A TWO-ORDER EFFECT MODEL OF IT BUSINESS VALUE:

THEORETICAL DEVELOPMENT AND EMPIRICAL TEST

by

VISHNU VINEKAR

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ABSTRACT

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Supervising Professor: Dr. James T. C. Teng

A new model for IT Business Value is proposed and empirically validated from longitudinal panel data. We posit that IT has a first-order effect that includes automating, and a second-order effect that is more dependent on informating. Our empirical results demonstrate that IT's contribution to firm performance is mediated via its impacts on productivity, which corresponds to the first–order effect. We further developed and validated a complex but parsimonious moderated-mediation model to show that these paths to business value from IT vary depending on industry information intensity, environmental dynamism, and environmental munificence.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Motivation and Overview

IT business value research, one of the central questions of the Information Systems field, has revolved around two main questions: Has IT improved firm productivity? Has IT improved Firm performance? The first question deals with whether the use of IT has resulted in more output for a given level of input. The second question deals with whether IT has improved profitability at the firm level (Hitt & Brynjolfsson, 1996)

As firm IT spending increased from 5% of capital expenditures in 1965, to 50% of capital expenditures in the late 1990s (Carr, 2003), IS research has searched for evidence of the supposed benefits that managers based this spending on. Initial debate on IT Business Value revolved around the productivity paradox (Brynjolfsson, 1993). However, later research showed a strong positive relation between IT investments and Firm Productivity (Brynjolfsson & Hitt, 1996). The question on whether IT improves Firm performance, however, is still mixed. Some studies have shown strong relations between IT and market measures (for example Anderson, Banker and Ravindran, 2003) but mixed results with firm profitability measures such as net income. These mixed results of IT and firm performance include no relationship to performance, and even negative relationship with performance (Hitt & Brynjolfsson, 1996). The difference between the findings of studies using market measures and those using firm profitability measures may be due to "irrational exuberance" in markets when it comes to IT. For example, Anderson, Banker and Ravindran (2003) found extremely high returns on stock price from IT investment announcements, but may have had skewed results due to the period that it studied: the "IT boom" period in the late 1990s when there was a proliferation of dotcom startups. These firms showed tremendous increase in stock price without any profitability, and when the market crashed in 2000, many of these firms declared bankruptcy. Therefore, market measures may not be a valid measure of firm performance when it comes to IT investments.

The dismal results of research that studied the IT investment to firm profitability relationship led several detractors to question the rationality behind the rapid growth in IT spending. For example, Nicholas Carr, one of the most vociferous critics, stated in his infamous article 'IT doesn't matter' that "studies of corporate IT spending consistently show that greater expenditures rarely translate into superior financial results. In fact, the opposite is usually true." (Carr, 2003), and calls the rise in IT spending 'overinvestment'

The central research questions of this study are the same as the central research questions of the IT business value stream, i.e., the impact of IT on firm productivity and firm profitability, with specific emphasis on explaining the mixed results on the latter relationship. This study explores the possibility that the mixed results on the IT to firm performance relationship may be due to the following limitations in previous studies.

First, the theoretical models tested generalize the effects of Information Technology as very similar to other technologies, such as mechanical technology. For example, Malone and Rockart (1991) theorize that the effects of IT are all due to the one central effect of IT – the reduction in coordination costs. They compare Information Technology to other technological advances in the past, primarily to advances in automobile technology, and contend that the effects of IT run parallel to the effects of automotive technology. Similarly, Clemons, Reddi and Row (1993) posit that the major impacts of IT are due to its reduction in coordination costs. More recently, Melville, Kraemer and Gurbaxani (2004) develop a resource based view of IT where they posit that IT combined with other resources generate value, very similar to any other resource that the firm may have. In the model, IT could be substituted by any other resource, and the model will still have conceptual and empirical validity. While such broad generalizations are important for the sake of parsimony, we believe that these may be over-generalizations and fails to differentiate the inherent differences between Information Technology and other technologies that came before it. It is based on this view that Carr (2003) dismisses the importance of IT, claiming that IT is no different from any other infrastructure technology such as electricity, and will be no more a source of competitive advantage to any firm than any other infrastructure technology.

Second, these models also cause researchers to evaluate simple, direct effect 'black box' empirical models (Chan 2000) where IT directly affects performance (For example, see Bharadwaj, 2000; Hitt & Brynjolfsson, 1996; Mahmood & Mann, 1993). These studies find conflicting results. For example, Mahmood & Mann (1993) find that

IT training positively affects performance, while IT Budget as a percentage of revenue negatively affects performance; Anderson, Banker and Ravindran (2003) find abnormally large stock price increases with IT investment announcements; Hitt & Brynjolfsson (1996) find a weak negative relationship between IT spending and firm performance. These conflicting results indicate that there may be other variables that also affect this relationship. In particular, there may be mediating and/or moderating variables that influence the relationship between firm IT investments and firm performance, which could explain these conflicting findings. Chan (2000) concurs with the corresponding theoretical and empirical gap after extensively reviewing the literature and finding that studies address the question "what value do IT investments provide" without addressing the related questions "why, where, when, how and to whom do these investments provide value?" .

Third, these models are often based on incorrect assumptions, such as the assumption of similarity between IT investments and its effects over varied industries and time periods. For example, several studies compare IT investments in terms of absolute dollar values across several industries and years. Inherent in this type of analysis is the assumption that these firms have a similar portfolio of IT investments, and therefore, have similar effects. However, this assumption may be grossly violated when several different industries and time periods are included in the sample. As the applications of IT are so varied, it follows that different industries and different time periods have very different ways of using IT, which may have different effects.

Fourth, there also seems to be an assumption that IT affects performance immediately, as evidenced by the number of studies that do not use a time lag between IT spending and performance impact (for example, see Bharadwaj, 2000; Mahmood & Mann, 1993.) Firm performance is a very downstream variable and it may take years for the theorized effects of IT to appear.

Fifth, several studies include longitudinal data and use price deflators to convert figures in dollar values to that of a single year. As IT depreciates at a much faster rate than other assets, different price deflators need to be used for IT spending than any other financials studied. This makes the results of the study sensitive to the price deflators used. Barua & Lee (1997) replicate Loveman's (1994) study on the same data set using different price deflators and find opposite results. Lee & Barua (1999) call for improved price deflators as necessary for studying IT value.

This study addresses these gaps in the literature by studying the following research questions: First, how exactly does IT affect performance? Is it very similar to other technologies such as mechanical technology, in which the application of the technology lowers costs and improves productivity, and any performance impacts are an accumulation of these productivity impacts? Or does IT have a fundamentally different effect from other technologies? Second, does this impact vary across different industries or different time periods? Third, if this does vary, are their optimal IT investment strategies depending on these contingencies?

This study addresses these research questions and makes the following contributions. First, we open the black-box of the IT – firm performance relationship and develop a two-order effect model of the differential effects of IT business value, in which IT has an impact over and above a technological impact. In this model, the first-order impact depends mostly on improved technology, similar to that of previous technological advances in the past. The second-order impact, on the other hand, involves the proactive and strategic application of information assets which is unique to information technology. This second order-impact may affect performance by providing strategic information to knowledge workers and decision makers.

Second, we look at possible mediating and moderating effects in the IT – firm performance relationship and develop a complex but parsimonious moderated-mediation model of IT business value to account for the environmental contingencies for our base models.

Third, we empirically validate this model using panel data across varied industries and time periods explicitly incorporating the theorized time-lags and addressing the methodological limitations of previous studies to provide evidence that there is a second-order impact over and above the technological impact on productivity.

Fourth, we empirically validate the theorized moderated-mediation model to support the idea that the first and second order impacts vary depending on the information intensity of the sector, as well as environmental dynamism and munificence, and that the path to IT business value varies depending on these factors.

Fifth, we address the methodical concerns in previous studies by comparing each firm only to its competitors in its time period; operationalizing the independent and dependent variables to be robust to price deflators; and also taking into account explicit time lags to incorporate the theorized time taken for IT to provide business value.

Through our empirical tests, we find strong support for the two-order effects of IT, as well as the moderated-mediation model. This leads us to conclude that firms may gain value from IT investments depending on how they invest in specific environments and industries. This allows us to make specific recommendations for research and practice.

1.2 Organization of the Dissertation

This dissertation is organized into six chapters. Chapter 1 provided a brief overview of the IT business value research and the motivation for this study. In chapter 2, we cover the relevant literature in this stream. Chapter 3 is dedicated to the theoretical development of the two-order effect model and the hypotheses that we derive from it. In Chapter 4, we describe our methodology and data collection process. In chapter 5, we present the results of the hypotheses tests. Finally, in Chapter 6, we conclude with a discussion of the results and contributions to research and practice.

CHAPTER 2

LITERATURE REVIEW

The literature review is organized into two sections – the first reviews the theoretical literature on IT business value at the firm level and the second reviews the empirical literature that supports it.

2.1 Theoretical Review

Malone and Rockart (1991) posit that the effects of Information Technology are very similar to the effects that automotive technology had in the past. They base this theory on the premise that the primary purpose of technology is to reduce costs – the primary purpose of automotive technology was to reduce transportation costs, while the primary purpose of information technology is to reduce coordination costs. This lowering in costs creates three effects for both technologies, the first of which is the substitution effect – just as advances in automotive technology caused animal transport to be replaced by automobiles; similarly, information technology will cause manual labor to be substituted by information systems. The second effect is increased use – just as automotive technology caused increased use of transportation, similarly, information technology will cause increased use of coordination. The third effect is the emergence of new structures – just as automotive technology caused the emergence of transportation intensive structures, information technology will cause the use of more coordination intensive structures.

While Malone and Rockart's (1991) theory is a good explanation at generalizing the effects of technological advances, it lacks in differentiating the specific effects of information technology. It is generalizable to other technologies, but the lack of clear constructs to study each of the effects has led to a lack of empirical work addressing this theory.

Bharadwaj (2000) and Melville, Kraemer & Gurbaxani (2004) develop IT business value models from the resource-based perspective. Bharadwaj (2000) defines IT capability as a firm's ability to deploy IT enabled capabilities in combination with other complementary resources to achieve competitive advantage. Key IT based resources were classified into tangible IT resources comprising of the physical components of IT, human IT resources comprising of the technical and managerial skills, and intangible IT-enabled resources, including knowledge assets, customer orientation, and synergy.

An integrative model of IT business value based on the resource-based view was developed by Melville, Kraemer & Gurbaxani (2004). This model has three domains: the focal firm, the competitive environment, and the macro environment, as shown in Figure 2. The focal firm is the organization that is acquiring or deploying the IT resource. The IT resource applied with complementary organizational resources may improve existing business processes or enable new ones. This affects business process performance, which in turn affects organizational performance.

