both buyer and its suppliers to share event calendars, contacts, FAQs and glossary of terms. Buyers provide each supplier a feedback on its performance on a regular basis (e.g., weekly, monthly or quarterly). The discussion forums provided by buyers allow suppliers to pose questions and receive answers from buyers or from other

suppliers. Such communication and collaboration channels develop a sense of community among the buyers and the suppliers. Hence,

H2.5: The higher the level of supplier-oriented IT applications, the higher the level of supplier-side digitization.

2.2.3.3 Internal System integration

System integration refers to the extent to which a firm integrates various existing IT systems and applications within the organization that allow all internal agents share information seamlessly and provides visibility to customer or supplier data. Silos of diverse applications within an organization restrict its customer orientation (e.g., online customization, order management), supplier orientation, and internal decision-making. There is evidence in the literature that non-integrated systems affect traditional performance metrics, such as cycle time, and customer service time (Lee and Billington 1992). Systems integration enables firms to react, innovate, and make continuous improvements by identifying and sharing information across products/services/business units that enhance organizational knowledge and readiness (Hammer and Champy 1993).

Successful Internet enabled business in a traditional organization necessitates the seamless flow and sharing of order and customer information throughout the value chain across all channels of operation. Home Depot, a $38 billion home improvement retailer, is an excellent example of an organization that has approached this problem methodically by ensuring a complete integration between its online and back office capabilities (Whiting 2000). By contrast, Toys 'R Us experienced major difficulties during the holiday season of 1999 because

their internal systems could not keep track of many orders coming through their Web site.

An organization with high level of systems integration across different channels of operation must be able to transmit, combine and process data from customers and suppliers/vendors. Its external and internal systems must be able to monitor order status at various stages in the process (e.g., manufacturing, shipment) and automatically reflect order changes in downstream processes or systems (e.g., inventory and manufacturing systems). Further, it should be easy to share data among various internal systems (e.g., forecasting, production, shipment, accounting, etc.) and to retrieve information from various databases for decision support (e.g., cost information, reporting tools) (Sikora and Shaw 1998). Hence,

H2.6: The higher the level of systems integration within a firm, the higher the level of customer-oriented IT applications.

H2.7: The higher the level of systems integration within a firm, the higher the level of supplier-oriented IT applications.

2.2.3.4 Customer and supplier related processes

These two constructs refer to the level of alignment between the Internet enabled IT capability and corresponding business operation routines, which results from the redesign of supplier and customer related business processes. The conceptualization of alignment or "fit" here follows the "fit as profile deviation" model (Venkatraman 1989a). The use of Internet and related technology for customer and supplier interaction requires the firm to have a certain profile of

business processes. The fit is defined as the "degree of adherence to [this] profile," and this level of adherence will be positively related to certain performance measure (Venkatraman 1989a, p. 433).

The relationship between technology implementation and business process redesign has long been recognized (Hammer and Champy 1993). For example, prior research on EDI adoption has shown that the potential of EDI to improve the performance of the adopter can only be fully realized by combining changes in business processes (Clark and Stoddard 1996; Riggins and Mukhopadhyay 1994). Venkatraman (1994) also argued that firms would not be able to fully reap the benefits from IT capabilities if they are only overlaid on current business processes.

Online transaction and relationship with suppliers can reduce the level of uncertainty and enable firms to react quickly to environmental changes (e.g., demand changes), innovation and competition. However, the realization of the perceived benefits depends on aligning supplier processes and incentives to enable suppliers to participate in online relationships and to share information. Firms must put in place a clear supplier selection strategy that provides incentives to the right suppliers to participate in online information sharing (Bakos and Brynjolfsson 1993; Srinivasan et al. 1994). Firms also need processes that reduce approval steps, paper work, and exception handling for all purchasing decisions. Furthermore, firms have to redefine processes that will consolidate fragmented ordering within the organization to allow negotiation of better overall prices.

H2.8: Better supplier processes lead to higher levels of supplier-side digitization.

In order to use the Internet for better customer relationship and service, firms must re-evaluate their customer processes (El Sawy and Bowles 1997). Customers in need of service should be able to contact online and communicate their needs effectively through a single point of contact. Further, once a customer service is received, ideally, there should be no "coordination gaps" (Rathnam et al. 1995), which is caused by the lack of fit between customer support processes and the attributes of IT used. Therefore, customer processes must be designed such that the use of IT fits the task.

H2.9: Better customer processes lead to higher levels of customer-side digitization.

2.2.3.5 Customer and supplier electronic business readiness

Readiness refers to the extent to which firm's trading partners are willing and capable to do business online with the firm. The proverbial saying "the whole is worth more than the sum of its parts" is relevant in the context of electronic business. The success of the Internet initiatives of a firm depends not only on its own efforts to digitize its value chain, but also on the readiness of its customers, suppliers and trading partners to engage in electronic interactions and transactions. Organizational (internal) readiness has been shown to inhibit IT adoption in organizations where readiness is defined as the availability of needed organizational resources (Crook and Kumar 1998; Grover 1993; Iacovou et al. 1995; Premkumar and Ramamurthy 1995; Premkumar et al. 1994; Saunders and

Clark 1992; Swatman and Swatman 1992). However, this study is concerned with the readiness of customers and suppliers, since the success of a firm's Internet initiatives is likely to be influenced by its partners' ability to conduct business electronically (Chwelos et al. 2001; Crook and Kumar 1998; Hart and Saunders 1997). In the context of Internet enabled electronic business, the readiness across the entire value chain must be achieved so that information can flow freely not only within but also across organizational boundaries. If any player in the value chain is not ready or willing to participate in the electronic information exchange and business transaction, they are very likely to become the bottleneck that render the electronic business initiatives of other players less valuable. While it is intuitive to think of this readiness as something external to an organization, it is best considered as an enabler that requires a proactive commitment of resources. Firms can design certain incentive mechanism such as subsidy or guaranteed business to encourage their business partners to get connected with them. Firms can also invest in resources to help increase the capability of their partners to do business electronically, such as providing training (Riggins et al. 1994; Wang and Seidmann 1995).

External links can easily become the weakest link in a value chain. Consider Amazon.com, which uses Internet based technologies heavily in all its operations from customer interaction to warehouse management. Unfortunately, the cost for most of the publishers to create an infrastructure to manufacture any number of books the same day Amazon.com receives the order, and drop ship them that very night is too high. This lack of Internet enabled business readiness

coupled with the need to deliver books to customers as soon as possible have forced Amazon to build its own warehouses and distribution capability (Barua et al. 2000a).

H2.10: The higher the electronic business readiness of customers, the higher the level of customer-side digitization.

H2.11: The higher the electronic business readiness of suppliers, the higher the level of supplier-side digitization.

2.3 RESEARCH METHOD

2.3.1 Operationalization of constructs

2.3.1.1 Financial performance

Four financial performance measures are selected: percentage increase in (1) revenue per employee (ROE), (2) gross profit margin (GPM), (3) return on assets (ROA), and (4) return on invested capital (ROIC) that are attributable to electronic business initiatives. There is evidence that firms have begun to monitor and track some of these measures through internal cost-benefit analyses and activity-based costing (Moozakis 2000; Slater 1997).

While ROA and ROIC have been extensively used in previous IT productivity and business value literature (e.g. Barua et al. 1995; Hitt and Brynjolfsson 1996; Strassman 1990; Weill 1992), the first two are also critical to understand the impact of Internet enabled business. In fact, Francalanci and Galal (1998) used "premium income per employee", which is analogous to sales per employee in the current context, as one of the indicators of productivity in their research on the life insurance industry. The metamorphosis to electronic business

will lead to an increase in revenue per employee, since firms may be able to acquire new business online without increasing personnel, or deliver cost-efficient service with fewer employees using online informational and transactional capabilities. Similarly, the cost efficiency throughout the value chain will lead to increase in gross profit margin as well.

2.3.1.2 Digitization level

Electronic business enablers have first-order impact on the day-to-day operational performance measures of a firm. This study considers six performance measures of electronic business operation – the percentage of (1) total business transacted online, (2) existing customers conducting business online, (3) new customers acquired online, (4) customer service provided online, (5) Maintenance Repair and Operations (MRO) items purchased online, and (6) production goods procured online. The first four metrics are used to measure the level of customer-side digitization, while the last two are used to measure the level of supplier-side digitization. These measures are developed for the specific context of Internet enabled business. Although it is natural to think of the traditional operational measures such as inventory turnover, and capacity utilization, it is arguably more desirable to focus on the external linkage in the current context where the Internet and related technologies are likely to improve the coordination and communication between firm and its value chain partners.

2.3.1.3 Electronic business enablers

All enabler constructs are measured by items based on a seven-point Likert scale ranging from 1 ("strongly disagree") to 7 ("strongly agree").

Customer-oriented IT applications construct is operationalized by six items related to the capability of providing product information, product customization, web site personalization, service, and order management online (Feeny and Willcocks 1998; Konsynski 1993; Konsynski and McFarlan 1990; Zaheer and Venkatraman 1994). Three constructs, each of which is measured by three corresponding items, are developed to measure the capabilities of exchanging information related to quality, resource availability and relationship management with suppliers. These items have been generated based on extensive discussion with managers in Fortune 50 firms, and operations management literature (Lee and Billington 1992; Lee et al. 1997b; Lovejoy 1995). These three constructs are combined into a second-order construct to measure the overall level of supplier-oriented IT applications.[3] Systems integration is measured by five items mainly focusing on the ease of sharing information across different systems (Hasselbring 2000). The supplier process construct includes five items about whether firms have well-defined procedures, metrics, and methods to guide its online procurement activities (Lee and Billington 1992). The customer process construct consists of questions related to customer interactions, conflict resolution, and customer feedback. The two readiness constructs are operationalized by measuring the beliefs and motivations of customers and suppliers toward the Internet enabled business (Chwelos et al. 2001; Iacovou et al. 1995; Parasuraman 2000).

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[3] The author thanks the SE of MIS Quarterly for suggesting this second-order construct to reduce the complexity of the model.

2.3.2 Instrument design and refinement

The initial structured questionnaire was generated based on existing academic and practitioner-oriented literature as well as interviews with managers involved in electronic business transformation in several large companies. Many of the constructs included in the study are specific to the Internet, and have no precedence in the business value literature. The initial questionnaire was pre-tested by multiple faculty members, doctoral students, and managers in a large manufacturing organization that has successfully adopted electronic business practices. Each item was reviewed for its content, scope and purpose (content validity). A seven-point Likert scale was used to collect most responses, while some questions involved absolute numbers, percentages or binary variables. The final questionnaire consisted of thirty nine items for ten constructs, thirteen operational performance measures related to customers and suppliers[4], four financial performance measures, eight items related to transactional capabilities[5], and ten questions pertaining to industry sector, number of employees, estimated revenue, type of Internet business related software used, and the number of months and years since the inception of Internet initiatives.

2.3.3 Data collection

The sample consists of only those firms who had a corporate Web site, and who also used traditional channels of business (i.e., accept orders through sales force, phone, fax and mail). The selected firms must not be pure "dot coms", since

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[4] Not all these measures are used in the final model, though.
[5] These are yes/no questions and are not used in the final structural model.

the focus of the study is the value of electronic business transformation. Further, the sample consists of a mix of small, medium and large organizations to reflect their mix in the economy.

Given the difficulties in collecting data of this complexity, the data collection is conducted by a professional research organization that has extensive expertise and contacts to collect data from multiple managers within a company. A number of conditions are stipulated on this agency to induce transparency in data collection. Firms were selected from a universe of Web sites (compiled by a combination of searches using specialized bots, specific Internet searches, and InterNIC information). Any specific requirements to include in the data sample were handled in a telephone-based screening. After the firms were screened for a number of days, service firms were eliminated, and only manufacturers, retailers, distributors and wholesalers were retained. Over 4500 respondents were contacted via telephone contacts. Of those, approximately 25% were chosen and agreed to participate in the survey. The respondents were given a choice to complete the survey over the phone or on a special Web site containing the questionnaire.