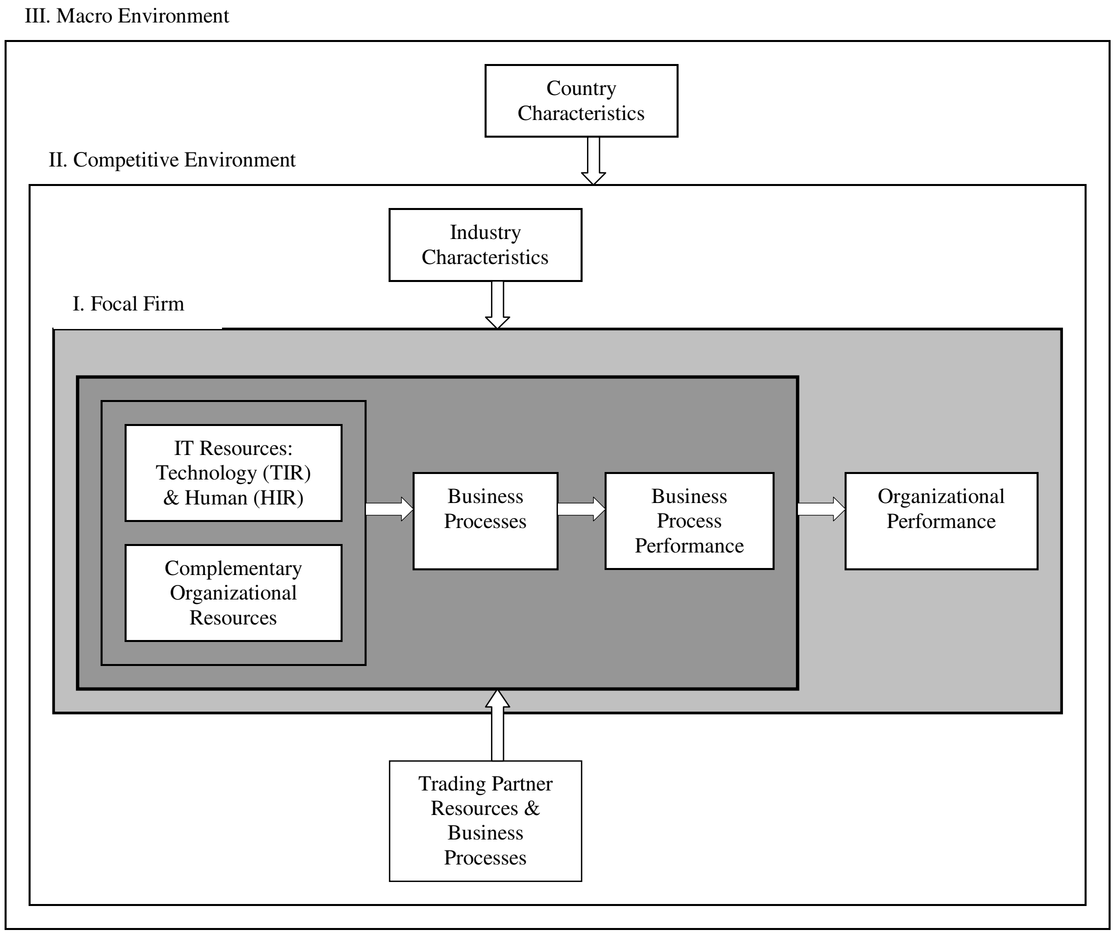

Figure 2.1: Resource-Based View IT Business Value Model.
Melville, Kraemer & Gurbaxani (2004)

Melville, Kraemer & Gurbaxani (2004) improve on previous theory by positing the mediating effect of business process on organizational performance, as well as the effect of industry and environmental characteristics. However, this theory also fails to distinguish between differential effects of Information Technology vis-à-vis other resources. In this theory, Melville, Kraemer & Gurbaxani (2004) emphasize the importance of combining complementary resources with IT to provide business value, but several other resources may have been substituted for information technology and could have had the same effect. For example, mechanical technology, combined with mechanical human resources and managerial resources, could similarly be deployed within business processes to improve organizational performance, with similar effects. It is on the basis of this lack of differentiation between IT and other technological resources that detractors attack the claimed importance of IT. Arguing from a resource-based perspective, Carr (2003) claims that IT is ubiquitous, but it is scarcity that gives rise to competitive advantage from a resource, while ubiquity decreases its value.

Attempts to differentiate IT from other technology in terms of their impacts were proposed by Leavitt & Whisler (1958), Galbraith (1974), Lucas (1999) and Zuboff (1985).

Leavitt & Whisler (1958) defined the term “information technology” and were among the first to predict the vast impacts that this new technology would have. They predicted that IT will have the greatest impact on top and middle management. In particular, they predicted that IT will move the boundary between planning and performance upward; large industrial organizations will recentralize with top managers taking on a larger share of innovation, planning and creative activities; certain classes of middle management will move downward while others will move upward into top management; and the line separating top management from the rest of the organization will be drawn more clearly than before.

Galbraith (1974), in his seminal work on the information processing view, posited that "the greater the uncertainty of the task, the greater the amount of information that must be processed between decision makers during the execution of the task to get a given level of performance". Firms invest in information systems to reduce this uncertainty, as condensing the flow of information by building specialized languages and computer systems can help analysis and decision making.

Lucas (1999) develops a preliminary model in which he suggests that IT investments have ‘direct impacts’ and ‘second order impacts’. This is shown in the figure below:

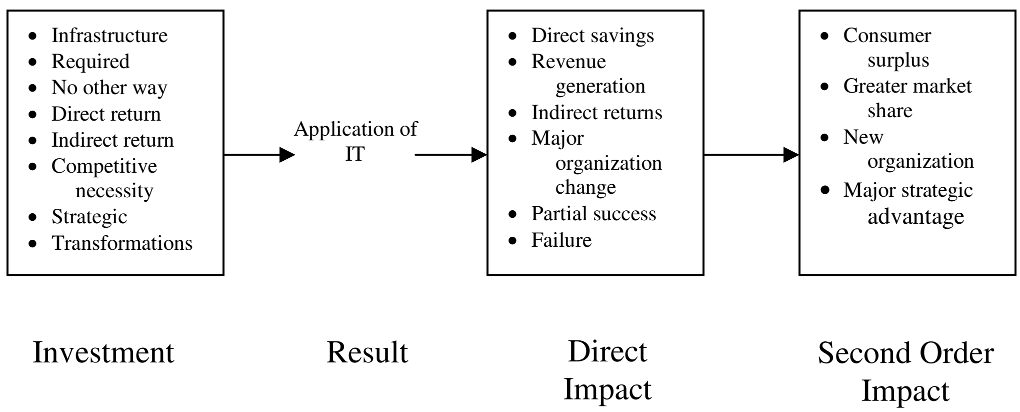

Figure 2.2: The Payoff from Investments in IT. From Lucas, (1999), page 23

In Lucas’ model, organizations invest in several different categories of investment, and then try to convert each investment into a working application of IT. After implementation, the investment may result in direct impacts which include direct saving or additional revenue generation for the firm. There may also be indirect impacts which include organizational change. The second-order impact may be better products and services, major strategic initiatives, and even new organizational forms. Lucas goes on to posit that the total impact of IT is more than the sum of contributions of individual applications.

Zuboff (1985) posited that IT had two divergent conceptions that had different implications for the organization of work: automating and informating. IT is therefore characterized by an inherent duality. Automating is essentially similar to mechanical technology such as auto manufacturing. Its purpose is to replace human effort and skill with technology that enables the same task to be carried out at a lower cost, with increased control and continuity. IT is also used for the second purpose of informating, i.e. create information. Even applications designed to automate can capture data about organizational processes, which in turn, can be used to informate. Informating through online transaction processing and communication systems can make tacit knowledge explicit, and can organize information. The implications of automation are familiar to organizations as they have seen this before with previous technology; however, those of informating are not yet well understood, although they seem to have equally significant impacts. Informating can provide a deeper and more thorough understanding of the organization which can help improve and innovate the business. While IT can provide a strong contribution through automating, its capacity to informate is unique. While informating may be an unintended by-product of automating, organizations can choose to invest in developing this informating capacity. The organization's strategy may emphasize one over the other depending on how management perceives each capacity to provide value to their business. However, it must be emphasized that organizational innovations are necessary to benefit from the informating process. The difference between using IT to automate and IT to informate may be that the former depends on smart machines, while the latter depends on smart people.

2.2 Empirical Review

As the more refined theoretical models developed in the literature tend to view the effects of IT as very similar to previous technological advances, empirical studies that derive from them consequently tend to analyze simple direct relationships between IT and firm-level outcomes. These studies have one or more measures of IT as independent variables and one or more measures of firm performance or firm productivity as dependent variables. Most of these studies have a direct relationship between IT and firm performance or firm productivity, i.e. without any mediating or moderating effects. Several studies include both firm productivity and firm performance measures, but fail to distinguish between them. For example, Bharadwaj (2000) uses eight different dependent variables including cost measures such as cost of goods sold to sales, selling and general administration expense, operating expense to sales, as well as more downstream profitability variables such as return on assets, return on sales, operating income to assets, operating income to sales, operating income to employees. However, she calls all these variables performance, and does not theorize about how IT affects each. Similarly, Peslak (2003) uses fourteen different dependent variables, including eight financial measures and six market measures, and calls all these productivity measures. Peslak also uses several different measures of IT investment from InformationWeek and Computerworld, and finds negative or insignificant correlations between most measures of IT investment and the fourteen dependent variables.

Hitt & Brynjolfsson (1996) were one of the first studies to emphasize that productivity and profitability are different measures of IT business value. Their study finds a strong positive relationship between IT and firm productivity, but a weak negative effect on firm profitability. They conclude that the positive effect of IT on firm productivity may be passed on to consumers and not retained by the firm in terms of profit.

Some studies using market measures as dependent variables find positive relationships with IT investments. Using Tobin's Q as a dependent variable, Bharadwaj, Bharadwaj & Konsynski (1999) and a number of other event studies (for example, see Sabherwal & Sabherwal, 2005) find significant relationships between IT investment announcements and firm market value. Bharadwaj, Bharadwaj, and Konsynski (1999) study the effect of firm performance on Tobin's q, a market performance measure. They find that IT expenditure had a statistically significant association with Tobin's q in all 5 years. However, the magnitude of this drops in more recent years, between 1988 and 1993. Anderson, Banker and Ravindran (2003) find highly abnormal returns from announcements of investments in information technology, which they term "the new productivity paradox'. This study's findings of huge returns from IT may be mainly due to the fact that the period it studied was during the late 1990s, where Information technology firms were in a "market bubble". If the study was done in the period of the market crash immediately following, it may have found abnormally negative returns from information technology. This leads us to conclude that market measures may not be as valid a measure of firm performance as profitability measures such as net income.

A few studies used the matched pair approach instead of measuring IT investments, comparing firms that appear in industry lists of prominent IT users matched to other firms in the same industry that are in similar in size. Bharadwaj (2000) found a strong relationship between IT and firm profitability by using InformationWeek's rankings as a measure of IT capability. However, the methodology she used has certain weaknesses, as the time lag between the independent variable and the dependent variable is inconsistent. Firms ranked at least twice in a four year period (1991-1994) by InformationWeek magazine are considered "market leaders" in IT and compared to a similar set of firms that were not ranked by InformationWeek. These two groups are compared based on their average performance in the same four year period. This methodology would mean that a firm may have been ranked in 1991 and 1992, while another firm may have been ranked in 1993 and 1994, but both firms' performance is measured over the same period, 1991 to 1994. This makes it possible that the relationship between IT ranking and firm performance may be because some firms had higher performance in 1991 and 1992, and, possibly due to this, were ranked by InformationWeek in 1993 and 1994. Following the reasoning that these firms are ranked in InformationWeek because of their prior performance, Santhanam & Hartono (2003) found that the relationship is greatly reduced and inconsistent when previous financial performance is controlled for. Similar results were obtained by Stratopoulos & Dehning (2000) and Dehning & Stratopoulos (2003) using Computerworld magazine's annual rankings of the top 100 IT users in a similar matched pair analysis. As Santhanam & Hartono (2003) and Stratopoulos & Dehning (2000) note, the ranked firms demonstrate superior performance before they were ranked, indicating that the ranking may be based on past financial performance and not on superior IT use. This may mean that the results obtained could merely be a reflection of this reverse causality.

Some studies use a multitude of independent and dependent variables in canonical correlation analysis. The independent variables consist of several different measures of IT investment and the dependent variable consists of several different measures of firm-level outcomes. Sircar, Turnbow and Bordoloi (2000) use an aggregate set of spending measures that include both IT and non-IT spending and analyze its relationship with a set of firm performance measures. They find that some IT spending and non-IT spending are directly related to some firm performance indices. MIS staff training is significantly and positively related to performance in at least four industry sectors. MIS staff and MIS other budgets are positively correlated with performance. In a similar exploratory study, Mahmood and Mann (1993) use canonical correlation between several measures of firm IT investment and several measures of firm productivity and firm performance. They find a combination of strongly positive and strongly negative results. For example, IT budget spent on employee training is positively and significantly related to sales by total assets, market value to book value, and return on investment. However, IT budget as a percentage of total revenue is significantly negatively correlated with return on investment, sales by total assets, and market to book value. Mahmood & Mann interpret this to mean that firms are overspending on IT. Peslak (2003) uses several different measures of IT spending from InformationWeek and Computerworld databases as independent variables, and uses fourteen different financial and market measures as dependent variables. However, the study finds that most of the relationships are negative or insignificant. These studies seem to be more exploratory in nature, and use data mining to look for possible correlations between any measures of IT and firm-level outcomes. Without the theoretical justification behind the exact constructs and measures used, these studies risk finding spurious correlations and making incorrect interpretations.

Hitt & Brynjolfsson (1996) emphasized that productivity and performance are theoretically and empirically distinct constructs, and empirically demonstrated that while IT spending increased business productivity and increase consumer surplus, it did not affect business profitability. They interpret these results as firms invest in IT to maintain competitive parity, but are unable to gain competitive advantage from it. Other studies on firm productivity find some support for the benefits of IT spending here. This may be due to the fact that productivity is closer to IT spending whereas other performance variables are more downstream.

In Edelman's (1981) field experiment at RCA, fourteen of RCA's eighteen operating units fell into two groups – a target group of nine companies with 42,000 employees that adopted a particular information system, and a control group of five companies with 21,000 employees that did not. The companies in the target group had a "cost avoidance" of 30%, representing the cost of the labor force that the companies that implemented the information system did not have to hire to meet the rapidly growing demands for information.

Shin (1997, 1999) studied the impact of IT on coordination costs. He theorized that coordination costs should mediate the relationship between IT and business profitability and productivity, but only tested for a direct relationship between IT and coordination costs. He found that coordination costs are related to IT spending in the manufacturing and trade sectors, but not in the transportation and utility sectors. He does not use any time lag between the spending in IT and the reduction in coordination costs.

Mitra and Chaya (1996) study the impact of IT spending on cost effectiveness of a firm. They find that higher spenders of IT have lower total costs, lower production costs, but higher overhead costs. This seems to contradict the prediction that IT leads to lower coordination costs (Clemons, Reddi & Row, 1993; Galbraith, 1974) , but might support the prediction that IT would lead to an increase in the overall amount of coordination used (Malone and Rockart, 1991). Mitra and Chaya (1996) also find that IT has no relation with clerical labor costs. In addition, larger companies spend a higher percentage of their sales on IT.

Table 2.1: Summary of Empirical Review

Study	Sample	Independent Variable	Dependent Variable	Controls	IV-DV Time Lag	Results
Bharadwaj (2000)	Period: 1991-1994 #Firms: 108 Observations: unstated	Name: IT Capability Dataset: IW Measure: Firms selected as IT leaders in 2 of the 4 years	Name: Firm Performance Dataset: Compustat Measures: Profit Ratios: ROA, ROS, OI/A, OI/S, OI/E, OEXP/S, Cost Ratios: COGS/S, SGA/S, (COGS + SGA)/S		Could vary from 3 years to -3 years.	Profit Ratios in all 4 years were higher for IT leaders than for control firms. OEXP/S significantly lower, COGS/S lower but less significant, but SGA/S higher for leaders than control.
Santhanam & Hartono (2003)	Period: 1991- 1994 #Firms: 56 leaders, 56 control, unspecified 2^{nd} control group	Name: IT Capability Dataset: IW Measure: Firms selected as IT leaders in 2 of the 4 years	Name: Firm Performance Dataset: Compustat Measures: ROA, ROS, OI/A, OI/S, OI/E, OEXP/S, COGS/S, SGA/S, (COGS+SGA)/S	Financial performance of previous year	Cross-sectional, also test for a one to five year time lag.	IT capability effect has only partial support after controlling for past performance. In subsequent years, IT leaders show stronger performance.
Bharadwaj,	Period:	Name:	Name: Tobin's Q	Industry: WIC,	None	In all 5 years, IT

Table 2.1 - continued

Study	Sample	Independent Variable	Dependent Variable	Controls	IV-DV Time Lag	Results
Bharadwaj & Konsynski, (1999)	1989-1993 #Firms: 631	IT spending Dataset: IW Measure: IT Budget / S	Dataset: Compustat Measure: (MVE + PS + DEBT) / TA	WICI, WIQR, regulation Firm: WMS, R&D, entropy, firm size.		expenditure had a statistically significant association with Tobin's q. However, its magnitude drops in more recent years
Sircar, Turnbow & Bordoloi (2000)	Period: 1988-1993 #Firms: 624 Observations: 2009	Name: IT Spending Dataset: IDC Measures: Non_cc, Labor, Staff, Other, Train, CPU, PC/Emp	Gross Annual Sales, Net income before taxes, Total net assets, Market share, Total equity, Closing price, Outstanding shares	Industry: SIC Code	None	IT spending has a positive correlation with sales revenues and a negative correlation with ROA. IT staff spending is positively correlated with multiple performance variables.
Sabherwal & Sabherwal (2005)	Observations: 89 US for-profit / government firms	Name: IT-based KM Announcements Alignment (KM process- Industry innovativeness) Alignment (KM process-Firm efficiency) Dataset:	Cumulative Abnormal Return (CAR) Dataset: Compustat	• Firm-specific instability • Firm diversification		CARs from IT-based KM announcements are greater when: • the KM process is aligned with firm efficiency • firm-specific instability is lower • firm diversification is higher Alignment (KM

Table 2.1 - continued

Study	Sample	Independent Variable	Dependent Variable	Controls	IV-DV Time Lag	Results
		LexisNexis				process-Industry innovativeness) has no effect
Stratopoulos & Dehning (2000)	Period: 1993 Firms: 71	Name: Successful IT Users Dataset: Computer World Premier 100	Name: Financial performance Dataset: Compustat Measures: Growth in net sales, Gross profit margin, Operating profit margin, Net profit margin, ROA, ROE, ROI, Fixed assets turnover, Total assets turnover, Inventory turnover		One to Five Years	Successful users of IT have superior performance Financial performance is short-lived (3-5 years) as competitors may imitate the IT projects
Dehning & Stratopoulos (2003)	Period :1993 Firms: 65	Dataset: Computer World Premier 100 Measures: Management rating, Spending on IS	Dataset: Compustat Measures: ROA, Differential in 5 year growth rate 88-92			• Management rating positively affects duration • Technical IT skills and IT infrastructure have no effect • Visibility has a

Table 2.1 - continued

Study	Sample	Independent Variable	Dependent Variable	Controls	IV-DV Time Lag	Results
		Staff, Spending on IS Training, Other IS Spending, Processor Market value, Number of PCs, PCs per employee, Peer rating				negative effect
Shin (1999)	Period:1988-1992 Firms: 232 Observations: 549	Name: IT Spending Dataset: IDG Measure: IS Budget / Employees	Name: Coordination Costs Dataset: Compustat Measure: (SGA – AD - R&D - Software - Bad debt - Pension - Retirement) / Sales	R&D, AD, Industry, Year.	None	The negative relationship between IT and coordination costs is significant in the manufacturing and trade sectors, but not in the transportation and utilities sector.
Mitra & Chaya (1996)	Period: 1988 - 1992 #Firms: 448 (Excluding banks,	Name: IT spending Dataset: Computerworld	Name: Cost Effectiveness Dataset: Compustat Measures:			Higher spenders on IT have: • lower total costs • lower production costs

Table 2.1 - continued

Study	Sample	Independent Variable	Dependent Variable	Controls	IV-DV Time Lag	Results
	insurance companies, and utilities)		Total cost Production cost Overhead cost Firm size Clerical labor costs			• higher overhead costs no relation with clerical labor costs larger companies spend a larger % of their sales on IT
Shin (1997)	Period:1988-1992 Firms: 232 Observations: 549	Name: IT Spending Dataset: IDG Measure: IS Budget / Employees	Name: Coordination Costs Dataset: Compustat Measure: (SGA – AD - R&D - Software - Bad debt - Pension - Retirement) / Sales	R&D, AD, Industry, Year.	None	IT spending is associated with lower coordination costs Expenses for Advertising and R&D are also significant The effect of IT is not significant in transportation and utilities
Mahmood & Mann (1993)	Period: 1993	Dataset: Computer World Premier 100 Measures: IT Budget / Revenue, Value of IT / Revenue, IT Budget spent	Compact DISCLOSURE Measures: ROS, Revenue growth, Sales / Total assets, ROI, Market value / book value, Sales / Employee.	None	None	IT budget spent on employee training is positively and significantly related to sales by total assets, market value to book value, and return on investment. IT budget as a

Table 2.1 - continued

Study	Sample	Independent Variable	Dependent Variable	Controls	IV-DV Time Lag	Results
		on staff, % of IT Budget spent on training IT staff, Number of PCs and terminals as percentage of total employees				percentage of total revenue is significantly negatively correlated with return on investment, sales by total assets, and market to book value.

Legend:
A = Assets
AD = Advertising Expenditure
CARs = Cumulative Abnormal Returns
COGS = Cost of Goods Sold
DEBT = (Current liabilities – Current assets) + (Book value of inventories) + (Long term debt)
E = Employees
Emp = Number of Employees
IDC = International Data Corporation
IDG = International Data Group
IW = InformationWeek
MVE = (Closing price of share at the end of the financial year)*(Number of common shares outstanding)
Non_cc = Non-Computer Capital
OEXP = Operating Expenses
OI = Operating Income
PS = Liquidating value of the firm's outstanding preferred stock
R&D = Research & Development Expenditure
ROA = Return on Assets = Net Income / Assets
ROI = Return on Investment = Net Income / Investment
ROS = Return on Sales = Net Income / Sales
S = Sales
SGA = Sales, General & Administrative Expenses
TA = Book value of total assets
WIC = Weighted Industry Concentration = 4 firm concentration for industry i * proportion of firm's sales in SIC i.
WICI = Weighted Industry Capital Index = Capital intensity for industry i * proportion of firm's sales in SIC i.
WIQR = Weighted Industry q Ratio = Tobin's Q ratio for industry i * proportion of firm's sales in SIC i.
WMS = Weighted market Share = Firm's market share in each of its industries "i" * proportion of firm's sales in SIC i.

2.3 Summary: Literature Review

From the literature review, we see that very few theoretical models have attempted to distinguish the effects of IT from the effects of previous technological advances. This not only leads detractors to claim that IT is not different from other technological advances, but also creates the lack of a good foundation to base empirical studies on. From the counterintuitive findings of empirical literature, the need for stronger theoretical foundation becomes all the more necessary. We base our theoretical model on the initial attempts to differentiate IT from previous technological advances by Zuboff (1985) and Lucas (1999).

Table 2.1 summarizes the empirical literature on IT Business Value. From this review, we see that the results are mixed. Increased IT spending seems to result in a temporary increase in stock price, but do not tend to have effects on other measures of performance. Rankings of companies based on their IT strategies seem to differentiate between good and bad performers, but this ranking may be based on past performance instead of superior IT capability. Firm productivity may be closer to the investment in IT, and may better be able to discern the immediate effects of IT. However, how this impacts firm performance is not clear, and has been debated. For example, Hitt & Brynjolfsson (1996) explain the strong relationship with productivity and the weak negative relationship with performance by positing that the productivity gains may competed away by other firms in the industry and these gains may be passed on to consumers instead of being retained by the firms as profit. Therefore, we may need to consider a more complex model that includes intermediate processes and interacting effects that may provide greater explanatory power to the elusive link between IT and firm performance. In addition, we see that there are several different measures for IT investment, firm productivity and firm performance. Several studies use a multitude of measures and claim contribution when they discern any relationship. To make a meaningful contribution, we need to define constructs and measures based on the theory instead of data mining through all possible measures of IT investment and firm level outcomes.

Empirical studies have analyzed very simple models with direct effects of IT on either firm productivity or firm performance. This may be due to the use of theoretical models that do not differentiate between the effects of IT and the effects of other technological advances. The mixed empirical support for the direct relationships indicates that these relationships are missing mediating and/or moderating variables.

In the next chapter we refine the model of IT business value to that encompasses the unique effects of IT. Firm performance is the dependent variable in this model, and firm productivity is theorized to partially mediate this effect.

In addition, we note that most of the empirical studies do not test for a time lag between the IT spending and the firm level effect. This seems problematic from theoretical as well as empirical standpoints. Theoretically, IT spending tends to require learning periods before benefits are realized. Empirically, studies show that several investments demonstrate benefits only after a time lag. For example, Nicolaou (2004) finds that ERP investments only show benefits two years after implementation.