To minimize potential biases, the respondents were told that their responses and identity would remain confidential, and that only aggregate information would be published. Respondents were allowed to specify ranges of values for operational and financial performance if they could not provide point estimates. Further, a "don't know" response category was added to each question in order to minimize the risk of obtaining inaccurate responses from participants

who may not know the answers to certain questions. This would enable a respondent to avoid feeling pressured to respond to a question that they did not feel confident about. For instance, in a binary question (yes/no) involving improvements in financial performance through electronic business initiatives, many respondents responded in the affirmative, but chose the "don't know" response when asked to provide percentage gains in specific financial measures. Given the large scale of the study, and the anecdotal evidence that firms are increasingly focusing on cost-benefit analyses of their e-business initiatives (Moozakis 2000), these "don't know" responses were not expected to pose major problems in terms of sample size.

The titles of the individuals who completed the questionnaire differed widely across firms. In smaller companies (e.g., those with annual revenues less than $10 million), owners and principals were able to answer for an entire organization. In larger companies, the information was dispersed throughout the organization. Many of the questions were oriented towards an IT or systems respondent, while others were financial in nature. Multiple individuals were contacted inside each company over many separate calls. In a number of instances, the interview began with one individual, and if that person was unable to answer some of the questions, s/he was then asked for a referral for someone else inside the organization. Typically, over one hour was required to identify appropriate respondents inside qualified organizations.

Telephone surveys were monitored for data quality and several steps were taken to minimize any possible transcription errors. The data collection agency

had validation screens programmed into the interviewing software to verify revenue and other figures that may be publicly available (e.g., number of employees, industry type). After the data collection was complete, all responses were checked for validity and compared to industry norms and third party sources, where available. When specific responses raised questions that could not be verified though external sources, the respondents were re-contacted. If the re-contact attempt was unsuccessful, the case was deleted from further analysis. At the end of the data collection process, 1026 data points were retained. Some information about the size and industry of the sample is contained in .

After receiving the raw data from the agency, a separate group of researchers completed an independent and extensive cross-validation of responses, and analyzed over 250 Web sites for assessing the accuracy of stated informational and transactional capabilities. Also analyzed are all publicly traded companies in the sample for which data were available online to verify Web site content, transactional features, revenue figures, number of employees, and any published information about their capabilities from many different sites like www.hoover.com, www.yahoo.com, www.techweb.com, www.informationweek.com, and www.barrons.com. It was found that the replies from respondents to be reliable and consistent with the independent investigation. Random "sanity checks" are also conducted on the data. For example, it is highly unlikely that a firm that had a large increase in revenue per employee to have no increase in gross profit margin or other financial measures. No systematic evidence of such cases was found.

The key limitation of the data is the self-reported nature of the dependent variables. While the empirical literature in MIS has often relied on self-reported performance data, it is certainly desirable to have independent assessment of performance. It should be noted that IT business value research has relied on secondary data from sources such as IDG/ComputerWorld, InformationWeek, Management Productivity and Information Technology (MPIT) database from Strategic Planning Institute, and Fortune Magazine. As in the present study, these data sets were also collected through surveys, and are therefore subject to similar shortcomings that may affect the data. The belief is that the theoretically rigorous survey instruments design followed by checks and balances imposed during and after the data collection add to the confidence that can be placed in the quality of the data set.

Table 2. 2 describes the number of items in each enabler construct, digitization level, and financial measure, and the reliability as measured by Cronbach's alpha.

2.4 DATA ANALYSIS

2.4.1 The Measurement Model

The model investigated in this study consisted of 13 latent variables corresponding to the ten electronic business enablers, two digitization level constructs, and one financial performance construct. Each of the 13 latent variables was measured by at least two indicator variables. Exploratory factor analysis (EFA) was first conducted to check the proposed factor structures are

indeed consistent with the actual data. The factor structures suggested by the EFA are exactly the same as the one proposed in the research model.

Next, confirmatory factor analysis (CFA) was conducted to check the reliability and validity of the measurement model. In this measurement model, no unidirectional path is specified between any latent variables. Instead, a covariance is estimated to connect each latent variable with every other latent variable. This measurement model was estimated using AMOS 4.0.

2.4.1.1 Reliability

Reliability of a model refers to its ability to provide essentially the same set of measurement scores for a group of variables being measured by this model. The model is tested for the measurement model in the following ways:

Scale reliability: Coefficient alpha reliability estimates (Cronbach 1951) all exceed 0.70. This is the most widely used test for scale reliability based on internal consistency.

Indicator reliability: The reliability of an indicator variable, defined as the square of the standardized factor loadings, reflects the percent of variation in the indicator that is explained by the construct it is supposed to measure (Long 1983). The indicator reliabilities in this model vary from a low of .257 to a high of .966. It is necessary to assess the composite reliability of those constructs measured by indicators with relatively low reliability.

Composite reliability: When performing confirmatory factor analysis, it is possible to compute a composite reliability index for each latent factor included in the model. This index is analogous to the coefficient alpha, and reflects the

internal consistency of the indicators measuring a given factor and has been frequently used by MIS researchers to test model reliability (Raghunathan et al. 1999; Smith et al. 1996; Thong et al. 1996b; Vandenbosch and Higgins 1996; Wright et al. 1998 among others). The composite reliability index is calculated for all thirteen constructs following the formula given by Fornell and Larcker (1981). All latent constructs demonstrate composite reliability index higher than 0.60, and only one lower than 0.70 (with a very close value of .692), which is the preferred acceptable level.

Variance extracted estimate: This is a measure of the amount of variance captured by a construct, relative to the variance due to random measurement error (Fornell and Larcker 1981). Eleven of the thirteen constructs demonstrate variance extracted estimate in excess of 0.50. However, this test is quite conservative in that variance extracted estimates are very often below 0.50, even when reliabilities are acceptable. Therefore, it is not used as often as composite reliability to test the model reliability (Keil et al. 2000; Thong et al. 1996b; Vandenbosch and Higgins 1996; Wright et al. 1998 among others). However, it has been frequently used to test the discriminant validity of the model, which is discussed later in this section. Overall, the thirteen constructs and their indicators in the model perform fairly well in terms of reliability.

2.4.1.2 Validity

Validity shows the extent to which the instruments in a model measure and only measure what they are supposed to measure. The convergent validity shows whether the scores from different instruments that are used to measure the

same construct are strongly correlated to each other. On the other hand, discriminant validity shows whether the correlation between instruments that are used to measure different constructs are low.

Convergent validity: Convergent validity is assessed by reviewing the *t* tests for the factor loadings (Thong et al. 1996b). The *t* values for all indicators range from 13.755 to 35.284, all significant at level p < .001. This provides evidence supporting the convergent validity of the indicators (Anderson and Gerbing 1988).

Discriminant validity: One of the common ways to test discriminant validity is the chi-square difference test (e.g. Agarwal and Prasa 1998; Raghunathan et al. 1999; Segars and Grover 1998). It involves fixing the correlation of each pair of latent variables one at a time and estimating the constrained measurement model. If the chi-square value is significantly different from the one of the unconstrained measurement models, the discriminant validity is supported for that pair of latent constructs. However, this test suffers from the problem that when there is a relatively large number of constructs, the number of tests of all possible pairs of latent constructs goes up quickly, reducing the overall significance of the group of tests to an unacceptably low level, even if the significance level of each individual test is as low as .01 (Anderson and Gerbing 1988; Finn 1974)[6]. Since there are thirteen latent constructs in this model, the chi-square difference test is not used.

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[6] The significance level $\hat{\alpha}$ of a group of *n* tests each with significance level of α can be calculated by $\hat{\alpha} = 1 - (1 - \alpha)^n$. In current model, $\hat{\alpha} = 1 - (1 - .01)^{78} = .54$.

Another common used test for discriminant validity involves comparing the variance extracted (VE) of each latent construct to the square of correlations between this construct and every other construct. If the former number is greater, the discriminant validity is supported (e.g. Segars and Grover 1998; Thong et al. 1996b; Vandenbosch and Higgins 1996). The result of this test for the measurement model is presented in Table 2. 3. The discriminant validity is supported for all latent constructs except the squared correlation between ITC and RDYC is slightly higher than VE of ITC but still less than VE of RDYC. Therefore, the discriminant validity is still supported for these two constructs.

Lastly, the confidence interval test is performed to test the discriminant validity of the model. For each pair of constructs a confidence interval is calculated using the estimated correlation plus and minus 2 times the standard errors (See Table 2. 4). None of these intervals included 1.0, which supports the discriminant validity of the model (Anderson and Gerbing 1988).

These above findings support the reliability and validity of the constructs and their indicators. The properties of the measurement model are summarized in Table 2. 5.

2.4.2 The Structural Model

The structural model tested in the present study is shown in Figure 2. 1. All enabler constructs except the two IT applications constructs are allowed to covary with each other. This model was estimated using AMOS 4.0. Various fit indices are as follows:

Chi-square / df	3.116
Tucker-Lewis index	0.974
Comparative fit index	0.977
Parsimony-adjusted NFI	0.860
RMSEA	0.045
RMSEA lower bound	0.043
RMSEA upper bound	0.047

In practice, chi-square statistic of a latent variable model is sensitive to sample size and departures from multivariate normality, and will very often result in the rejection of a well-fitting model (James et al. 1982). For this reason, in real-world applications, it is a common practice to seek a model with a relatively small chi-square value, i.e. a low chi-square/df ratio, rather than a model with an insignificant value (e.g. Agarwal and Prasa 1998; Raghunathan et al. 1999; Segars and Grover 1998; Wright et al. 1998). Various authors have suggested cut-off value as low as two or as high as five for a reasonable fit (Byrne 1989; Carmines and McIver 1981; Marsh and Hocevar 1985; Wheaton et al. 1977). For the current model, the ratio 3.116 is within the acceptable range. This should be supplemented by other model fit statistics to make the final assessment of the fit between the model and the data.

Several goodness of fit indices of the measurement model have been widely used in IS research and are presented above. The Tucker-Lewis index, also known as non-normed fit index (NNFI) (Bentler and Bonett 1980), and the comparative fit index (CFI) (Bentler 1990) are all very close to 1, suggesting an excellent fit between the structural model and the data. RMSEA is well below the suggested value 0.08 (Browne and Cudeck 1992). The parsimony-adjusted NFI

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(James et al. 1982) of the revised model is 0.846, which is significantly above the suggested value of .60 (Netemeyer et al. 1990; Williams and Hazer 1986), indicating highly acceptable levels of parsimony and fit of the overall model. All these fit indices are well acceptable, suggesting that the overall structural model provides a good fit of the data.

The results of the structural model are presented in Figure 2. 2. The squared multiple correlation (SMC) values, which are similar to R-square in regression analysis, show that this model accounts for 47% of the variance in customer-side digitization, 18% of the variance in supplier-side digitization, and 41% of the variance in the financial performance construct. Most of the paths are significant and positive, supporting the corresponding hypothesis. However, there are some exceptions. One is that the link between the supplier process and the corresponding digitization construct is insignificant. Another is that the direct link between supplier-side digitization and financial performance shows a small but significant and negative coefficient. These findings are discussed below. A summary of the hypothesis test results is provided in Table 2. 6.

2.5 DISCUSSION OF RESULTS

The structural analysis provides strong support for the relationship between the level of customer-side digitization and financial benefits from electronic business (Hypothesis 1). It suggests firms that are doing more business online, acquiring new customers online, bringing existing customers online and providing online customer service are experiencing positive financial impacts from such initiatives. Further, supplier-side digitization is found to have a strong

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positive influence on customer-side digitization. As suggested earlier, successful electronic interactions and transactions with customers cannot take place without building stronger relationships on the supplier side, and the above result underscores the importance of a holistic digitization of the entire value chain. This finding suggests that firms can expect higher levels of performance impacts as they complement their customer facing initiatives with online supply chain management. This can be partly justified by the coordinated changes of the various initiatives of Internet enable business (Barua et al. 1996; Milgrom and Roberts 1990). The digitization should be done across the entire value chain from customer interaction to supply chain management. However, at this stage, most of the firms are still concentrating on the customer-side initiatives while paying lesser attention to the supplier side[7]. Without an efficient and integrated supply chain to transmit information and fulfill the requirements of the newly digitized customer relationship, the gain from customer-side Internet business initiatives will be greatly restricted and even diluted. Given the importance of the simultaneous investments, it is not surprising to see that supplier-side digitization is having a positive impact on customer-side digitization.

Contrary to the expectation in Hypothesis 2, supplier-side digitization is found to have a small but significant and negative direct impact on financial performance. The magnitude of this negative path coefficient (-.10) is much lower than the indirect effect of supplier-side digitization on financial performance through customer-side digitization (.48 * .69 = .33). Table 2. 7 shows that the

[7] On an average, more than 50% of the firms in the sample have adopted customer-oriented IT applications to some extent, while only less than 25% have adopted any supplier-oriented IT applications.

total effect of supplier-side digitization on financial performance is positive (.23). How can the direct impact of supplier-side digitization be negative even though it has a significant positive influence on customer-side digitization? It should be noted that increasing the level of supply-side digitization is a complex initiative that involves major internal and inter-organizational technology and process changes. There is a steep learning curve in this supply side transformation, and firms may not see direct benefits in the early phases. However, as firms start communicating and transacting with their suppliers electronically, their ability to serve customers better is likely to improve rapidly.

While customer process has a significant positive influence on customer-side digitization, the impact of supplier processes on supplier-side digitization is insignificant. While the latter result is contrary to the theoretical expectations, the lackluster impact of supplier processes may be attributable to the time frame of the study. As mentioned above, most firms were in the early phases of electronic business transformation and the re-learning and organizational cultural changes required are slow to come by. The organizational changes usually involve redesigning organization structure, training staff, building new standards and incentive mechanisms, which are time consuming (Cooper and Markus 1995; Jarvenpaa and Stoddard 1998). Firms need to develop closer relationships and build trust to be able to design procedures and rules for information sharing. It usually takes longer time to align the business processes to the new information technology than to acquire the technology itself. Therefore, the impact of new

business processes on the supply side might be delayed. Past research in IT productivity also posited such "lag" effects (Brynjolfsson and Hitt 1998).

The lack of support for supplier processes has important implication for business managers. Since business process reengineering has been established to be critical to the success of new IT applications (e.g. Venkatraman 1994), it is desirable for the managers to take processes into their consideration when developing Internet business strategy. The RBV of the firm has long argued that competitive advantages come from valuable, rare, imperfectly imitable and non-substitutable resources of firm (Barney 1991). Given the increasing availability of Internet and related business applications, what really differentiate firms in terms of the success of Internet business initiatives is the unique way of accommodating new technologies by revamping the current business processes and routines. Adopting RBV, several studies in IT business value argued that superior firm performance can be linked to the ability of a firm to mobilize and deploy IT-based resources – IT infrastructure, human IT resources and IT-enabled intangibles – in conjunction with other organizational resources and capabilities (e.g. Bharadwaj 2000). The same argument can be applied in the current context to support the importance of processes.

The hypothesis involving the impact of customer-oriented IT applications on customer-side digitization is strongly supported by the data, which emphasizes the importance of appropriate interfaces and functionality. There also exists a strong linkage between supplier-oriented IT applications and the level of supplier-side digitization. Much of the past research in IT business value has investigated

the IT investment effect on financial performance without differentiating the type of IT investments such as informational and transactional capabilities or whether they are customer or supplier-side applications.

Furthermore, the results show that system integration plays an important role in transforming stand-alone applications into various informational and transactional capabilities on both customer and supplier sides of the business. Internet enabled business is not just about conducting transactions online, but also about providing a ubiquitous global network infrastructure to facilitate faster and more efficient information flow both within and among firms. The extent to which the potential of the Internet to facilitate information flow can be fully exploited depends, technically, on how well different systems can communicate to each other (Hammer and Champy 1993; Lee and Billington 1992). According to the literature, system integration consists three vertical levels: business architecture, application architecture, and technology architecture. In addition, system integration usually involves inter-organizational integration of business processes and applications (Hasselbring 2000). The scope of the current system integration construct involves the application and technology levels within the firm. The business architecture level integration is addressed by the process constructs, while the inter-organizational integration is partly captured by the readiness constructs.

Customer and supplier readiness are shown to have a strong positive impact on the levels of customer and supplier-side digitization respectively (Hypotheses 10 and 11). This is one of the major contributions of this research.

The IT business value research has generally not focused on the impacts of business partners' adoption of same technology on a specific firm's payoff. This might be appropriate in the context of traditional technology that is mainly used to automate and streamline internal operations. However, in the context of Internet and related technologies, which focus on the communication and coordination among business partners, the readiness and willingness of business partners to engage in the electronic transaction and information exchange become a factor that cannot be ignored (Chwelos et al. 2001; Crook and Kumar 1998; Hart and Saunders 1997).

2.6 LIMITATIONS

This study is subject to several data-related limitations. First, firm performance figures attributed to Internet business initiatives are self-reported. While it is desirable to use publicly available performance data, generally used in other IT business value research, such data will not delineate the effect of Internet-based initiatives, and therefore, defeats the purpose of the study. However, several checks and balances within data collection and the fact that multiple responses were used in data collection, effects of any biases are reduced. Most importantly, the survey was designed such that respondents can choose "don't known" in the event they have no Internet initiatives specific performance data.

Second, the existence of certain missing values in performance measures restricted the range of statistical analyses that could be performed. Full Information Maximum Likelihood (FIML) method could estimate the structural

model in the presence of missing values; however, it is not possible to use other statistical methods such as regression analysis to test possible interactions between different enabler constructs due to the lack of enough complete data points.

The size of the firms in the sample ranged from small through medium to large. It is also possible that firms of different sizes can have different advantages and disadvantages in utilizing the Internet and related technologies. Given the factor analysis model, the controlling of size and industry can be achieved by estimating the same model separately for different groups. Unfortunately, such an approach requires a much larger sample size than the current data set. However, the next chapter attempts to study the impact of size alone on the electronic business transformation. It is also expected that firms starting Internet initiatives earlier may do better than those starting later, which suggests incorporating time effect into the model. However, due to the restriction of the factor analysis model, time is not included in the current model.

2.7 CONCLUSION

Traditional organizations are undergoing a major metamorphosis to take advantage of the ubiquity of the Internet and related technologies. This chapter argues that there are significant differences between the organizational transformation enabled by the Internet and that enabled by proprietary technologies like EDI. Thus, while there is some evidence of economic impacts from IT such as EDI, there is no systematic evidence to support whether electronic business efforts are paying off. In particular, Internet technologies may

necessitate large-scale changes within an organization as well as its relationships with customers and suppliers. By contrast, reengineering and enterprise resource planning changes have often been internally focused. Managers need to know the types of technology, process and other initiatives to undertake, and can benefit from an empirically validated reference business model showing where different types of operational and economic impacts are typically created by the adoption of the Internet.

This study is among the first to provide empirical evidence of the relationships between electronic business initiatives and benefits. Multiple new constructs related to Internet technologies, processes, and business partner readiness were developed. The various constructs and scale items are highly reliable and can provide a foundation for future research in IT adoption and electronic business transformation. The results obtained from this exploratory study suggest that the overall effects of both customer and supplier digitization level on financial measures are significantly positive. Further, the study also validates the linkages between digitization level and enabler constructs related to Internet applications and business partner readiness. While the supplier process construct did not turn out to be a key enabler of supplier-side digitization level, in most firms electronic business initiatives are still in their nascent stages; more coordination and learning are required within the value chain for simultaneous adoption of Internet based business practices by all partners.

While subject to the usual noise and inaccuracy that are likely to accompany survey-based data with self-reported dependent variables, the large

data set deployed in this study appears to be consistent and reliable based on a set of checks conducted by the data collection agency and ourselves. However, since there is no other data set reported in the literature, it is not possible to compare and contrast the characteristics of the data with any existing benchmark.

Future research in this area should focus on potential complementarities between the enabler constructs and between digitization levels. In order to maximize operational performance, firms need to invest or commit resources for a set of key complementary enablers. Investing in IT alone may not translate into digitization level as evident from re-engineering literature of the last decade. A body of research in IT business value incorporating the complementarity framework is emerging both using production function and process-based view. For example, higher levels of IT usage is found to be associated with organizational architecture such as incentives, decision rights and skills, and it is concluded that "*organizational practices are important determinants of IT productivity, and vice-versa*" (Brynjolfsson and Hitt 1996a). While it is beyond the scope of path-analytic modeling to handle complementary relationships, more generalized econometric techniques can be deployed to study the presence of complementarities in a business value model.

Chapter 3 Difference in Adoption of the Internet Enabled Business: Small vs. Large Firms

3.1 INTRODUCTION

Policy makers and researchers recognize the important role of small firms in the overall economic growth and job creation (Acs 1999). Small firms represent more than 99% of all employers and employ 52% of private-sector workers. In terms of the output, small firms provide 51% of the private sector output and represent 96% of all exporters of goods (http://www.sba.gov). Despite the obvious importance of small firms to the overall economy, there is not any systematic research to document or to understand the adoption and benefits of the Internet vis-à-vis large firms. Relying on business value literature and electronic business transformation model discussed in Chapter 2, this chapter – in the spirit of early research on Internet enabled electronic business transformation of small firms – addresses these important differences.

Much of the research in information systems and electronic commerce is focused on large firms. However, it is unclear if the research findings using large firms are applicable to small firms given that previous research recognizes that there is significant differences between small and large firms (Storey 1994). The likely focus on larger firms may be explained with the traditional Schumpeterian hypothesis that innovations are mainly driven by large firms because large firms can provide necessary economies of scale, an essential element to obtain the necessary resource to complete the innovation activity successfully (Schumpeter

1976). Internet enabled electronic business transformation can be one such innovative activity. However, several economics researchers find large firms are more innovative than small firms only under market condition of imperfect competition, while in competitive markets small firms are more innovative than large firms (Acs and Audretsch 1987; Link 1980). This raises several important questions: (a) are there any systematic differences in the drivers, e.g., processes, readiness and technology (Barua et al. 2001a; Barua et al. 2001b), of electronic business transformation between small and large firms? (b) Are there significant differences in how benefits accrue from electronic business transformation between small and large firms? This chapter addresses the differences between small and large firms regarding adoption, impacts, and benefits. The paper relies on electronic transformation model discussed in chapter 2 and Barua et al. (2001a; 2001b).

Literature on small firms recognizes fundamental differences between small and large firms that necessitate closer examination. Wynarczyk et al. (1993) identify that smaller firms face greater uncertainty because of their relatively lower market share, and limited customer and supplier base. These affect small firms' bargaining power and their ability to influence the prices of products and services[8]. They also argue that flexible organizational structures and higher incentive for risk taking might help small firms to be more innovative. Small

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[8] However, some researchers have challenged the price-taker assumption of small firms. They argue that in practice many small firms play in "niches" market by providing highly unique product or service, which enables higher prices or profits at least in the short and possibly in the medium term (Porter 1979).

firms are also more flexible to adapt to environment and to respond to customers' changing needs and demand (Levy and Powell 1998).

Small firms are also very different from their large counterparts in the way they interact with their customers and suppliers. Some marketing literature reports that small firms emphasize more interaction and network marketing than large firms, and rely on more informal marketing plans (Coviello et al. 2000). In terms of the relationship with suppliers, some studies on just-in-time (JIT) manufacturing argue that small firms lack capital, expertise and clout with suppliers, which make it difficult for small firms to implement JIT (Finch 1986; Manoochehri 1988; Newman 1988; Stamm and Golhar 1991).

The above "core characteristics" of small firms lead to various strengths and weaknesses. The strengths include motivated management, lower bureaucracy, internal flexibility and close relationships with customers, while weaknesses include diseconomies of small scale, lack of functional expertise, higher risk, etc. (Nooteboom 1994). In contrast, large firms are characterized by scope of products and customers, higher level of specialization, economies of scale, abundant resources, etc. (Rothwell 1989). Based on the above analysis, Nooteboom (1994) suggests that there might be a possible complementarity between small and large firms. He argues that small and large firms *are good at different things and in different ways, in different stages or aspects of innovation*" (Nooteboom 1994).

What can be learned from the literature on the differences between small and large firms that can be applied in the current context of electronic business

adoption? The strength of the Internet is its relatively cheap, global infrastructure. Firms can potentially use the Internet to reach broader customer base, find better suppliers, and streamline their value chain to improve market share, provide better service, enhance efficiency, and lower costs. Given the potential benefits one may presume that both small and large firms would adopt and use the Internet to the same extent. However, since firms of different sizes deal with different types of customers and suppliers, and different sizes give firms different bargaining power, one expects different levels of adoption of Internet enabled business initiatives between small firms and large firms. Such differences may exist both in the customer side and the supplier side. Specifically, since small firms are dealing with relatively small customer and product base, there will be more opportunities for small firms to adopt new technology and business processes on the customer side to reach broader customer base. On the other hand, since small firms have virtually no power when dealing with their suppliers, and are expected to adopt new technology and business processes on supplier side to the same extent as those of large firms.