Therefore, in our model, we explicitly consider time lags between IT spending and its effects on firm performance and firm productivity.

CHAPTER 3

DEVELOPMENT OF RESEARCH MODELS AND HYPOTHESES

In this section, we address four research questions in four sections. The first section deals with the development of a two-order effect model through which IT provides value. The second deals with the moderating effects of information intensity of the industry. The third deals with the moderating effects of environmental dynamism, and the fourth deals with the moderating effects of environmental munificence.

3.1 The Two-Order Effect Model

As the first contribution of this paper, we attempt to open the black-box of how IT provides business value. We base this model on Lucas' (1999) model, which suggests that IT investments have two order impacts. We draw parallels between these two-order effects and Zuboff's (1985) concepts of informate and automate and refine the propositions to develop a parsimonious theoretical model that we can derive testable hypotheses from.

We posit that IT provides business value in two order effects. In this model, we agree with previous theoretical models that posit that IT has a first-order effect that includes technological effects such as the automation of transaction processes or communication processes. This first-order effect could serve to improve the productivity of information workers through improved technology that allows information workers to process a greater amount of information in a shorter amount of time.

For example, Point-of-Sale (PoS) systems enable sales employees to automatically record all the information regarding the sale instantly and accurately through technology such as barcode scans. This also served to reduce the amount of additional expenditure in time and effort to perform end-of-day and end-of-month accounting. It also reduced error rates by improving accuracy and therefore reduced the time spent in finding and correcting errors in transaction records. This impact of IT is very similar to Zuboff's (1985) concept of "automate", using technology to replace human effort in order to achieve lower costs, greater control, and greater speed.

Hand-held computers given to mobile employees who deliver goods and services, such as those given to delivery employees at Frito-Lay or Federal Express, serve a similar purpose. They increase the productivity of these employees by automatically capturing the data regarding the transaction instantly, reducing the amount of manual effort and time spent on doing this, as well as the time spent in reconciling accounts at the end of the day. This allows these employees to complete a larger volume of sales.

In addition to sales, internal resource management tasks such as billing, payroll, accounting, finance, human resources, and administration that have to deal with processing large volumes of data for daily, routine, and programmed tasks were able to improve their productivity through information technology.

There are also improvements in communication systems, such as intranets, email group support systems that can increase productivity (King, 1998), as these allow each employee to manage a larger volume of work. This may also serve to flatten the organizational hierarchy by reducing the number and layers of mid-level management needed for the same task.

In addition, IT may allow for the company to handle an increase in revenue growth without a corresponding increase in employees. This was demonstrated by Edelman's (1981) field experiment at RCA, in which the companies adopting an information system were able to handle rapid growth without hiring the large number of additional employees than the companies that did not implement the information system needed to hire.

In summation, the first-order effect of IT may largely be manifested in productivity improvement, due to two main reasons. First, most IT would at least reduce the time and expense involved in capturing, storing, and transmitting data, or "coordination costs". This improves productivity by allowing the same volume of work to be completed by a lesser number of employees. There may also be a revenue improvement as the first-order impact may allow the same number of employees to perform a greater volume of work. Such improvements in productivity take time to show, as implementations of information systems take time, and in addition, there is a learning curve associated with every new system. However, these productivity improvements may not translate into a performance effects immediately, as performance is more downstream variable and may have several other influencing factors (Brynjolfsson & Hitt, 1996)

H1: Firm IT Intensity in time 1 will have a positive relationship with Firm Productivity in time 2.

In this hypothesis, we specify that it is the IT intensity of the firm that is the differentiating factor. Firm IT Intensity refers to the IT investment per employee. This construct is chosen as the theorized first-order effect occurs by making employees more productive. Therefore, it is the employees who are empowered through IT, and this is what is theorized to cause the first order effect.

In the first-order effect, the impact of IT is similar to that of other technologies such as automotive technology or mechanical technology. For example, improvements in manufacturing technology allowed for mass production through greater automation of manual tasks, allowing the same amount of work to be completed by lesser number of employees, or by allowing the same number of employees to complete an increased amount of work.

However, IT goes beyond the first-order effect as it is different from other technologies in an important aspect – it primarily deals with data. The systems that improve productivity of information workers generate huge amounts of data, and store this data, almost as a by-product of the automated transaction processing and communication systems in the first-order effect. Although such databases were mainly used for archival purposes earlier, strategic decision makers have come to realize that this is a valuable source of information to achieve competitive advantage. This data can be used to generate information for decision making through means that could vary from basic reports such as key-indicators, drill-down, and exception reports to more sophisticated added investments in IT such as data warehousing, online analytical processing (OLAP), and data mining for patterns and predictions. This is very similar to Zuboff's (1985) concept of "informate", in which IT provides information to strategic decision makers to improve their effectiveness. In addition, other information systems such as group support systems and knowledge management systems may be used for knowledge generation, sharing and collaboration. Such knowledge and information can provide for increased decision support and better decision making at middle and upper levels of management. This can be used strategically by identifying strengths and weakness of the current organizational processes, as well as specific environmental changes, opportunities and threats. This allows managers to find new products and services that the organization could move into in the future, and identify potential problems before they arise so that the organization can devise methods to prepare for them and respond to them in a timely manner. All these are part of the second-order effect, which impacts firm performance by improving strategic decisions. The effect can take even longer to impact performance, not only because performance is a more downstream variable, but also because this requires sufficient data to be collected, which could be a result of information system use through the first order effect. In addition to the longer period of time required for information and knowledge generation, time is needed for the learning curve for decision makers and data miners to familiarize themselves with the data and its applications.

H2: Firm IT Intensity in time 1 will have a positive relationship with Firm Performance in time 3.

As with hypothesis 1, it is the IT intensity of the firm, i.e. IT investment per employee, which is the differentiating factor. As with the first-order effect, the second-order effect occurs by giving employees relevant information for improved strategic decision-making. Here too, it is the employees who are empowered through IT, and this is what is theorized to cause the second order effect.

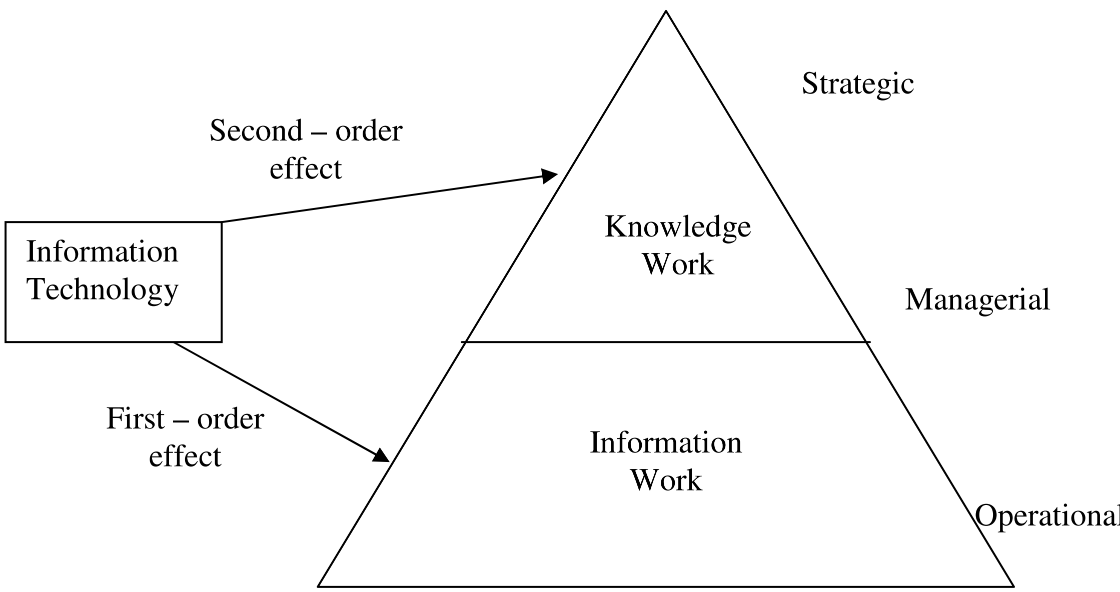

Figure 3.1: The Organizational Pyramid and the Two-Order Effects of IT

As both the first and second order effects of it empower the organization's people, it may be possible to generalize these first and second order effects as affecting different levels of the organizational pyramid. The first order effect affects mainly the 'information workers' at the operational level of the pyramid, while the second order effect may have a greater impact on the 'knowledge workers' in the strategic layer.

From the theoretical discussion, it follows that it may be possible that effect that IT has on performance at time 3 may be mediated by its impact on productivity at time 2. This may be because the second-order effect may be dependent on the first. For example, the second-order effect may be dependent on sufficient quantities of data available for analysis to make strategic decisions. This data generation, in turn, may be dependent on system use of transactional systems involved in the first order effect. However, this size of this effect may be much less than the productivity – performance link of industrial economics. Because productivity has a strong positive impact on performance, with the notable exception of the productivity dilemma (Abernathy 1978, Benner & Tushman 2003) the impact of IT in performance may be due to the impact of IT on productivity. However, the impact on performance that comes through the impact on productivity may be only a part of the effect of IT on performance, as there may be a direct effect on performance as theorized by the second-order effect. Therefore, we arrive at hypothesis 3:

H3: The relationship between Firm IT Intensity in time 1 and Firm Performance in time 3 will be mediated by Firm productivity in Time 2

This hypothesis brings additional questions: Was the first-order effect necessary for the second, i.e., was the effect on firm productivity necessary for the effect on performance? Is it possible that the second-order effect could improve performance even if the first-order effect had no impact on productivity? For example, could IT have provided strategic information to decision makers caused an improvement in performance even if productivity was not impacted? Are there situations in which the second-order effect completely explains the impact of IT on performance? Are there others in which the improvement in performance comes entirely from the first-order impact?

To answer these research questions, we look in the IS literature on Information intensity, as well as strategic management literature on the environment and the productivity dilemma, and theorize the moderating role of the environment. Specifically, we look at the productivity dilemma literature which focuses on the role of the environment in the productivity-performance link (for example, Benner & Tushman 2003). In addition, we look at strategic management literature that focuses on the role of the environment in the link between strategic decision making and firm performance (for example, Priem, Rasheed & Kotulic 1995), since the second-order effect is theorized to include impacts on performance through strategic decision making. From this, we theorize that information intensity and the environmental dimensions of dynamism and munificence moderate the model, and arrive at a set of moderated-mediation hypotheses. Conceptually, moderated-mediation is a complex relationship in which a mediating relationship varies over levels of a moderating variable. This is different from mediated-moderation, in which a moderation relationship varies due to a mediating variable (Barron & Kenny, 1986; James & Brett, 1984)

3.2 Moderating Effects of Information Intensity

Traditional wisdom in Information Systems contends that different sectors of industry have different levels of information intensity. The manufacturing sector is assumed to be low in information intensity and the financial sector is assumed to be high in information intensity (Porter and Millar, 1985). We posit that in sectors that are high in Information Intensity, the very nature of the day-to-day work of information workers deal with information products and services, rather than material ones. This allows information technology to provide vast business value through the first-order effect.

H4: Firm IT Intensity will be more positively related to Firm Productivity in sectors with high information intensity than those with low information intensity.

In industries with high information intensity, both information workers as well as knowledge workers will have to deal with much higher levels of data, information and knowledge at all three levels of the organization – operational, managerial, and strategic. Therefore, in these environments, IT can make a bigger impact on performance through both the first-order impact as well as the second-order impact. As information workers have to deal with much higher volumes of data in their daily routines, they need IT to improve productivity through the first-order impact. As knowledge workers deal with higher volumes of information as inputs for strategic decision making, they need IT to improve strategic effectiveness through the second-order effect. As the impact of IT on performance is a combination of both first and second-order effect, firm IT intensity may have a more positive impact on performance in high information intensity environments.

H5: Firm IT Intensity will be more positively related to Firm Performance in sectors with high information intensity than those with low information intensity.