In contrast, large firms' customer base is more heterogeneous, making it difficult for them to find a cost-effective way to apply a single technology to all customers. However, large firms are more powerful when dealing with their suppliers, so it is expected that large firms have a higher level of Internet-enabled business adoption on the supplier side. There is anecdotal evidences in business-to-business marketplaces where large firms like to buy from marketplaces, but reluctant to sell through marketplaces.

In terms of the benefits that firms can reap from the Internet, the "complementarity of small and large firms" suggested by Nooteboom (Nooteboom 1994) implies that both small and large firms can benefit from adopting the Internet in their current business operation although these benefits might come from different aspects of adoption, e.g. customer or supplier side, technology or processes, etc., and are of different magnitudes.

To tackle the above research questions, this chapter relys on the IT business value literature to provide an appropriate framework to ground this study. During the past several decades, researchers have extensively studied the business value of IT and how this value is created. Many have established the significant impacts of IT on firm's financial as well as operational performance (for an extensive review of IT business value literature refer to (Barua and Mukhopadhyay 2000)). Among this literature, there is a line of process-oriented research that focuses on how the value is generated within firm through the "business value linkage" between IT investment and firm performance (e. g. Barua et al. 1995; Davamanirajan et al. 1999; Kauffman and Kriebel 1988a; Kauffman and Kriebel 1988b; Mukhopadhyay et al. 1997; Ragowsky et al. 2000). A process-oriented business value model has been adapted and empirically tested in Chapter 2 on the linkage between the adoption and usage of the Internet and the improvement of firm performance (also see Barua et al. 2001a; Barua et al. 2001b). In this cahpter, the same model developed in Chapter 2 is applied to study the difference between small and large firms in terms of their adoption and usage of the Internet and its impact on the performance.

The main contribution of this chapter is to first study systematically the differences in the adoption of Internet enabled business between firms of different sizes by using a process-oriented business value model. Basically, it is posited that small firms have higher level of adoption of Internet on the customer side to reach broader customer base relatively cheaper[9]. However, the adoption of Internet on the supplier side, which is characterized by a relatively low level of adoption at this time, may not show significant differences among small and large firms. This study also posits that both small and large firms benefit from their digitization of their business operation while the magnitudes of the benefits are significantly different across the two groups. Finally, it is argued that the impacts of customer-side Internet initiatives have higher impacts on performance for smaller firms.

The motivation and relevant literature are discussed in the next section, followed by the description of the model and the development of various hypotheses in section 3.3. Research method, data collection, and data analysis are presented in section 3.4, 3.5, and 3.6, respectively. The conclusion is drawn in section 3.7.

3.2 MOTIVATION AND LITERATURE

Since 1980s there has been a stream of research in information systems that studied the issue of IT adoption and implementation in the context of small business. Most of these studies focus on various technical, organizational and environmental factors that influence the small business's success in adoption and

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[9] There are other issues that affect customer acquisition over the Internet such as trust and logistics cost.

usage of IT. The often-used dependent variables are system usage and user satisfaction. While these early studies are important to our understanding, they are mostly exploratory in nature(Cragg and King 1993; Delone 1988; Montazemi 1988; Raymond 1985). These studies show that various factors such as top management involvement, in-house development, number of applications and IS staff, and coordinated planning are among the factors that lead to more successful IT adoption and usage in small firms.

Criticizing the lack of using well-established theory in the early studies, several recent studies tried to draw on existing models in decision theory as theoretical basis to study the small business IT adoption. Harrison et al (1997) used the theory of planned behavior (TPB) and Igbaria et al (1997) used the technology acceptance model (TAM) to explain the decision to adopt IT by small business managers.

The studies mentioned above explore the adoption and usage of personal computing that is mainly used within firms to facilitate internal operations. Several other researchers have studied inter-organizational information systems adoption such as EDI and e-mail. Iacovou et al., (1995) identified organizational readiness, external pressures, and perceived benefits as three major factors that influence the EDI adoption in small firms. Premkumar et al., (1994) drew on the general framework in innovation studies suggested by Tornatzky and Klein (1982) to study EDI adoption. The same framework was also used by Premkumar and Roberts (1999) in a research about the adoption of modern communication technologies in small firms.

The above line of research on small business IT adoption and implementation has provided us with a good understanding of what leads to the adoption and usage of IT by small businesses. However, whether and how the adoption and usage leads to improved firm performance has remained to be studied. Therefore, in addition to studying the differences in the pattern of adoption and usage of the Internet between small and large firms, this study delineates the differences in the Internet-attributable performance improvement and the differences in the value creation process.

Given the time frame of the previous small business IS research, it is not surprising that none of them covered the adoption of Internet-related electronic commerce initiatives, although only recently there have been a couple of studies of Internet adoption by small business (Mehrtens et al. 2001; Poon 2000; Poon and Swatman 1999). The new generation of Internet-based IT is arguably quite different from the traditional IT in both the technology infrastructure and application focus. The traditional IT mainly involves expensive proprietary systems to improve existing internal operations such as accounting and human resources while the new Internet-based IT utilizes the global Internet infrastructure and focuses on streamlining the entire value chain including relationships with various customers and suppliers (Barua et al. 2000a). Therefore, it is necessary to revisit the IS implementation issue in the new context of the Internet and electronic commerce.

Secondly, much of the small business IT adoption literature has been conducted without explicitly comparing the differences with that of large firms

within the same study, which makes comparison of adoption decisions difficult. The differences in data collection, measurements, and structure of models, make it difficult, if not impossible, to make meaningful comparisons. Therefore, it will be desirable to compile a data set of both small and large firms, apply a common theoretical framework, and make comparison between the two types of firms. In this study, the data are collected from both small and large firms using the same survey instrument and the same model is applied to both groups to study the difference between them.

Finally, most of the pervious studies have concentrated on the adoption of the technology itself. However, simply implementing a technology without complementary changes in firm's business processes, organization structure and relationship with value chain partners will not let the firm fully exploit the potential of the technology (Barua et al. 1996; Hammer and Champy 1993; Venkatraman 1994). Recent studies in IT business value have drawn on the theory of resource-based view (RBV) of firms. RBV links the firm's competitive advantage with firm-specific, hard-to-copy and non-substitutable resource and capability, such as knowledge, processes, and human resource (Barney 1991). For example, Bharadwaj (2000) suggests a theoretical frame work for studying the relationship between IT and firm performance based on RBV and argues that since IT can be copied by competitor easily, what matters is not IT *per se* but the firm's capability to leverage the IT in combination with other organizational resources. Therefore, a more holistic view of adoption incorporating firms' changes in organizational variables and environmental variables is desirable. This

study looks at firm's adoption of the Internet from three aspects: IT applications, related business processes, and related business partners' adoption or readiness to adopt.

Economists have considered computer and information technology as general-purpose technology (GPT) like steam engine and electric dynamo, which have the potential to raise output and productivity of the entire economy (David 1990). These GPTs are characterized by their role of "enabling technologies", which pave the way for a series of complementary innovations that diffuse throughout the whole economy. At the center of the new-generation information technology, the Internet and related technology are providing new ways of doing business in almost every industry. Well-known anecdotes involving Cisco Systems, Dell Computers, and GE demonstrate how traditional bricks-and-mortar firms have embraced the Internet to gain significant improvement in productivity and profitability. However, extending the tradition of the early information systems research, most of the current research, especially empirical research in this field, has only investigated at large firms. This might be justified in the past by the fact that information technologies characterized by expensive proprietary and centralized systems were only affordable by large firms. This situation has changed drastically with the dramatic increase in computing power of personal computers and the proliferation of the Internet and related technologies.. As a result, most small firms now have access to the Internet based information technology at an affordable cost and can enjoy the network externality of the

Internet. Therefore, this justifies a study to examine the possible difference in the adoption of Internet among firms of different sizes.

Classic innovation literature in organization study has drawn a positive relationship between innovative activity and organization size (Damanpour 1992). Large organizations have necessary resources (e.g. managerial skills, research capabilities, past experience, employee training) to facilitate adoption of innovation. These resources also increase the tolerance of the possible adoption failure. On the other hand, some organizational researchers argue that small organizations could be more innovative due to higher flexibility, higher ability to adapt and less difficulty to implement change (Hage 1980). And the empirical findings have been far less than consistent in terms of magnitude and even direction of the size-innovation relationship. That is, researchers have reported positive, insignificant, and even negative relationships between organizational size and innovative activity. Therefore, in terms of the adoption of the Internet, it is not clear whether small firms tend to adopt more than large firms or vice versa.

In economic literature about innovation and firm size, Schumpeter (1976) was among the first to see innovation as the engine of economic growth. In his later work often called Schumpeterian hypotheses, Schumpeter claimed that large incumbent firms have an advantage for innovation since they possess resources to conduct the costly R&D, control of the market to reap the rewards of the innovation. However, recent literature in the industrial organization field has found that large firms are not necessarily more innovative than small firms in every industry. It is shown that small firms tend to be relatively more innovative

in industries with relatively low capital intensity, low concentration and high innovation level (Acs and Audretsch 1987).

The above review of the relevant literature suggests that both large and small firms could be active adopters of the Internet enabled business innovations. However, the disparity of the large and small firms suggests that they might adopt these innovations in different aspects and to different extent. To better understand the relative strength and weakness of large and small firms with regard to their transformation to electronic business, it is important to identify the various aspects of firm's adoption of Internet enabled business initiatives.

3.3 MODEL AND HYPOTHESES

This chapter relys on the electronic business transformation model discussed in chapter 2 and Barua et al. (Barua et al. 2001a; Barua et al. 2001b) to study the two main research questions: (a) differences in the adoption of various Internet enabled business initiatives, and (b) differences in the impact of the adoption on performance between small and large firms. The model shown in Figure 3. 1 has roots to process-oriented IT business value model proposed in Barua, Kriebel and Mukhopadhyaya (1991) based on the idea of of "business value linkages" (Kauffman and Kriebel 1988a; Kauffman and Kriebel 1988b). The model suggest that a firm's adoption of electronic business will first increase the level of digitization in various operations on both customer and supplier side, which will in turn lead to the improvements in the financial performance of the firm.

While IT applications are important enablers for electronic business transformation, the model recognizes that without the complementary changes in other organization dynamics such as business processes, incentives, customer orientation and organization design the expected performance payoff will not be achieved (Barua et al. 1996; Bharadwaj 2000; Bresnahan et al. 2002; Brynjolfsson et al. 1997; Davenport 1993; El Sawy et al. 1999; Henderson and Venkatraman 1999; Mata et al. 1995; Venkatraman 1994). The proponents of the resource-based view (RBV) of IT impacts also argue that firm-specific competencies and resources (e.g., intangibles such as organizational knowledge, customer orientation) that are difficult to replicate determine how firms leverage IT for sustained advantages (Bharadwaj 2000; Clemons and Row 1991; Jarvenpaa and Leidner 1998; Mata et al. 1995). Barua et al. (2001a; 2001b) argue that firms must commit certain resources and make complementary changes with sustained efforts in certain areas in its transition to Internet-based electronic business. They term these complementary changes "drivers." Based on the past literature in diverse areas of research, Barua et al. (2001a; Barua et al. 2001b) identify three distinct but complementary changes critical for transformation to electronic business: IT applications, business processes, and the readiness of partners to engage in electronic business. These three areas are consistent with the technology-organization-environment paradigm that has been used to study the adoption of IT (Chau and Tam 1997; Iacovou et al. 1995; Kuan and Chau 2001). The drivers in these three areas can also be thought of as a set of business strategies focused on suppliers and customers and corresponding IT strategies

(Henderson and Venkatraman 1999; Konsynski 1993; Palmer and Markus 2000; Reich and Benbasat 1996). That is, these drivers are a result of the strategic alignment between IT strategy and corporate strategy to maximize business value proposed in management and MIS literature (Prahalad and Hamel 1990; Venkatraman 1989b).

3.3.1 IT applications

IT applications refer to various Internet and related technologies that enable firm to communicate, coordinate, and collaborate with customers and suppliers. Two constructs are considered related to IT applications: customer oriented IT and supplier oriented IT.

Customer oriented IT construct measures the level of customer-related informational and transactional capabilities that result from the adoption of the Internet and related technologies. The Internet and related technologies provide a way to communicate information related to various products and services to customers while receiving order and other transactional information from customers without the barriers of time and space. Therefore, gamut of IT applications has been developed to help firms reach wider customer base and to enhance interaction richness with the customers. However, since it is reasonable to assume that large firms would have reputation and a large customer base for its products and services, the potential to expand their customer base by going online is somewhat limited relative to a small firm. In addition, given the extreme diversity of the customer base and product lines of large firms, it is relatively more difficult to develop application for large firms to serve all customers. Hence:

Hypothesis 3.1: Small firms are more likely to have higher level of adoption of customer oriented IT compared to large firms (ITC).

Supplier oriented IT construct refers to a firm's capability to share critical information with the suppliers through the Internet and related technologies to improve supply chain efficiency. In the past, inter-organizational information systems (IOI) such as EDI have been used to improve supply chain efficiency and much work has been done to investigate the antecedents of adoption and benefits of these IOS (e.g. Barua and Lee 1997a; Clark and Stoddard 1996; Drury and Farhoomand 1996; Hart and Saunders 1998; Iacovou et al. 1995; Massetti and Zmud 1996; Mukhopadhyay et al. 1995; Premkumar and Ramamurthy 1995; Riggins and Mukhopadhyay 1994; Srinivasan et al. 1994; Zaheer and Venkatraman 1994). However, the scope and capabilities of these IOS (e.g., EDI) are highly constrained due to the limitations on the type of information that can be exchanged (Johnston and Mak 2000; Mishra et al. 2001; Senn 1998; Threlkel and Kavan 1999) and the economic characteristics of IT such as cost, flexibility, availability and openness In contrast, the Internet-based technologies enable firm to share both structured and unstructured information including product roadmaps, demand forecast, product availability, quality, innovation, and real-time monitoring and feedback (Barua et al. 2001a; Barua et al. 2001b) that are critical for maintaining and sustaining meaningful relationships.

Barua et al. (Barua et al. 2001a; Barua et al. 2001b) identified three types of information that are shared among firms and the suppliers: quality, resource availability, and relationship enhancing related information. Quality related

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information allows buyers to monitor quality in real time by exchanging data such as defect and yield rates from the supplier. Buyer can also provide information about design changes and customer feedback directly to suppliers to help suppliers make appropriate changes. Resource related information helps buyers and suppliers maintain the availability of materials and products at the optimal quantity, location and time by sharing demand and inventory information (Konsynski and McFarlan 1990). Suppliers provide information on the inventory levels, work-in-progress, machine constraints, if any, and lead-time. Such information allows buyers to maintain the continuity of its operations. Other IT applications are oriented towards information exchange related to relationship management that enhances buyers maintain a closer relationship with suppliers (Bensaou 1997). These capabilities enable both buyer and its suppliers to share event calendars, contacts, FAQs and glossary of terms. The discussion forums provided by buyers allow suppliers to pose questions and receive answers from buyers or from other suppliers. Such communication and collaboration channels develop a sense of community among the buyers and the suppliers.

Research has shown that the pressure of large firms on their small partners plays an important role in the adoption of EDI (Chwelos et al. 2001; Iacovou et al. 1995). Similarly, when adopting the Internet based supplier oriented IT applications, large firms have an advantage over small firms because of large firms' buying power. Most of the customer oriented IT applications do not require customers to make significant investments except for the Internet access. However, supplier oriented IT applications usually require the supplier to invest

significant resources, such as technology, training, etc. and change the business process. Therefore, in order to implement the supplier oriented IT applications, the involvement of the suppliers is critical. Small firms lack the clout to force their suppliers to interact electronically, which impacts their ability to implement supplier oriented IT applications. Hence,

Hypothesis 3.2: Small firms are more likely to have lower level of adoption of supplier oriented IT compared to large firms (ITS).

3.3.2 Customer and supplier related processes

The customer and supplier related process constructs refer to the level of alignment between the Internet enabled IT capability and corresponding business processes. Research has long recognized the importance of business process redesign to the implementation of new technology (Hammer and Champy 1993). For example, prior EDI research has shown that changes in related business processes are necessary for the adoption of EDI to fully realize the potential performance benefits (Clark and Stoddard 1996; Riggins and Mukhopadhyay 1994). Venkatraman (1994) argued that firms would not be able to fully reap the benefits from IT capabilities if they are simply overlaid on current business processes.

On the customer side, in order to use the Internet for better customer service and relationship, firms must re-evaluate their current customer processes (El Sawy and Bowles 1997). Customers in need of service should be able to contact online and communicate their needs effectively through a single point of contact. Further, once a customer service is received, ideally, there should be no

"coordination gaps" (Rathnam et al. 1995), which is caused by the lack of fit between customer support processes and the attributes of IT used.

On the supplier side, online transaction and information exchange with suppliers can reduce uncertainty and improve promptness of reaction to changes. However, firms must provide incentives for suppliers to participate in online transaction and information exchange (Bakos and Brynjolfsson 1993; Srinivasan et al. 1994), which can be achieved through redesign of supplier related business processes.

It has been stated in section 3.2 that small customer base and close proximity to customer are two distinguishing characteristics of small firms. This facilitates small firms to adopt customer oriented IT applications. Similarly, this should also explain the differences in the Internet related business process reengineering between small and large firms. Several studies in small business reengineering have found that reengineering in small firms should be driven by customer focus and should try to meet customer needs (Hale and Cragg 1996), that small firm reengineering should focus on customers and customer-related processes (Barrier 1994), and that customer informed reengineering will be driven by the tight bond between small firms and their specific customers (Raymond et al. 1998). Hence,

Hypothesis 3.3: Small firms are more likely to reengineer customer processes compared with large firms (PRCC).

Supply-chain management literature has found that small firms follow less formalized procedures of supplier selection and evaluation than large firms do

(Pearson and Ellram 1995). Instead, small firms might rely more on personal relationship with their suppliers. In addition, the lack of clout with suppliers, which is common among small firms, tends to make it difficult to reengineer the supplier processes without the involvement of suppliers. Hence,

Hypothesis 3.4: Small firms are less likely to reengineer supplier processes compared with large firms (PRCS).

3.3.3 Customer & supplier readiness

The customer and supplier readiness constructs measure the extent to which firm's customers and suppliers are willing and ready to conduct business online, respectively. It is argued that the synergy between the Internet enabled business initiatives of firms and their business partners plays an important role in leveraging the Internet to streamline the value chain (Barua et al. 2001a; Barua et al. 2001b; Chwelos et al. 2001). The success of the Internet initiatives of a firm depends not only on its own efforts to digitize its value chain, but also on the readiness of its customers, suppliers and trading partners to engage in electronic interactions and transactions. Rather than passively waiting for customers and suppliers to go online, firms can invest resources to help their value chain partners conform to their own Internet business strategy (Riggins et al. 1994; Wang and Seidmann 1995). Here, the small and large firms are expected to differ from each other again in the level of how their customers and suppliers are ready and willing to conduct business and exchange information online. However, it is not clear whose customers and suppliers have higher levels of readiness and willingness. Small firms, lacking resources and power are less likely to influence their

customers and suppliers to conform to their own Internet business strategy relative to large firms On the other hand, the readiness and willingness of customers and suppliers are also the results of their own Internet business strategy. Since it is not possible to draw conclusion theoretically, this study tests the hypothesis from previous empirical evidence. In a research on the Internet commerce benefit for small Australian firms, Poon (2000) found strong influence of customer participation, but lack influence for supplier involvement. This implies the following hypotheses:

Hypothesis 3.5: Small firms' customers are more likely to be ready and willing to conduct business online compared to large firms' customers (RDYC).

Hypothesis 3.6: Small firms' suppliers are less likely to be ready and willing to conduct business online compared to large firms' suppliers (RDYS).

3.3.4 Digitization levels and financial performance measure

After examining the differences in the adoption characteristics between small and large firms, this section investigates the differences in the impact on firms' performance. The structural model shown in Figure 3. 1 enables this analysis. The model implies that the benefit of the Internet business strategy is eventually judged by the improvements in the financial measures. The linkage between various Internet business strategies and the benefit is through increasing the level of digitization of the operation both on the customer side and the supplier side.

The financial performance construct measures the level of improvement in the bottom line such as sales per employee, gross margin, ROA and ROIC that

can be attributed to the adoption of the Internet and related technologies. The digitization level constructs measure the extent to which firms digitize their customer-facing and supplier-facing operations. Customer side digitization includes the percentage of total business transacted online, the percentage of existing customers doing business online, the percentage of new customers acquired online and the percentage of customer service conducted online. Supplier side digitization includes the percentage of procurement conducted online.

Numerous anecdotes support the belief that large firms (e.g., GE, Cisco, Dell) are able to reap the reward of investing in Internet enabled business initiatives. However, the critical question is whether small firms are able to benefit from Internet enabled business as well. From the above-mentioned innovation complementarity of small and large firms, it is reasonable to assume the following:

Hypothesis 3.7: Both small and large firms are able to benefit from the adoption of Internet enabled business (FIN). Adoption in different aspects has different impacts on firm's performance.

3.4 METHODOLOGY

A factor analysis is used to test the various hypotheses. The factor analysis consists of nine latent variables corresponding to six driver constructs (the supplier-oriented IT construct is a second-level construct consisting of three sub constructs), two digitization level constructs, and one financial performance construct.

A two-step factor analysis methodology to test the differences in the driver levels between large and small firms can be employed: First, a factor analysis is conducted to estimate the factor structure and to calculate the factor scores for each construct, and second, a two-sample t-test for the means of the factor scores tests whether the differences in the levels of each construct between the small and large firms are significant. Such an approach is commonly used to test differences. However, using factor scores for the two-sample t-test subjects to the weakness of incorporating measurement errors of the constructs into the t-test (Lee et al. 1997a). In addition, since there are missing data, not all the data points in the sample are used for the calculation of factor scores and t-test.

An alternative approach to test the hypotheses is a one-step confirmatory factor analysis to estimate the measurement model on two groups, i.e. small and large firms, simultaneously assuming the same factor structure across the two groups. Although the means of the constructs cannot be estimated simultaneously for two groups due to the identification problem, the difference in the means of the constructs could be estimated and the above hypotheses regarding the differences in adoption can be tested (Sorbom 1974). To do this, group-invariant factor structures need to be assumed to make the model identified, that is, the measurement model can be applied to both groups with the same factor pattern and factor loadings. In addition, by using full information maximum likelihood (FIML) estimation, all the data points, even those with missing data, are used in the estimation. By using this one-step method, the measurement error of the constructs can be separated from the estimation of the difference in mean. The

following data analysis uses this one-step confirmatory factor analysis to test the differences in various adoption constructs.

As to the hypotheses regarding the impacts of adoption, one needs to estimate a structural model that has the same factor structure as the measurement model but involves causal paths relating adoption constructs to digitization level measures and digitization level measure constructs to financial performance construct, as shown in Figure 3. 1. This structural model is estimated simultaneously for both small and large firms and then the path coefficients are compared to see if they are significantly different between the small and large firms.

3.5 DATA

The data collection has been discussed in detail in chapter 2.

Researchers and government agencies have used different measures to classify a firm as a small firm (Storey 1994). These measures include number of employees, sales, market share, and ownership type. Each measure has its own strengths and weaknesses. In recent years, however, government agencies (e.g., Small Business Administration (SBA) and European Community (EC)) use the number of employee to classify firms as large or small. Past small business IS research has also used number of employees as the criterion, while the actual cutoff values used varied across a quite large range. Raymond (Raymond 1985) used 250 employees as a cutoff number for small manufacturing firm. DeLone (Delone 1988) used 300 employee or 30 million sales as criteria for small firms. Harrison et al. (Harrison et al. 1997) considered firms with between 25 and 200

employees "small". Collecting data in Singapore, Thong et al. (Thong et al. 1996a) adopted even a criteria of less than 100 employees.

In this research, firms with less than 400 employees are considered to be small firms while those with at least 400 employees are large firms. This number is smaller than 500-employee definition currently used by the SBA. This yields a sub-sample of 736 small firms and 323 large firms out of a whole sample of 1059 observations. Firms that chose not to reveal the number of employees were removed for analyses.