However, we contend that due to the information intensive nature of the work, productivity can have a wide variance in high information intensive industries. Productivity in highly information intensive environments is highly complex, and requires specialized skills, resources, values and processes. For example, banks and insurance companies deal with products that are information intensive. Processing a security, for example, needs a considerable amount of expenditure in time, effort and skilled human resources. Manufacturing industries, which are lower in information intensity, on the other hand, already have mature processes such as mass manufacturing that have improved productivity for the majority of firms in the industry. However, information-intensive industries are still attempting to improve their productivity through information technology, and are still experiencing challenges in customizing information systems to deal with the specialized nature of the individual information products that their business revolves around. Hence, organizations that improve in productivity will have a strong competitive advantage over those who do not in highly information-intensive industries. Productivity can become one of the primary differentiating factors in firm performance in these sectors due to this

H6: Firm Productivity will be more positively related to Firm Performance in sectors with high information intensity than those with low information intensity.

The first-order effect was theorized to have similar impacts as advances in other technologies had in the past. Therefore, the effects of Information Technology in information-intensive industries may have similarities with the effect that mechanical technology had on manufacturing industries over the twentieth century. Industries that dealt mainly with mechanical products saw huge increases in productivity through advances in mechanical technology through this period, making productivity a strong differentiating factor. Now that these industries have matured in terms of mechanical technology, most firms in the industry have already experienced these productivity gains that mechanical technology had to offer. In the twenty-first century, there may not be much competitive advantage to gain from productivity improvements through mechanical technology; therefore, these firms may be attempting to inject information into their processes through information technology (Porter & Millar, 1985). The impact of IT on the productivity of information-intensive industries has begun to show (Calderon, Seo & Kim, 2001; Hua and Quan, 2005), but is yet to reach the maturity of mechanical technology in manufacturing industries. Therefore, productivity is still a strong differentiating factor in high information intensity sectors; and we believe that the performance benefits may come primarily through the first-order effect. As follows from Hypotheses 4, 5, and 6, firm IT intensity may have a greater impact on firm productivity in industries that are higher in information intensity (H4). Firm IT intensity may also have a greater impact on firm performance in industries that are higher in information intensity (H5). By combining this with H6, firm productivity will have a larger impact on firm performance in industries that are higher in information intensity. Deductively, in industries that are higher in information intensity, the higher firm performance (H5) may be a result of firm productivity (H6), which in turn, may be a result of firm IT intensity (H4). However, in low information intensity environments, firms deal with products where the physical content is much greater than the information content. Although firms in these industries cannot compete based on the information content of their products, they may still gain competitive advantage by adding information into their processes (Porter & Millar, 1985). Hence in low information intensity sectors, the benefits from IT come through both the first and second order effects. For example, manufacturing firms could move towards inventory systems to keep track of their inventory depletion from inventory movement in real-time. They could then use this information about their business processes to allow them to become more efficient by maintaining lower inventory levels. They can take this a step further by giving their suppliers visibility to this information, tying together information systems with partners to enable just-in-time manufacturing. By using information technology to automate these processes through the first-order effect, these firms may be able to increase productivity. In addition, firms may also be able to gain access to information from their wholesalers, distributors, and retailers. Such information may allow them to keep track of the very downstream product sales in real time, allowing them to make strategic decisions on developing new products lines, and discarding old ones. This may also help them avoid reacting to 'bullwhip effects' from lack of downstream information. In this manner, firms in industries with low information intensity may inject information into their processes to compete using both the first-order as well as the second-order effect of IT. However, such gains from firm IT intensity may not be as large as those in industries that are higher in information intensity, as follows from hypotheses 4 and 5. In addition, since productivity is not as strong a predictor of performance in industries with low information intensity (hypothesis 6), gains in performance may come less through first-order effects in productivity and more through second-order effects on performance.

H7: The relationship between Firm IT Intensity and Firm Performance is more positively mediated by Firm productivity in environments with high information intensity than environments with low information intensity

The hypothesis posited above is theorized as a moderated mediation relationship, i.e., the mediation relation varies across the levels of a moderating variable (Barron & Kenny, 1986; James & Brett, 1984)

3.3 Moderating Effects of Environmental Dynamism

Environmental dynamism, also termed as environmental uncertainty (Downey, Hellriegel and Slocum, 1975; Duncan, 1972) consists of three types of uncertainty: State uncertainty, effect uncertainty and response uncertainty (Milliken, 1987). State uncertainty refers to a lack of information on the present state of the environment. Effect uncertainty refers to a lack of information on the effect that changes in the environment will have on the organization. Response uncertainty refers to a lack of information on what response options are present to the organization and what the value of each option may be.

Galbraith (1974) argued that “the greater the uncertainty of the task, the greater the amount of information that must be processed between decision makers during the execution of the task to get a given level of performance". Therefore, organizations invest in information systems to obtain information to lower this uncertainty. Through the second-order effect, or the information effect, organization can lower all three forms of uncertainty. Point-of-sale and other OLTP (Online Transaction Processing) systems provide information on current sales, so managers have current information on what products and services are selling and what are not. From this they can generate trends and patterns to predict the direction the market is headed, reducing state uncertainty. Management information systems give information to managers about the present state of the internal working of the organizations, with exception reporting to give instant notice of any problems, reducing effect uncertainty. Information systems can also keep track of new initiatives and projects and their effects, reducing response uncertainty. In addition, databases with historical data can be mined for trends and patterns, and advances in technology such as neural networks can be used to make predictions and do "what-if" analysis, further reducing the three forms of uncertainty. As with Galbraith's (1974) argument, in environments with higher dynamism, higher information processing is needed to maintain a given level of performance. Therefore, we expect the impact of IT on firm performance through the second-order effect or the information effect will be higher in environments with higher dynamism.

H8: Firm IT Intensity will be more positively related to Firm Performance in environments with high dynamism.

In expounding on the "productivity dilemma" Benner and Tushman (2003) argue that in stable environments, organizations need to focus on improving performance through incremental process improvements. However, in dynamic environments, productivity may be disrupted as new markets need to be identified, and radical changes are needed in existing processes. Therefore they hypothesize that productivity has a strong positive impact on performance in stable environments, but this productivity link may be greatly reduced, absent or even negative in dynamic environments. This was demonstrated by Ittner and Larcker (1997), who compared the productivity improvements in the auto industry and the computer industry, hypothesizing that the computer industry had higher environmental dynamism than the auto industry. They concluded that process improvement techniques are associated with improved performance in the auto industry, but not in the computer industry. Benner and Tushman (2002) argue that productivity improvements may actually negatively impact performance in dynamic industries. We test this hypothesis as a base for additional hypothesis on the first and second order effects of IT

H9: Firm Productivity will be more positively related to Firm Performance in environments with low dynamism.

Since productivity has little to no impact on performance in dynamic environments, or perhaps even a negative impact on performance, firms may not be attempting to increase productivity through the first-order effect of IT. Instead, firms in dynamic environments may invest more to obtain the second-order effect to obtain information to reduce state, effect and response uncertainty. For example, firms in more stable environments may be investing in information systems to improve productivity on processes involving a specific product or a specific distribution system. However, in dynamic environments, such investments in improving productivity may lower the firm's ability to compete. For example, semiconductor firms that invested heavily in productivity improvements with vacuum tube processes were slower to enter the silicon chip market (Tushman & O'Reilly, 1996). Therefore, firms in highly dynamic environments may be wary of improving productivity through IT, lest it reduce their ability to retaliate to the next threat or avail of the next opportunity in the constantly changing environment. Therefore, we arrive at the following hypothesis:

H10: Firm IT Intensity will be more positively related to Firm Productivity in environments with low dynamism than with high dynamism.

From hypothesis 5 and 6, we can derive a hypothesis for moderated mediation (Figure 3.2). In environments with low dynamism, we theorized that the relationship between firm IT Intensity and Firm productivity is more positive (path 1 in the model). In addition, the relationship between Firm Productivity and Firm Performance is more positive (path 2 in the model) at low dynamism. The relationship between Firm IT Intensity and Firm performance (path 3 in the model) is less positive at low dynamism. Therefore, we can deduce that at low dynamism, Firm IT Intensity would impact Firm performance more through firm productivity, i.e. more through path 1 and path 2 and less through path 3. In other words, as dynamism decreases, the relationship between Firm IT Intensity and Firm Performance should be more mediated by Firm Productivity.

At high dynamism however, the relationships are different. The relationship between Firm IT Intensity and Firm productivity (path 1) is theorized to be less positive, and the relationship between Firm Productivity and Firm performance (path 2) is also less positive in environments with high dynamism. However, the relationship between Firm IT Intensity and Firm performance is theorized to be more positive (path 3). Therefore, we can deductively infer that at high dynamism, Firm IT Intensity has a more direct relationship with firm performance, i.e., more through path 3 and less through paths 1 and 2. In other words, as dynamism increases, the relationship between Firm IT Intensity and Firm Performance should be less mediated by Firm Productivity.

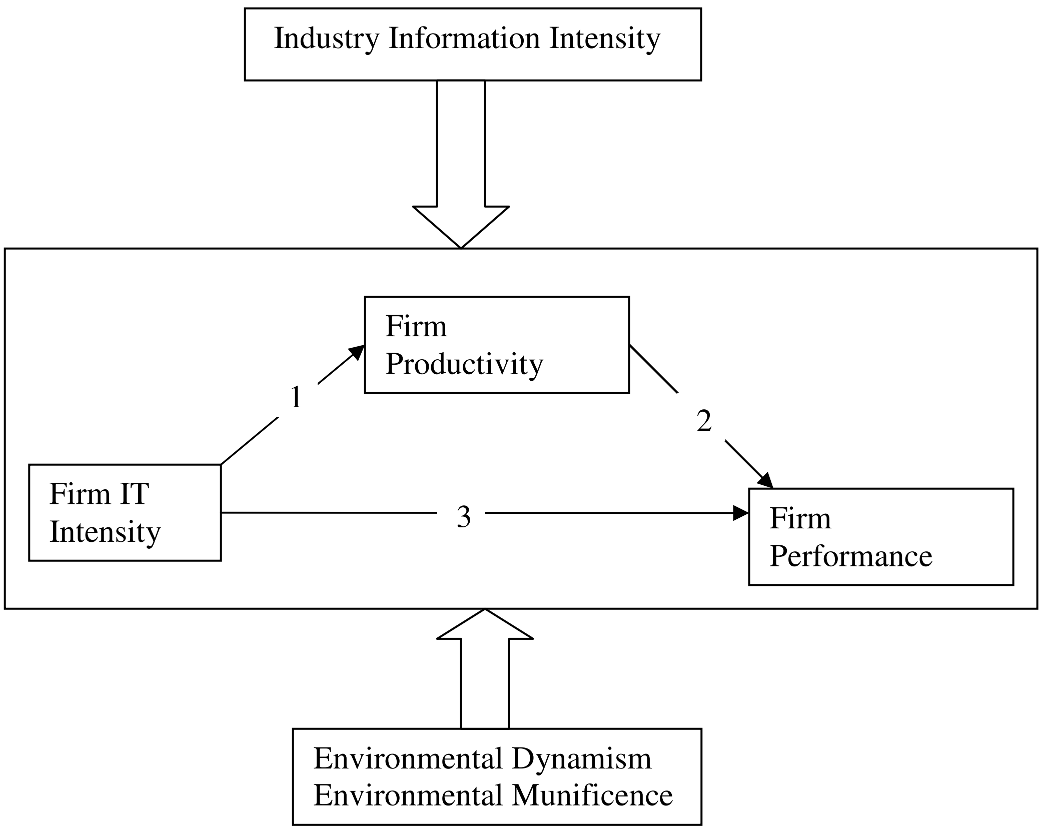

Figure 3.2: Moderated-Mediation in the Two-Order Effect Model

This leads us to theorize that the mediating effect of productivity on the Firm IT Intensity to firm performance relationship is moderated by Environmental Dynamism.

H11: The relationship between Firm IT Intensity and Firm Performance is more positively mediated by Firm productivity in environments with Low dynamism than environments with high dynamism.

3.4 Moderating Effects of Environmental Munificence

Environmental munificence is the ability of the environment to support the firm (Castrogiovanni, 1991). Munificence is the opposite of environmental scarcity or environmental hostility, or the lack of resources in the environment. This is frequently operationalized as the growth in sales at the industry level (Al-Shammari, 2006; Dess & Beard 1984; Goll & Rasheed, 1997). Firm in environments that are higher in munificence experience higher rates of growth, and with this, there is a corresponding increase in information that needs to be processed, both internal as well as external. Following our earlier argument on the first-order effect of IT, investments in IT enable employees to become more productive, and therefore enable firms to handle growth in revenue without a corresponding growth in employees. This was demonstrated by Edelman's (1981) field experiment with RCA, in which firms that adopted an information system were able to handle RCA's growth without the increase in employees that control firms, which did not implement the information system, needed for the same growth. Therefore, it follows that the first-order effect can have more significant impacts on firms that are in environments that are higher in munificence.

H12: Firm IT Intensity will have a more positive relationship with Firm productivity in environments with high munificence than environments with low munificence.

While theorizing on the effect of firm IT intensity on firm performance, we need to theorize on how this may be affected through the first-order effect, i.e. through firm productivity. In environments with high munificence, firms will experience sales growth and may need to invest in additional resources to handle this growth. Particularly expensive may be the human resources needed, as they need training specific to the organization's skills, tools, procedures, processes and familiarity with the organization's structure, strategy and culture. However, more productive organizations may be able to handle the sales growth with less need for the considerable time and expense involved in finding, recruiting, training, and supporting the additional human resources needed. However, in environments that are low in munificence, firms may be experiencing little or no growth, or even a decline in revenue. In this case, there may be several other factors involved in improving firm performance, including drastic changes in strategy and structure, and possibly even exiting current markets and entering new ones. Consistent with this argument, Covin & Slevin (1989) find that in hostile environments, firms with organic structures, entrepreneurial strategic postures, and concern for predicting industry trends had higher performance. In munificent environments, firms with more mechanistic structures, conservative strategies, and emphasis on product refinement had higher performance. Firm productivity may be less important as compared to these other factors in environments with low munificence, as they may have to focus on effectiveness, i.e., "doing the right thing" rather than on efficiency, i.e., "doing things right".

H13: Firm Productivity will have a more positive relationship with Firm Performance in environments with high munificence than environments with low munificence.

With the growth in the industry in environments with higher munificence, there is a corresponding growth in external information as well, as the environment now has an abundance of resources and opportunities to support the firms within it (Castrogiovanni, 1991). Therefore, firms will need to invest in IT to handle this growth in external information, as well as the growing opportunities in the external environment. On the other hand, with environments that are lower in munificence, firms may be experiencing a low growth rate, no growth, or even a decline. There is consequently less information for the firms to process, at all levels in the organization. Such environments are termed 'scarce' and are marked by a scarcity of information as well. As firm performance is impacted both by the first-order effect of IT as well as the second-order effect of IT, and because the information that needs to be processed to obtain benefits from either effect is much higher in environments that are higher in munificence, we expect that firms in high munificence environments to have a stronger relationship between firm IT Intensity and Firm Performance.

H14: Firm IT Intensity will have a more positive relationship with Firm Performance in environments with high munificence than environments with low munificence.

This leads to the question of how the mediating effect of firm productivity is moderated by environmental munificence. In the reasoning for hypothesis 7, we theorized that firms in high munificence environments may experience more significant gains in productivity through the first order effect than firms in low munificence environments. Such productivity gains may make a strong impact on performance as well in environments that are higher in munificence. Therefore, we expect that the mediating effect of firm productivity should be high in environments with high munificence.

In environments with low munificence, however, firms may be experiencing low growth rates, including declines in growth, and therefore, do not stand to benefit from improvements in productivity as much as firms in environments with higher munificence. Such firms have to compete for the scarce resources in these environments. These environments are also termed 'hostile' environments (Covin & Slevin, 1989), as firms have to constantly watch for threats in these hostile environments. In these environments, organizations may get benefits from the second-order effect of IT by investing in information technologies that help identify these scarce resources, as well as using IT to identify specific threats in the hostile environment, enabling prompt and appropriate responses to these threats. Therefore, firms in environments with high munificence as well as those in low munificence stand to gain more from the second-order effect of IT than the first order effect of IT. Consequently, we expect the mediating effect of firm productivity to be lower in environments that are lower in munificence.

H15: The relationship between Firm IT Intensity and Firm Performance is more positively mediated by Firm productivity in environments with high munificence than environments with low munificence.

CHAPTER 4

METHODOLOGY

This chapter is organized into two sections – the first deals with the sources from which we gathered the data to conduct empirical tests of our hypotheses, and the second deal with the measurement of the constructs in the study.

4.1 Data Sources

The data was obtained from several secondary sources, including IS budgets from InformationWeek magazine, firm financials from Standard & Poor's Compustat database, and value of shipments for industries from the Bureau of Economic Analysis.

Data on IS budgets was gathered from InformationWeek magazine's website. InformationWeek magazine publishes an annual survey of 500 firms called the InformationWeek 500, in which it collects data on IT practices of various large firms in the United States, and ranks 500 of these firms based on the magazine editor's criteria for IT innovation. This data is collected through an extensive mail, phone, and fax survey of firms with at least one billion dollars in annual revenue. As part of this survey, data on IS Budgets is also collected from the respondents. The list is available online with archives going back to 1991, and for the surveys for 1991 through 1997, the data on IS Budgets is included as part of the online publication. We collected this data, along with the company's name and revenue for these eight years.

Standard & Poor's Compustat database was used to collect data on firm financials to measure productivity and performance. We matched the firms in the InformationWeek data set to those in the Compustat database. Initially, we attempted to match these firms by matching the name of the firm reported by InformationWeek to the most similar name in the Compustat database. However, this method was highly inaccurate due to name changes, mergers, and acquisitions. For example, "Monsanto" in the InformationWeek data set was matched to "Monsanto Co" in the Compustat database. However, these are two different companies – "Monsanto" as referred to in InformationWeek merged with Pharmacia in 2000 and took the Pharmacia name. Pharmacia, in turn, spun off its agriculture business and named it Monsanto, and the latter firm is the one in Compustat named "Monsanto Co". The firm that InformationWeek referred to is named "Pharmacia Corp" in the Compustat database. To ensure data integrity, we used revenue as a primary factor to match between the two data sets. This factor is more credible as InformationWeek verifies the company's revenue as it only includes US firms with at least one billion dollars in annual revenue into its lists. As part of its prequalification application, InformationWeek asks for the organization's annual revenue for the most recent fiscal year as well as a source to confirm the revenue against (InformationWeek, 2007). Therefore, we matched the revenue in InformationWeek against the revenue of the previous fiscal year in Compustat. As InformationWeek reported revenues rounded to the nearest million, we rounded the revenue in Compustat to the nearest million for matching purposes. We found an exact match between the two databases on revenue for a majority of the companies, providing us with strong confidence that the companies are indeed the same. If the names of the companies were not the same, the company's history was perused through the company's website, the websites encyclopedia of company histories, Wikipedia, Answers.com, as well as searches using the Internet search engine Google. Data was retained only for companies that met both criteria, i.e., there had to be an exact match between the revenue reported in InformationWeek and Compustat, and if the names were not the same, the name change had to be verified through the public data sources used. The rigorous criteria used for matching increase the confidence in the integrity of our data set.

4.2 Measurement of Research Variables

In this section, we define measures for our variables based on the two-order effect theory. The measures for the independent, dependent, and mediating variables, in particular, should follow as close as possible from the theory to increase validity of the study. In doing so, we make a valuable contribution over previous studies that chose arbitrary measures for productivity and performance, or included multiple measures of productivity or performance and searched for relationships with any or all of these measures (for examples, see Bharadwaj 2000; Mahmood & Mann 1993; Peslak 2003; Sircar, Turnbow & Bordoloi 2000)

In the hypotheses development, we specified that it is the IT intensity of the firm that is the differentiating factor. Firm IT Intensity refers to the IT investment per employee. This construct is chosen as the theorized first-order effect occurs by making employees more productive. Therefore, it is the employees who are empowered through IT, and this is what is theorized to cause the first order effect.

The variable Firm Productivity was operationalized as Revenue divided by Employees. This operationalization captures the theorized effect of IT on productivity, i.e.; IT allows the same number of employees to do an increased amount of work or that for a given volume of sales the number of employees can be reduced with IT. This is also demonstrated by the examples of Frito-Lay, the RCA experiment, and Merrill-Lynch where a growth in sales could be handled without a corresponding growth in the number of employees.

Similarly, the second order effect is theorized to increase firm performance by empowering knowledge workers with more valuable information to improve their decision-making. Therefore, we expect each employee to improve their performance, and this is best captured through Net Income of the firm per employee.

In addition, we also note that the size of the firm was controlled for, as we operationalize the independent, dependent and mediating variables as a ratio of the number of employees.

We further refine our operationalization by addressing several concerns in using absolute dollar values in the variables. First, when IT investment is compared across industries and time, there is an inherent assumption that firms invest in similar information technologies across the sample, and therefore, their effects are comparable. However, the way IT is invested varies greatly across industry and over the years, grossly violating this assumption. Second, there are external industry and temporal effects that could affect the results of our data set. Third, the results may be sensitive to price deflators as IT depreciates at a faster rate than other assets and this differential depreciation can affect the results of this study. To take care of these issues, the independent, dependent and mediating variables are operationalized as relative to their competitors in each 2 digit sic code for each year. Therefore, the variables are operationalized as z scores for each industry for each year.

Industry-level data for the environmental variables were obtained from the Bureau of Economic Analysis (BEA), which is an agency of the United States Department of Commerce, and part of the Department's Economics and Statistics Administration (Bureau of Economic Analysis, 2007). The BEA conducts the Census of Manufactures every 5 years, in years ending with "2" and "7", and collects data from all United States establishments that fall in the Standard Industrial Classification (SIC) Division D (Manufacturing) (Bureau of Economic Analysis, 2007). In the years between the five-year Censuses, the BEA conducts the Annual Survey of Manufactures. The Census of Manufactures as well as the Annual Survey of Manufactures includes data on Value of Shipments, which has been used as a surrogate for the total volume of sales in an industry (Al-Shammari, 2006; Dess & beard 1984; Goll & Rasheed 1997, 2004, 2005; Rasheed & Prescott, 1992). Following Rasheed and Prescott (1992), environmental munificence was operationalized as the growth rate in the value of shipments, obtained by the regression coefficient of the value of shipments regressed against the year for ten years preceding the data point. Environmental dynamism was operationalized as the error term in the regression coefficient divided by the mean value of shipments for the ten years in the regression equation (Goll & Rasheed, 1997). Environmental dynamism and munificence was calculated at the two-digit SIC level for ten years preceding the data point. For example, for Dole Foods in 1997, environmental dynamism and munificence were calculated for SIC group 20 from the years 1987-1996. A time lag of one year was chosen between the independent, mediating, and dependent variables, as this was the smallest time lag allowed by the data set. A time lag of two years may be too long as that would mean a four year time lag between the independent and dependent variable, which may be too long to discern any significant relationships between the variables.

CHAPTER 5

ANALYSIS OF RESULTS

This chapter is organized into four sections corresponding to the four research questions of our study. The first section presents the results of the hypotheses tests for the base two-order effect model. The second section deals with the research question of the moderating effects of industry information intensity. The third and fourth section present the results for the third and fourth research questions, the moderating effects of environmental dynamism, and the moderating effects of environmental munificence, respectively.

5.1 The Two-Order Effect Model

To test Hypothesis 1, the effect of Firm IT Intensity in time 1 on Productivity in time 2, we ran the model in table 5.1. As we can see from this table the effects of the years and the industries are completely controlled for by our operationalization of Firm IT Intensity and Productivity as z scores for each industry for each year. As hypothesized, Firm IT Intensity in time 1 is significantly and positively related to Firm Productivity in time 2 ($b=0.430$, $p<=0.001$). This lends strong support for hypothesis 1.