To test the robustness of the results with the 400-employee cut-off value, same analysis is conducted using 100 as an alternative cut-off value. There is no substantial difference in the results.

3.6 ANALYSIS AND DISCUSSION

3.6.1 Reliability and validity

Various tests on reliability and validity have been discussed in chapter 2. Please refer to the related account and tables there.

3.6.2 Test based on measurement model with structured means

The measurement model is estimated using AMOS 4.0. In this model, all the latent constructs are allowed to covariate with each other. There is no causal link between any constructs. The model is estimated simultaneously for the two groups. The means of the six adoption constructs are set to zero for large firms and the same are free parameters to be estimated for small firms. The overall fit of the model can be evaluated by the following fit statistics:

Chi-square/df: 2.12

Tucker-Lewis index: 0.975

Comparative fit index: 0.978

RMSEA: 0.033

RMSEA lower bound: 0.031

RMSEA upper bound: 0.034

The ratio of chi-square to degree of freedom (df) is well within the acceptable ratio of five or less (Wheaton et al. 1977). Other fit indices such as the Tucker-Lewis index and comparative fit are close to one, and the RMSEA is below the acceptable level of .08, providing a strong support to the overall model fit.

The estimates of the means of small firm's adoption constructs are in Table 3. 1 (fixing the means for large firms to zero). These estimates can be interpreted as the differences in the levels of adoptions of small firms compared with those of large firms. These results show that small firms have significantly higher levels of customer-oriented IT, customer related process and customer readiness, and significantly lower levels of supplier related process. These support hypotheses 3.1, 3.3 and 3.5. Small firms are more likely to adopt the Internet business on the customer side in terms of both technology and business processes. In addition, small firms' customers are more ready and willing to conduct business electronically compared to customers of large firms. In contrast, compared with large firms, small firms are less likely to redesign their supplier related business processes to match the Internet business strategy (Hypothesis 3.4). However, the differences in the level of supplier-oriented IT (Hypothesis

3.2) and supplier readiness (Hypothesis 3.6) are not significant. This lack of difference could be attributed to the relative newness of the use of Internet in business, especially in the supply chain management. As pointed by Barua et al. (2001a), while many firms have used the Internet to reach more customers and interact with current customers, relatively fewer firms have adopted the Internet to manage their supply chain[10]. This might be due to the fact that the supplier side digitization is much more complex than customer side digitization, and involves significantly more cooperation and coordination with various business partners. Therefore, the lack of difference could be simply due to the overall low level of adoption.

3.6.3 Two sample z-test for transactional capability

The above differences in the adoption can also be analyzed through a group of binary variables. There are eight binary (yes/no) questions regarding the Internet-enabled transactional capabilities in the survey. They are not included in the factor analysis due to the binary nature of the response. However, the difference in the proportion of firms having a certain transactional capability can be tested between small and large firms. The results are in Table 3. 2.

The results show that the differences in customer related transaction capabilities are significant for all five questions with a higher adoption percentage by small firms, which supports hypothesis 3.1 (ITC) from another perspective. Small firms are more likely to provide IT capability for their customers to place

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[10] In the sample, in average, 45% do not adopt any customer oriented IT while 78% do not adopt any supplier oriented IT.

and modify order, make payment, and track order status online compared to large firms.

While the hypothesis 3.2 (ITS) is not supported by the measurement model, the difference in supplier transaction capabilities is significant for two out of three questions. Compared with small firms, large firms are more likely to transmit invoices with suppliers and pay suppliers electronically, which partially supports hypothesis 3.2.

It should be noted that these binary questions are only concerning the IT capability to facilitate basic day-to-day transaction. They do not reflect more advanced IT capabilities supporting exchange of richer information.

3.6.4 Test for payback in financial measure

There are four questions in the survey regarding the percentage increase of revenue per employee, gross margin, ROA and ROI that can be attributed to the adoption of electronic business initiatives. Various tests can be conducted to see whether there is difference in the payoff in adopting various electronic business initiatives.

First, a two-sample test of the proportion of firms experiencing an increase in various financial measures attributable to Internet enabled business adoption is conducted for each of the four financial measures. The results (see Table 3. 3) show that more small firms have observed payoffs in all four financial measures relative to large firms.

Next, to examine the differences in the level of payoff, a two-sample test is conducted on the mean of the percentage increases of payoff in large and small

firms. As the result in Table 3. 4 shows, small firms reported a consistently higher level of payoff for all four financial measures than large firms. This is also supported by the t-test of means of financial performance construct (see Table 3. 1), which shows that the mean of this construct for large firms is significantly lower than that for small firms.

The above two results show that small firms are more likely to benefit from the Internet initiatives than large firms and the level of benefit is relatively higher for small firms than it is for large firms. This could be explained by the fact that small firms are more flexible than large firms. Higher flexibility leads to faster adoption of new information technological opportunities for small firms. However, the differences in the payoff are expected to disappear in the long run as large firms make complete transformation to electronic business.

An alternative explanation of the above difference in payoff is related to the potential bias that could have been created by the fact that the entire survey is more likely to be completed by the same person in case of small firms. It is possible that a respondent with positive attitude toward the Internet might exaggerate the benefit from the Internet. Therefore, the above difference in the financial performance could simply imply a higher perception of the Internet related benefit by small firms than that by large firms. This is a major limitation of the current study.

Finally, the means of the percent increase in all four financial measures for all the companies in the data set are significantly different from zero for both

large and small firms[11]. This implies that both small and large firms can benefit from adopting the Internet business initiatives.

3.6.5 Test for difference in impacts of adoption

Last, a structural model based on the above measurement model is estimated to see whether the various adoption constructs contribute differently to firm performance for small and large firms. In this model, the various driver constructs are expected to have impacts on the level of digitization of firm operation on customer and supplier side respectively, which in turn is expected to affect the financial performance of the firm.

To see whether various drivers have different impacts on digitization levels and whether digitization levels have different impacts on financial performance measures, the causal paths are allowed to take different values across the two groups. When this model is estimated for the two groups simultaneously using AMOS 4.0 – in addition to the path coefficient estimates of the two groups – a critical ratio of difference in the estimates is also provided. This difference can be used to test the hypotheses that the path coefficients are significantly different across the two groups. These results are shown in Figure 3. 1.

Figure 3. 1 shows that the impact of customer oriented IT on customer side digitization for small firms is significantly larger than that for large firms. It is also shown that customer side digitization is having significantly larger impact on financial performance for small firms than for large firms. These results are

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[11] Treat the percentage of no increase as zero.

consistent with earlier findings that small firms are more flexible and have potential for reaching a broader customer base through the Internet.

Note that in Figure 1 not all path coefficient estimates turn out to be significant. There are a couple of negative estimates. For example, the link between supplier related process and supplier side digitization is negative but insignificant for both small and large firms. The link between supplier side digitization and financial performance is also negative but insignificant for both groups. As pointed by Barua et al. (2001a), one possible explanation might be that the whole process of the transformation from the traditional technology and processes to the new Internet enabled technology and processes is still in the very beginning for most of the firms. Relatively more efforts have been made to digitize the customer-related business operation while the transformation in the supplier-related aspects has yet reached a critical mass to have any observable impacts. However, since the result shows a positive and significant link from supplier side digitization to customer side digitization, the importance of supplier side digitization cannot be ignored because its overall effect on financial performance is still significant.

3.7 LIMITATION AND CONCLUSION

This study is subject to several data-related limitations. First, dependent variables, improvement in firm performance attributed to Internet business initiatives, are self-reported. While it is desirable to use publicly available performance data, which are generally used in other IT business value research, such data do not separate the effect of Internet-based initiatives, and therefore,

cannot be used for the purpose of the current study. There are also many private companies in the sample for whom public accounting data are not available. In addition, in the case where single respondent completes the entire survey, it is possible that those respondents who have positive attitude toward the Internet will inflate the performance improvement figure, therefore generating the common-method bias. Fortunately, this can be partially alleviated by the fact that in most medium and large firms it takes more than one respondents to finish the survey.

Although the data contain the size of the firms, there is no data on the size of the customers and suppliers whom these firms are dealing with. Had this information been available, this study could have better explained the differences in the adoption. For example, if majority of the suppliers of a large firm consists of small firms, this can better explain why small firms are better at customer side digitization while large firms are good at supplier side digitization. However, the lack of this information limits further analysis.

The traditional bricks-and-mortar companies are in the process of a major transformation in various aspects of their business activities. During this process, different types of firms will follow different paths due to their unique economic and organizational attributes. This study proposes that the firm size is an important attribute that influences how a firm adopts various Internet enabled business initiatives at the beginning stage. In general, the results show that large firms have been more involved in supplier related technology adoption and business process reengineering while small firms have focused more on customer related aspects. Compared with large firms, small firms are more likely to adopt

customer oriented IT applications. Small firms are also more likely to redesign their customer related business processes to align with their Internet business strategy. Customers of small firms are more willing and ready to conduct business online compared to customers of large firms. Due to the power that large firms have over their suppliers, large firms are more likely to be involved in redesigning their supplier related processes. This does not imply that small firms are less willing to adopt Internet enabled application and process to improve their supply chain management but rather that they lack the clout on their suppliers. This might suggest the possible alliance among small firms to form purchasing group to gain more bargaining power.

This study does not find significant difference in the adoption of supplier oriented IT application and the readiness of suppliers between small and large firms. This could be attributed to the fact that most firms are still in the very beginning of the transformation toward an Internet business model. At this stage, many firms concentrate on customer side digitization since supplier chain digitization involves more cooperation and coordination However, in the long run, firms need to invest resource in this aspect because the results show that supplier side digitization is an important precedent of customer side digitization.

As to the payoff from the above-mentioned transformation, the results suggest that both large and small firms are able to benefit from Internet enabled business. However, small firms seem to have more space to grow, i.e. they show a higher percent increase in various financial measures compared with large firms. In addition, the customer-oriented IT application contributes more to the customer

side digitization for small firms, and the customer side digitization contributes more to small firms' financial performance. This suggest that currently small firms can benefit more from digitizing their customer related operation since they have a less complicated supply chain compared with large firms.

This research contributes to the area of electronic business research that has been dominated by research focused exclusively on large firms. By uncovering some interesting facts about the small firms' adoption of the Internet enabled business, this study justifies more in-depth studies into this unique and important business sector of the entire economy.

Tables and Figures

Table 1.1 Characteristics of Digital and Physical Dot Coms

Characteristics	Digital.com	Physical.com
Interaction with customers	Digital	Digital
Main inputs (products)	Digital	Physical
Business and expansion strategies	Digital	Mostly physical
Business processes	Digital	Mostly physical during the early phase of electronic commerce
Distribution	Digital	Physical

Table 1.2 Summary Statistics for Digital and Physical Dot Coms
(Means for Firms Having Positive Gross Income**)

	Digital (n = 78)	Physical (n = 27)
Sales*	$ 9,988	$ 11,111
Gross Profits*	$ 4,362	$ 2,038
IT Capital*	$ 2,270	$ 898
nonIT Capital*	$ 400	$ 228
Labor Cost*	$ 6,452	$ 3,323
Employee Number	149	106
Year	2.60	2.26

* In $1,000
** Calculated based on log values except year

Table 1.3 Summary Statistics for Digital and Physical Dot Coms
(Means over Full Sample**, in Constant 1996 Dollars)

	Digital (n = 116)	Physical (n = 33)
Sales*	$5,566	$6,374
IT Capital*	$2,132	$ 798
nonIT Capital*	$ 365	$ 219
Labor Cost*	$5,916	$2,869
Employee Number	136	92
Year	2.27	2.06

* In $1,000
** Calculated based on the log values except year

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Table 1.4 Industry Hourly Labor Cost

Industry	Hourly rate*	Physical	Digital
Manufacturing	$22.60	2	
Transportation and public utilities	$25.33	7	
Wholesale trade	$21.63	5	1
Retail trade	$13.32	34	1
Finance, insurance, and real estate	$25.56	7	
Services	$20.42	5	120

*Source: BLS: Employer Costs for Employee Compensation, 1986-99.