Table 5.1: Testing Hypothesis 1

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.004	.104		-.034	.973
y92	.001	.113	.001	.013	.990
y93	.014	.112	.005	.125	.901
y94	-.001	.117	.000	-.005	.996
y95	.002	.102	.001	.018	.986
y96	.002	.103	.001	.016	.987
y97	.003	.152	.001	.019	.985
sic20	.001	.151	.000	.010	.992
sic22	.001	.364	.000	.004	.997
sic23	.002	.614	.000	.003	.998
sic24	-.002	.272	.000	-.006	.996
sic25	.002	.272	.000	.008	.994
sic26	.000	.143	.000	.001	.999
sic27	.002	.164	.000	.010	.992
sic28	.001	.120	.000	.006	.996
sic29	.000	.172	.000	-.001	.999
sic30	.002	.263	.000	.008	.994
sic32	.002	.361	.000	.005	.996
sic33	.000	.160	.000	.003	.998
sic34	.000	.180	.000	.000	1.000
sic35	.001	.120	.000	.007	.994
sic36	.000	.152	.000	.003	.998
sic37	.001	.129	.000	.006	.995
sic38	.001	.145	.000	.008	.994
sic61	-.001	.316	.000	-.005	.996
sic62	.003	.237	.000	.012	.991
sic63	.032	.152	.008	.208	.835
sic64	.002	.437	.000	.004	.997
sic67	.002	.613	.000	.003	.998
Firm IT Intensity	.430	.032	.431	13.634	.000

a Dependent Variable: Firm Productivity

We then test the relationship between Firm IT Intensity in time 1 and Firm Performance in time 3 for Hypothesis 2:

Table 5.2: Testing Hypothesis 2

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.005	.112		-.047	.962
y92	.002	.121	.001	.018	.986
y93	.021	.121	.008	.172	.863
y94	-.001	.126	.000	-.006	.995
y95	.003	.109	.001	.024	.980
y96	.003	.111	.001	.023	.982
y97	.004	.164	.001	.026	.979
sic20	.002	.162	.001	.013	.989
sic22	.002	.391	.000	.006	.995
sic23	.003	.659	.000	.004	.997
sic24	-.002	.293	.000	-.008	.994
sic25	.003	.292	.000	.011	.991
sic26	.000	.154	.000	.001	.999
sic27	.002	.177	.001	.014	.989
sic28	.001	.129	.000	.008	.994
sic29	.000	.185	.000	-.002	.999
sic30	.003	.283	.000	.011	.992
sic32	.003	.388	.000	.007	.994
sic33	.001	.172	.000	.004	.997
sic34	.000	.193	.000	.000	1.000
sic35	.001	.129	.000	.010	.992
sic36	.001	.163	.000	.004	.997
sic37	.001	.138	.000	.009	.993
sic38	.002	.155	.000	.010	.992
sic61	-.002	.340	.000	-.006	.995
sic62	.004	.254	.001	.016	.987
sic63	.047	.164	.011	.286	.775
sic64	.003	.470	.000	.006	.995
sic67	.003	.658	.000	.004	.997
Firm IT Intensity	.239	.034	.239	7.051	.000

a Dependent Variable: Firm Performance

Here we see that Firm IT Intensity in time 1 has a strong and significant effect on Firm Performance in time 3 (b=0.239, p<=0.001). However, we see that the size of the relationship is less than that on Firm Productivity at time 2, as seen in the previous hypothesis test. This finding is consistent with previous research that finds a strong relationship with productivity but much less of a relationship with firm performance. Hitt and Brynjolfsson (1996), for example, found a significant, positive relationship between IT investment and firm productivity but a weak negative relationship with performance. The weaker relationship between IT and Performance is as expected because performance is a more downstream variable than productivity, and several other factors may influence it.

To test the mediating effect of productivity on the IT to firm performance relationship, we run two additional models. The previous two models tested the effect of the independent variable (Firm IT Intensity) on the mediator (Firm Productivity) and the dependent variable (Firm Performance). To assess the mediating effect, we also have to test the effect of the mediator on the dependent variable, and the relative significance of the independent and mediating variables on the dependent.

As with the industrial economics thesis, Firm productivity has a strong and positive relationship with firm performance ($b=0.330$, $p<=0.001$). While the relationship is highly significant, the size of the relationship is small, but larger than that of Firm IT Intensity in time 1. This lends some credence to our reasoning that Firm IT Intensity is more upstream than Firm Productivity in trying to predict Firm Performance.

Table 5.3: Testing Hypothesis 3

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.004	.109		-.040	.968
y92	.002	.118	.001	.015	.988
y93	.017	.117	.006	.144	.886
y94	-.001	.122	.000	-.005	.996
y95	.002	.106	.001	.020	.984
y96	.002	.108	.001	.019	.985
y97	.003	.159	.001	.022	.983
sic20	.002	.158	.000	.011	.991
sic22	.002	.380	.000	.005	.996
sic23	.002	.641	.000	.004	.997
sic24	-.002	.284	.000	-.006	.995
sic25	.003	.283	.000	.009	.993
sic26	.000	.150	.000	.001	.999
sic27	.002	.172	.000	.011	.991
sic28	.001	.125	.000	.006	.995
sic29	.000	.180	.000	-.001	.999
sic30	.002	.275	.000	.009	.993
sic32	.002	.377	.000	.006	.995
sic33	.001	.167	.000	.003	.997
sic34	.000	.188	.000	.000	1.000
sic35	.001	.125	.000	.009	.993
sic36	.001	.158	.000	.003	.997
sic37	.001	.134	.000	.007	.994
sic38	.001	.151	.000	.009	.993
sic61	-.002	.330	.000	-.005	.996
sic62	.003	.247	.000	.014	.989
sic63	.038	.159	.009	.239	.811
sic64	.002	.457	.000	.005	.996
sic67	.002	.640	.000	.003	.997
Firm Productivity	.330	.033	.331	10.022	.000

a Dependent Variable: Firm Performance

To check for support for the two-order effect of IT, we test the mediating model by entering Firm IT Intensity as an independent variable into the model above. If the effect of IT on performance is a cumulative effect of its effect on productivity, then we should see complete mediation. However, if IT has a second-order effect on performance above that what is produced by its effect on productivity, we should see an independent, direct effect.

Table 5.4: Testing Hypothesis 3

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.004	.108		-.040	.968
y92	.002	.117	.001	.015	.988
y93	.017	.117	.006	.145	.885
y94	-.001	.122	.000	-.005	.996
y95	.002	.105	.001	.021	.984
y96	.002	.107	.001	.019	.985
y97	.003	.158	.001	.022	.983
sic20	.002	.157	.000	.011	.991
sic22	.002	.378	.000	.005	.996
sic23	.002	.637	.000	.004	.997
sic24	-.002	.283	.000	-.006	.995
sic25	.003	.282	.000	.009	.993
sic26	.000	.149	.000	.001	.999
sic27	.002	.171	.000	.011	.991
sic28	.001	.125	.000	.006	.995
sic29	.000	.179	.000	-.001	.999
sic30	.002	.273	.000	.009	.993
sic32	.002	.375	.000	.006	.995
sic33	.001	.166	.000	.003	.997
sic34	.000	.187	.000	.000	1.000
sic35	.001	.125	.000	.009	.993
sic36	.001	.157	.000	.003	.997
sic37	.001	.133	.000	.007	.994
sic38	.001	.150	.000	.009	.993
sic61	-.002	.328	.000	-.005	.996
sic62	.003	.246	.000	.014	.989
sic63	.038	.158	.009	.240	.810
sic64	.002	.454	.000	.005	.996
sic67	.002	.636	.000	.003	.997
Firm IT Intensity	.119	.036	.119	3.276	.001
Firm Productivity	.279	.036	.280	7.689	.000

a Dependent Variable: Firm Performance

When we put both Firm IT Intensity and Firm Productivity in the model to predict Firm performance, we see that both the variables are significant and positive predictors. However, their effects are reduced from the models in which they were used to predict Firm performance independent of each other. In model 3 (Table 5.3), Firm Productivity had a beta of 0.330 while in model 4 (Table 5.4); the beta has reduced to 0.279. In model 2 (Table 5.2), Firm IT Intensity had a beta of 0.239 while in model 4 (Table 5.4); the regression coefficient reduces to 0.119. From this, we see that while both coefficients have reduced in value, we see that the coefficient for IT Intensity has reduced more than the coefficient for Productivity. In addition, while the Productivity stays highly significant ($p<0.001$), IT Intensity has reduced in significance. In the model without Productivity, IT Intensity was a highly significant predictor of performance ($p<0.001$). However, when Productivity is added to the model, the significance of IT Intensity reduces ($p<0.05$) (Baron and Kenny, 1986). Therefore, we conclude that Firm Productivity in time 2 mediates the effect of Firm IT Intensity in time 1 to Firm performance in time 3, lending support for Hypothesis 3. These relationships are shown in figures 5.1 and 5.2.

This goes to show that the effect of Firm IT Intensity on Firm Performance is not merely the results of the productivity improvements that IT causes. In addition to this effect, we also have a direct, independent effect on performance. This is a very important finding as it lends strong support for the two-order effect model. In addition, the partial mediation of Productivity on the IT Intensity – Performance relationship lends support to our claim that the effect of IT Intensity on Performance may be direct in some environments, and mediated by Productivity in other environments. In Table 5.5, the results for testing hypotheses related to the base research model are summarized.

Table 5.5: Results of Hypotheses Tests for Base Model

Hypothesis	Result
H1: Firm IT Intensity in time 1 will have a positive relationship with Firm Productivity in time 2	Strongly Supported
H2: Firm IT Intensity in time 1 will have a positive relationship with Firm Performance in time 3	Strongly Supported
H3: The relationship between Firm IT Intensity in time 1 and Firm Performance in time 3 will be mediated by Firm productivity in Time 2	Supported

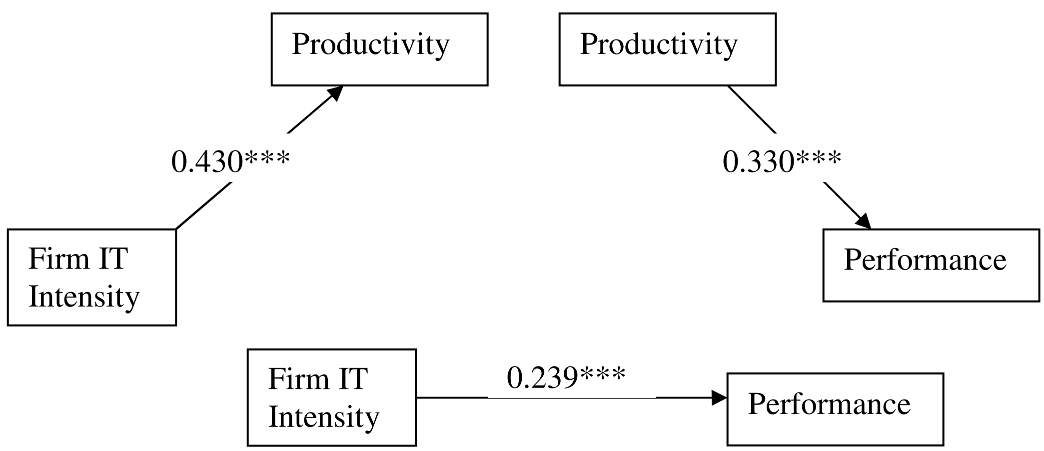

Figure 5.1: Direct Relationships between Variables in the Two-Order Effect Model

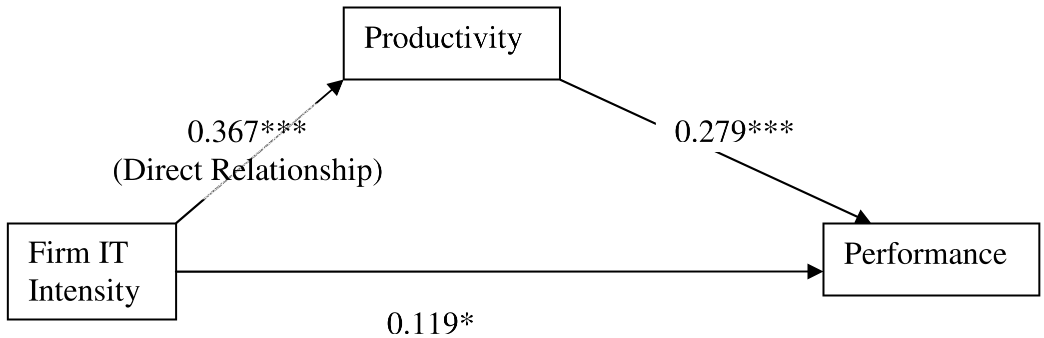

Figure 5.2: Mediating Effect of Firm Productivity on the Firm IT Intensity to Firm Performance Relationship

5.2 Moderating Effects of Information Intensity

We now test the moderating effects of Information Intensity. To test the moderating effect on Firm productivity, we run the following model:

$$\text{Firm Productivity} = \beta + \beta_1 \text{ IT} + \beta_2 \text{ Info Intensity} + \beta_3 \text{ IT x Info Intensity} + e$$

Where

IT is the Firm IT Intensity

Info Intensity is a dummy variable for the information intensity of the sector – this is coded as 1 for high information intensive sector and 0 for low information intensive sector

At low information intensity:

Info Intensity = 0

The model simplifies to:

$$\text{Firm Productivity} = \beta + \beta_1 \text{ IT} + \beta_2 \text{ x } 0 + \beta_3 \text{ IT x } 0 + e$$

$$\text{Firm Productivity} = \beta + \beta_1 \text{ IT} + e$$

This indicates that β1 is the coefficient for Firm IT Intensity for the Low Information Intensity subset.