Table 1.5 Regression Results Using Cobb-Douglas Production Function

Dependent Variable	Sales						Gross Profit					
Labor input measure	Employee number			Labor cost			Employee number			Labor cost		
	Pooled	Digital	Physical	Pooled	Digital	Physical	Pooled	Digital	Physical	Pooled	Digital	Physical
IT Capital	.1372 (.1313)	.3262** (.1384)	-.1104 (.3663)	.1596 (.1349)	.3162** (.1374)	-0.0623 (.3741)	.3331** (.1671)	.4067** (.1824)	.0052 (.4386)	.3056* (.1704)	.4015** (.1821)	-.0566 (.4372)
Non-IT Capital	.2182** (.0980)	.1003 (.1029)	.5505** (.2542)	.2467** (.0975)	.0967 (.1022)	0.5922** (.2531)	.2170* (.1179)	.0883 (.1259)	.7397*** (.3134)	.2206* (.1158)	.0889 (.1252)	.7316** (.3092)
Labor	.5732*** (.1861)	.4478** (.1979)	.7797 (.4615)	.4493** (.1761)	.4726** (.1919)	0.6021 (.4209)	.2655 (.2315)	.3486 (.2604)	.0790 (.5213)	.2928 (.2173)	.3529 (.2535)	.1738 (.4633)
Year	.3211*** (.0787)	.3542*** (.0790)	.0916 (.2312)	.3308*** (.0793)	.3538*** (.0786)	0.1148 (.2356)	.2303** (.0922)	.2156** (.0965)	.1819 (.2547)	.2335** (.0919)	.2168** (.0963)	.1911 (.2554)
Con. index		22.97	22.62		36.27	30.14		25.29	24.95		38.85	31.73
R-square	.5783	.6197	.5997	.5699	.6227	.5890	.5891	.6117	.5810	.5911	.6125	.5832
N	149	116	33	149	116	33	105	78	27	105	78	27
White test for hetero-skedasticity		χ^2=16.38 p=.2906	χ^2=17.21 p=.2452		χ^2=16.44 p=.2873	χ^2=18.71 p=.1762		χ^2=13.11 p=.5181	χ^2=13.16 p=.5137		χ^2=12.67 p=.5527	χ^2=12.23 p=.5875
H_0:CRTS		p=.3190	p=.3956		p=.3506	p=.5840		p=.3052	p=.5217		p=.2918	p=.5460
Chow test for structural difference		F=2.60**, p=.0280			F=3.13**, p=.0103			F=1.11, p=.3585			F=1.08, p=.3788	

*** p<.01; ** p<.05; * p<.1

Table 1.6 Translog Input Elasticity for Digital Dot Coms

Labor input measure	Number of Employees		Labor cost	
Estimate	Elasticity	F-test p-value	Elasticity	F-test p-value
IT Capital	.2933**	.0437	.2886**	.0459
Non-IT Capital	.0314	.7964	.0316	.7921
Labor	.5319**	.0154	.5440**	.0101
Year	.5057***	<.0001	.5038***	<.0001

*** p<.01; ** p<.05; * p<.1

Table 1.7 Cob-Douglas Function Using Per Employee Inputs and Output

Dependent Variable	Sales per employee			Gross Profit per employee		
	Pooled	Physical	Digital	Pooled	Physical	Digital
IT per employee	.1279 (.1301)	-.1012 (.3645)	.3132** (.1378)	.2944 (.1655)	-.0364 (.4284)	.3782** (.1804)
NonIT per employee	.2074** (.0962)	.5619** (.2527)	.0773 (.1003)	.1856 (.1163)	.7366** (.3094)	.0555 (.1219)
Year	.3045*** (.0739)	.1643 (.2144)	.3272*** (.0743)	.1876 (.0875)	.1305 (.2391)	.1810** (.0905)
N	149	33	116	105	27	78
R^2	.22	.22	.28	.21	.32	.21
Chow test	F=2.86** p=.0258			F=1.51 p=.2052		
Con. Index		7.02	7.86		7.69	8.14
Test for heteroske-dasticity.		χ^2=7.67 p=.5675	χ^2=12.28 p=.1978		χ^2=10.37 p=.3216	χ^2=9.80 p=.3672

*** p<.01; ** p<.05; * p<.1

Table 1.8 Cob-Douglas Function with Dummy Variable

Dependent Variable	Sales		Gross Profit		Sales per employee	Gross Profit per employee
Labor measure	Labor cost	Employee number	Labor cost	Employee number		
IT	-.2144 (.2629)	-.3004 (.2401)	.0232 (.3144)	.1299 (.2933)	-.2279 (.1906)	.0430 (.2321)
NonIT	.7122*** (.2156)	.6115*** (.2202)	.7381*** (.2728)	.7635*** (.2777)	.5648*** (.1993)	.6999** (.2539)
Labor	.2867 (.1953)	.4829** (.2033)	.0971 (.2216)	-.0217 (.2264)	-	-
Year	.1450 (.1693)	.1186 (.1664)	.1340 (.1854)	.1255 (.1846)	.2116 (.2086)	.1290 (.2376)
Dummy	-.1206* (.0628)	-.1054* (.0620)	-.0533 (.0797)	-.0424 (.0790)	-.1338* (.0827)	-.0029 (.1064)
Dummy*IT	.4901* (.2932)	.5849** (.2726)	.3285 (.3571)	.2263 (.3389)	.4477** (.2168)	.2266 (.2689)
Dummy*nonIT	-.6116** (.2445)	-.5071** (.2483)	-.6451** (.3062)	-.6711** (.3109)	-.4917** (.2236)	-.6466** (.2824)
Dummy*Labor	-.0218 (.2275)	-.2431 (.2328)	.1016 (.2684)	.2092 (.2710)	-	-
Dummy*Year	.1622 (.1847)	.1889 (.1818)	.0550 (.2057)	.0625 (.2051)	.1690 (.2281)	.0849 (.2631)
N	149	149	105	105	149	105
R^2	.60	.60	.61	.61	.27	.26
Con. Index	18.23	17.21	20.21	19.37	8.37	9.30

*** $p<.01$; ** $p<.05$; * $p<.1$

Table 1.9 Instrumental Variables Estimators

Dependent Variable	Sales	
	Digital	Physical
IT	.6171 (.2065)	-.4776 (.8821)
NonIT	-.0389 (.1532)	.7080 (.6929)
Labor	.2923 (.2358)	.8877 (.5431)
Year	.3400 (.0795)	.1498 (.2611)
H	3.8972	0.6572
df	2	2
p-value	0.1425	0.7199

Table 2. 1 Distribution of Firms in the Sample

Employee	# of Obs	Percentage	Sales(mil.)	# of Obs	Percentage	Industry	# of Obs	Percentage
<50	555	51.6%	<10	501	46.6%	Retailer	443	58.3%
50-100	79	7.3%	10-100	67	6.2%	Manufacturer	349	32.4%
101-400	102	9.5%	100-500	127	11.8%	Distributor	111	10.3%
>400	323	30.0%	500-1000	37	3.4%	Wholesaler	90	8.4%
Missing	17	1.6%	>1000	54	5.0%	Missing	83	7.8%
			Missing	290	27.0%			

Table 2. 2 Summary of Constructs

Construct Name	Construct Identifier	Initial Number of Items	Number of Items carried Forward to the Analysis	Cronbach Alpha	Number of data points
Systems Integration	SYS	5	5	.83	1021
Customer-oriented IT applications	ITC	6	5	.76	1023
Supplier oriented IT applications – Quality	ITSQL	3	3	.84	1020
Supplier oriented IT applications – Resource	ITSRS	3	3	.84	1009
Supplier oriented IT applications – Relationship	ITSRL	3	3	.74	1026
Supplier related processes	PRCS	6	6	.90	953
Customer related processes	PRCC	3	3	.78	1007
Electronic business readiness of customers	RDYC	2	2	-	1026
Electronic business readiness of suppliers	RDYS	5	5	.81	1016
Supplier side digitization	OPS	2	2	-	777
Customer side digitization	OPC	4	4	.90	662
Financial measure improvement	FIN	4	4	.93	315

Table 2. 3 Comparison of VE and squared correlation

	SYS	ITC	ITS	PRCS	PRCC	RDYC	RDYS	OPS	OPC	FIN
SYS	**0.497**									
ITC	0.143	**0.376**								
ITS	0.226	0.306	**0.604**							
PRCS	0.187	0.073	0.270	**0.593**						
PRCC	0.043	0.138	0.011	0.029	**0.549**					
RDYC	0.086	0.420	0.154	0.081	0.134	**0.529**				
RDYS	0.099	0.103	0.207	0.086	0.047	0.371	**0.470**			
OPS	0.040	0.132	0.123	0.024	0.024	0.136	0.182	**0.654**		
OPC	0.028	0.327	0.088	0.026	0.073	0.305	0.075	0.398	**0.693**	
FIN	0.009	0.097	0.016	0.009	0.042	0.111	0.014	0.126	0.432	**0.772**

*VEs are on the diagonal; squared correlations are off-diagonal.

Table 2. 4 Confidence Interval of Estimated Correlation among Constructs

	Corr. Estimate	confidence interval			Corr. Estimate	confidence interval	
SYS <--> ITC	0.378	0.308	0.448	PRCC <--> RDYC	0.366	0.288	0.444
SYS <--> PRCS	0.432	0.372	0.492	PRCC <--> RDYS	0.217	0.143	0.291
SYS <--> PRCC	0.207	0.133	0.281	PRCC <--> OPS	0.156	0.074	0.238
SYS <--> RDYC	0.294	0.218	0.370	PRCC <--> FIN	0.206	0.120	0.292
SYS <--> RDYS	0.314	0.244	0.384	PRCC <--> OPC	0.271	0.199	0.343
SYS <--> OPS	0.199	0.119	0.279	PRCC <--> ITS	0.107	0.027	0.187
SYS <--> FIN	0.094	0.008	0.180	RDYC <--> RDYS	0.609	0.547	0.671
SYS <--> OPC	0.168	0.096	0.240	RDYC <--> OPS	0.369	0.287	0.451
SYS <--> ITS	0.475	0.409	0.541	RDYC <--> FIN	0.333	0.245	0.421
ITC <--> PRCS	0.270	0.198	0.342	RDYC <--> OPC	0.552	0.488	0.616
ITC <--> PRCC	0.372	0.300	0.444	RDYC <--> ITS	0.393	0.315	0.471
ITC <--> RDYC	0.648	0.584	0.712	RDYS <--> OPS	0.427	0.355	0.499
ITC <--> RDYS	0.321	0.249	0.393	RDYS <--> FIN	0.120	0.034	0.206
ITC <--> OPS	0.363	0.285	0.441	RDYS <--> OPC	0.273	0.203	0.343
ITC <--> FIN	0.311	0.227	0.395	RDYS <--> ITS	0.455	0.387	0.523
ITC <--> OPC	0.572	0.514	0.630	OPS <--> FIN	0.355	0.271	0.439
ITC <--> ITS	0.553	0.487	0.619	OPS <--> OPC	0.631	0.577	0.685
PRCS <--> PRCC	0.171	0.099	0.243	OPS <--> ITS	0.350	0.270	0.430
PRCS <--> RDYC	0.285	0.211	0.359	FIN <--> OPC	0.657	0.603	0.711
PRCS <--> RDYS	0.293	0.225	0.361	FIN <--> ITS	0.125	0.035	0.215
PRCS <--> OPS	0.154	0.076	0.232	OPC <--> ITS	0.297	0.225	0.369
PRCS <--> FIN	0.096	0.014	0.178				
PRCS <--> OPC	0.161	0.091	0.231				
PRCS <--> ITS	0.520	0.460	0.580				

Table 2. 5 Summary of the Measurement Model

Latent Construct	Indicator	Std. Loading	Composite Reliability	Variance extracted estimate	Latent Construct	Indicator	Std. Loading	Composite Reliability	Variance extracted estimate
SYS	SYSIT1	0.778	0.83	0.50	PRCS	PRCS1	0.685	0.90	0.59
	SYSIT2	0.652				PRCS2	0.684		
	SYSIT3	0.644				PRCS3	0.789		
	SYSIT4	0.691				PRCS4	0.728		
	SYSIT5	0.750				PRCS5	0.854		
ITC	ITC1	0.661	0.75	0.38		PRCS6	0.859		
	ITC2	0.675			PRCC	PRCC1	0.738	0.79	0.55
	ITC3	0.504				PRCC2	0.781		
	ITC4	0.637				PRCC3	0.703		
	ITC5	0.572			RDYC	RDYC1	0.729	0.69	0.53
ITSQL	ITSQL1	0.723	0.85	0.65		RDYC2	0.725		
	ITSQL2	0.830			RDYS	RDYS1	0.749	0.81	0.47
	ITSQL3	0.859				RDYS2	0.722		
ITSRS	ITSRS1	0.770	0.84	0.64		RDYS3	0.672		
	ITSRS2	0.831				RDYS4	0.722		
	ITSRS3	0.795				RDYS5	0.544		
ITSRL	ITSRL1	0.753	0.76	0.52	OPS	MRO%	0.815	0.79	0.65
	ITSRL2	0.599				PRO%	0.802		
	ITSRL3	0.798			OPC	REV%	0.890	0.90	0.69
ITS	ITSQL	0.769	0.82	0.60		SVC%	0.702		
	ITSRS	0.778				NEW%	0.839		
	ITSRL	0.785				EXS%	0.886		
					FIN	RPE%	0.745	0.93	0.77
						GMG%	0.841		
						ROA%	0.983		
						ROI%	0.927		

Table 2. 6 Summary of the Structural Model

Hypothesis	Path Coeff.	Supported?
H2.1: The higher the level of customer side digitization, the higher the financial performance attributable to electronic business	.69	Yes
H2.2: The higher the level of supplier side digitization, the higher the financial performance attributable to electronic business.	-.10	No*
H2.3: The higher the level of supplier side digitization, the higher the level of customer side digitization.	.48	Yes
H2.4: The higher the level of customer-oriented IT applications, the higher the level of customer side digitization.	.32	Yes
H2.5: The higher the level of supplier-oriented IT applications, the higher the level of supplier side digitization.	.21	Yes
H2.6: The higher the level of systems integration within a firm, the higher the level of customer-oriented IT applications.	.44	Yes
H2.7: The higher the level of systems integration within a firm, the higher the level of supplier-oriented IT applications.	.56	Yes
H2.8: Better supplier processes lead to higher levels of supplier side digitization.	-.05	No
H2.9: Better customer processes lead to higher levels of customer side digitization.	.06	Marginally
H2.10: The higher the electronic business readiness of customers, the higher the level of customer side digitization.	.19	Yes
H2.11: The higher the electronic business readiness of suppliers, the higher the level of supplier side digitization.	.35	Yes

* Direct effect is not supported but overall effect is supported.

Table 2. 7 Standardized Total Effects

	SYSIT	ITC	ITS	PRCC	PRCS	RDYC	RDYS	OPC	OPS
OPS	0.12		0.21		-0.05		0.35		
OPC	0.20	0.32	0.10	0.06	-0.02	0.19	0.16		0.48
FIN	0.12	0.22	0.05	0.04	-0.01	0.13	0.08	0.69	0.23

Table 3. 1 Result of Measurement Model with Structured Factor Means

Construct	Estimate of mean*	S.E.	Critical Ratio	P	Hypothesis number	Hypothesis supported?
ITC	**0.621**	0.105	5.938	0.000	3.1	Yes
ITS	0.047	0.085	0.554	0.580	3.2	No
PRCC	**0.757**	0.101	7.526	0.000	3.3	Yes
PRCS	**-0.169**	0.089	-1.910	0.056	3.4	Yes
RDYC	**0.583**	0.096	6.055	0.000	3.5	Yes
RDYS	0.039	0.098	0.395	0.693	3.6	No
OPS	**8.797**	1.460	6.027	0.000		
OPC	**24.877**	1.820	13.668	0.000		
FIN	**12.256**	1.429	8.577	0.000		

*This is the estimate of the mean for small firms while fixing the mean for large firms to zero.

Table 3. 2 Difference in proportion of adopting various transactional capabilities

|	Large		Small		p-value	Question
	N	% of Yes	n	% of Yes		
Customer Related	319	57%	736	75%	<.0001	Our customers can submit orders online.
	318	35%	736	49%	<.0001	Our customers can modify orders online (e.g., change quantity ordered, cancel order, change specification, etc.).
	320	36%	736	62%	<.0001	Our customers can pay online.
	317	37%	736	44%	0.0444	Our customers are notified of their order status automatically.
	320	49%	736	68%	<.0001	Our customers access a secure web site for ordering and other interactions.
Supplier related	314	46%	736	29%	<.0001	Our systems support automated invoice transmission and processing.
	311	31%	736	27%	0.1456	Our systems track online the status of orders we placed with our suppliers/vendors for our procurement.
	311	41%	736	23%	<.0001	We send payments electronically to our suppliers/vendors.

Table 3. 3 Z-test of the Proportion of Firms Seeing Financial Payoff

Financial Measure	Large firms		Small firms		p-value
	N	% of seeing increase	n	% of seeing increase	
Revenue/employee	256	39%	447	70%	<.0001
Gross margin	264	38%	500	65%	<.0001
ROA	234	29%	398	58%	<.0001
ROIC	229	28%	369	53%	<.0001

Table 3. 4 T-test of Means of Percent Increase in Financial Measures

Financial Measure	Large firms		Small firms		p-value	Large firms	Small firms
	N	Mean of % of increase	N	Mean of % of increase		Median of % of increase	Median of % of increase
Revenue/employee	45	16%	134	38%	<.0001	5%	25%
Gross margin	43	12%	131	34%	<.0001	7%	20%
ROA	26	13%	66	38%	<.0008	8%	25%
ROIC	29	21%	55	42%	0.0106	10%	25%

Figure 2. 1 Structural Model
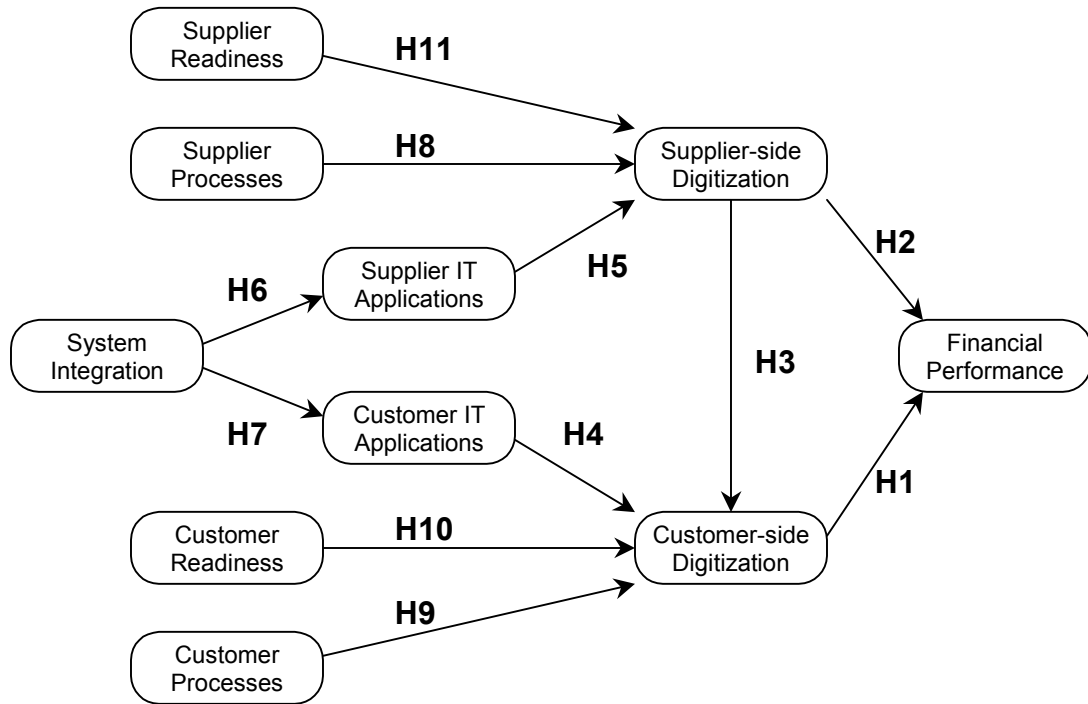
Figure 2. 2 Results of the Structural Model
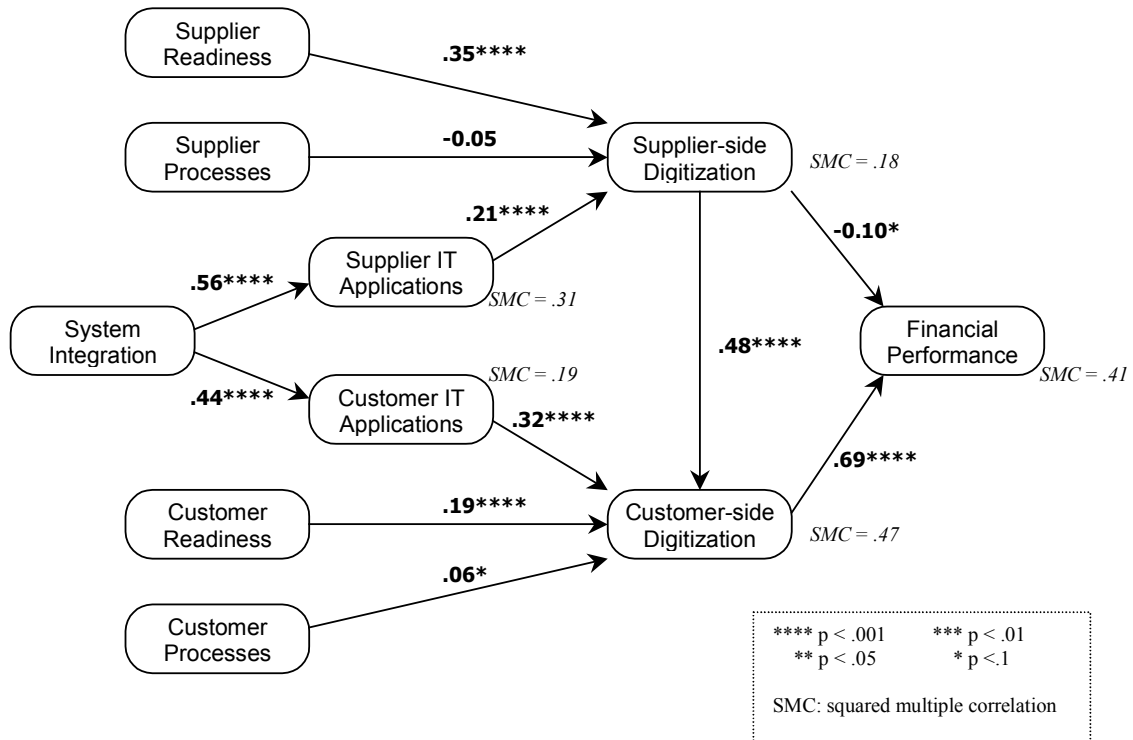
Figure 3. 1 Results of the Structural Model

	Supplier Readiness → Supplier-side Digitization	.29*** / .25****
	Supplier Processes → Supplier-side Digitization	-.10 / -.04
	Supplier IT Applications → Supplier-side Digitization	.31*** / .25****
	Supplier-side Digitization → Financial Performance	-.06 / -.10
	Supplier-side Digitization → Customer-side Digitization	.46**** / .43****
	Customer IT Applications → Customer-side Digitization	**.22***** / **.39*****
	Customer Readiness → Customer-side Digitization	.24*** / .10*
	Customer Processes → Customer-side Digitization	.01 / -.00
	Customer-side Digitization → Financial Performance	**.62***** / **.70*****

**** p < .001   *** p < .01
  ** p < .05   * p <.1

Estimates for large firms on top
Estimates for small firms on bottom
Estimates underlined are significantly
different between small and large firms

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Appendix

Z is obtained by replacing IT and non-IT inputs in the original X with the instrumental variables. Calculate the IV estimators

$$b_{IV} = (Z'X)^{-1}Z'y$$

and the estimated asymptotic variance-covariance matrix of IV estimators

$$Var[b_{IV}] = \hat{\sigma}^2(Z'X)^{-1}(Z'Z)(X'Z)^{-1}$$

The Hausman's specification test is conducted by calculating the following Wald statistic

$$H = (b_{IV} - b_{LS})'\{Var[b_{IV}] - Var[b_{LS}]\}^{-1}(b_{IV} - b_{LS})$$

that follows a Chi-square distribution with 2 degrees of freedom. In the above calculation, b_{LS} is the least square estimates and $Var[b_{LS}]$ is the corresponding variance-covariance matrix of least square estimates.

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