At high information intensity:

Info Intensity = 1

The model is:

$$\text{Firm Productivity} = \beta + \beta_1 \text{ IT} + \beta_2 \text{ x } 1 + \beta_3 \text{ IT x } 1 + e$$

$$\text{Firm Productivity} = (\beta + \beta_2) + (\beta_1 + \beta_3) \text{ IT} + e$$

This indicates that $(\beta_1 + \beta_3)$ is the coefficient for Firm IT Intensity for the High Information Intensity subset. Therefore the difference between the coefficients for the Low and High Information Subsets is:

$$(\beta_1 + \beta_3) - \beta_1 = \beta_3$$

Therefore, β_3 is the coefficient for the difference between the high and Low Information intensity subsets. If this term is significant, it will indicate that there is a significant difference between the coefficients for the IT effect for the high and low information intensity subsets, supporting the moderation hypothesis.

Table 5.6: Testing Hypothesis 4

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.032		.000	1.000
Firm IT Intensity	.379	.035	.379	10.851	.000
Info Intensity	.007	.070	.003	.098	.922
IT x Info Intensity	.235	.075	.110	3.143	.002

a Dependent Variable: Firm Productivity

In this model, we see that this coefficient is significant ($p<=0.01$), lending support for hypothesis 4. In low information intensive sectors, the coefficient for the effect of Firm IT Intensity on Firm Productivity is β_1, which in the above model is 0.379. In highly information intensive sectors, the coefficient for the effect of Firm IT Intensity on Firm Productivity is ($\beta_1 + \beta_3$), which is 0.379 + 0.235 = 0.614.

The high coefficient for Firm IT Intensity for highly information intensive sectors demonstrates the strong business value of IT in these sectors.

Similarly we test for the moderating effects of Information Intensity on Firm performance with the following model:

$$\text{Firm performance} = \beta + \beta_1 \text{ IT} + \beta_2 \text{ Info Intensity} + \beta_3 \text{ IT x Info Intensity} + e$$

At low information intensity:

$$\text{Firm performance} = \beta + \beta_1 \text{ IT} + e$$

At high information intensity:

$$\text{Firm performance} = (\beta + \beta_2) + (\beta_1 + \beta_3) \text{ IT} + e$$

Table 5.7: Testing Hypothesis 5

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.035		.000	1.000
Firm IT Intensity	.174	.037	.174	4.645	.000
Hi Info Intensity	.010	.075	.005	.138	.890
IT x Info Intensity	.299	.080	.140	3.728	.000

a Dependent Variable: Firm Performance

In this model, we see that the coefficient of Firm IT Intensity in predicting Firm Performance for Low Information Intensive sectors is 0.174 (β_1). The coefficient for

Firm IT Intensity in predicting Firm Performance for High Information Intensive sectors is ($\beta_1 + \beta_3$), which is 0.174 + 0.299 = 0.473. The difference between the two coefficients is significant ($p<=0.001$ for β_3), lending strong support for hypothesis 5.

Similarly, we test for differences in the effects of productivity on performance in high and low information intensive sectors with the following model:

$$\text{Firm performance} = \beta + \beta_1 \text{ Prod} + \beta_2 \text{ Info Intensity} + \beta_3 \text{ Prod x Info Intensity}$$

Where Prod = Firm Productivity

At low information intensity:

$$\text{Firm performance} = \beta + \beta_1 \text{ Prod} + e$$

At high information intensity:

$$\text{Firm performance} = (\beta + \beta_2) + (\beta_1 + \beta_3) \text{ Prod} + e$$

Table 5.8: Testing Hypothesis 6

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.033		.000	1.000
Firm Productivity	.225	.036	.225	6.273	.000
Hi Info Intensity	.006	.072	.002	.077	.938
Prod x Info Intensity	.492	.077	.229	6.378	.000

a Dependent Variable: Firm Performance

From the model, we see that the effect of Productivity on Performance in low information intensive sectors is low, at 0.225 (β_1). The effect of productivity on performance in high information intensive sectors is much higher, at 0.717 ($\beta1 + \beta_3$ =

0.225 + 0.492 = 0.717). The difference between the two slopes 0.492 (β_3), is highly significant ($p<=0.001$), lending strong support for hypothesis 6.

Finally we test the moderated mediation hypothesis using the following model.

$$\text{Firm Performance} = \beta_0 + \beta_1 \text{ IT x Lo Info Intensity} + \beta_2 \text{ IT x Hi Info Intensity} + \beta_3 \text{ Prod x Hi Info Intensity} + \beta_4 \text{ Prod x Lo Info Intensity} + e$$

For the Low Information Intensity subset, Lo Info Intensity = 1, Hi Info Intensity = 0, therefore the model becomes:

$$\text{Firm Performance} = \beta_0 + \beta_1 \text{ IT} + \beta_4 \text{ Prod} + e$$

For the High Information Intensity subset, Lo Info Intensity = 0, and Hi Info Intensity =1, therefore the model becomes:

$$\text{Firm Performance} = \beta_0 + \beta_2 \text{ IT} + \beta_3 \text{ Prod} + e$$

Table 5.9: Testing Hypothesis 7

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.001	.029		.041	.967
IT x Lo Info Intensity	.104	.039	.092	2.687	.007
IT x Hi Info Intensity	.053	.086	.025	.619	.536
Prod x Hi Info Intensity	.683	.087	.318	7.896	.000
Prod x Lo Info Intensity	.185	.039	.164	4.811	.000

a Dependent Variable: Firm Performance

From this model, we see that for the low information intensity subset, although Firm Productivity (β_4) is a significant predictor of firm performance, Firm IT Intensity is still significant (β_1), albeit with reduced slope and significance. This indicates partial mediation of Firm Productivity on the Firm IT Intensity to Firm Performance relationship at Low Information Intensity. However at high information intensity, Firm IT Intensity is insignificant (β_2) and Firm productivity remains strong and highly significant (β_3). This demonstrates complete mediation of Firm Productivity on the Firm IT Intensity to Firm Performance relationship at High Information Intensity, lending support for hypothesis 7.

Table 5.10: Results of Hypotheses Tests for Moderating Effects of Information Intensity

Hypothesis	Result
H4: Firm IT Intensity will be more positively related to Firm Productivity in sectors with high information intensity than those with low information intensity.	Supported
H5: Firm IT Intensity will be more positively related to Firm Performance in sectors with high information intensity than those with low information intensity.	Strongly Supported
H6: Firm Productivity will be more positively related to Firm Performance in sectors with high information intensity than those with low information intensity.	Strongly Supported
H7: The relationship between Firm IT Intensity and Firm Performance is more positively mediated by Firm productivity in environments with high information intensity than environments with low information intensity	Supported

5.3 Moderating Effects of Environmental Dynamism

To test the effects of environmental dynamism on the relationships in the base model, a dummy variable for dynamism was coded with 1 for high dynamism and 0 for low dynamism. To test the moderating effect on the IT to Productivity relationship, we run two regressions on the high and low dynamism subsets:

Table 5.11: Low Dynamism: IT Intensity (time 1) to Productivity (time 2)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.044		.000	1.000
Firm IT Intensity	.377	.048	.377	7.906	.000

a Dependent Variable: Productivity
b Selecting only cases for which Dynamism = 0

Table 5.12: High Dynamism: IT Intensity (time 1) to Productivity (time 2)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.064		.000	1.000
Firm IT Intensity	.347	.068	.347	5.085	.000

a Dependent Variable: Productivity
b Selecting only cases for which Dynamism = 1

From these, we see that the effect of IT Intensity on Productivity is higher for low dynamism environments than high dynamism environments. The direction of the moderating effect is the same as predicted by hypothesis 8. However, the difference between the regression slopes (0.377 for the low dynamism subset and 0.347 for the high dynamism subset) is very small. To test if this difference is significant, we run a model with the independent and interacting effects of Firm IT Intensity and Environmental Dynamism.

In this model, the coefficient for Firm IT Intensity represents the slope for the subset coded as 0 (in this case, low dynamism, $b=0.367$, $p<0.001$). The interaction term represents the difference between the slopes of the two subsets, i.e. the slope of the high dynamism subset – the slope of the low dynamism subset = the coefficient for the interaction term (0.347 – 0.377 = -.030). However, this difference is not significant; therefore Hypothesis 8 is not supported.

Table 5.13: Moderating Effects of Environmental Dynamism on the IT Intensity to Productivity Relationship

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.045		.000	1.000
Firm IT Intensity	.377	.048	.377	7.856	.000
Dynamism	.000	.077	.000	.000	1.000
IT x Dynamism	-.030	.083	-.018	-.365	.715

a Dependent Variable: Productivity

Next, we test the moderating effects on Environmental Dynamism on the Firm IT Intensity – Firm Performance relationship.

Table 5.14: Low Dynamism: IT Intensity (time 1) to Performance (time 3)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.047		.000	1.000
Firm IT Intensity	.158	.051	.158	3.116	.002

a Dependent Variable: Performance
b Selecting only cases for which Dynamism = 0

Table 5.15: High Dynamism: IT Intensity (time 1) to Performance (time 3)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.066		.000	1.000
Firm IT Intensity	.234	.071	.234	3.303	.001

a Dependent Variable: Performance
b Selecting only cases for which Dynamism = 1

From the models, we see that the coefficient for Firm IT Intensity is 0.234 (p<=0.001) in the high dynamism subset and 0.158 (p<=0.01) in the low dynamism subset. This is in accordance with hypothesis 9 which predicts that Firm IT Intensity will be more positively related to Firm performance in environments with high dynamism. To test if the difference between the slopes is significant, we enter the moderator and interaction term into the model:

Table 5.16: Moderating effects of Environmental Dynamism on the IT Intensity to Performance Relationship

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.047		.000	1.000
Firm IT Intensity	.158	.051	.158	3.126	.002
Dynamism	.000	.081	.000	.000	1.000
IT x Dynamism	.075	.087	.044	.860	.390

a Dependent Variable: Performance

From the table, we see that the difference between the slopes of the two subsets, represented by the interaction term IT x Dynamism is not significant. Therefore, we conclude that we do not have support for Hypothesis 9.

Next, we test the moderated mediation hypothesis, i.e., we test the moderating effects of environmental dynamism on the mediation of productivity on the IT – performance relationship. To test this, we first test the productivity-performance relationship.

Table 5.17: Low Dynamism: Productivity (time 2) to Performance (time 3)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.046		.000	1.000
Productivity	.290	.049	.290	5.893	.000

a Dependent Variable: Performance
b Selecting only cases for which Dynamism = 0

Table 5.18: High Dynamism: Productivity (time 2) to Performance (time 3)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.067		.000	1.000
Productivity	.176	.072	.176	2.455	.015

a Dependent Variable: Performance
b Selecting only cases for which Dynamism = 1

Table 5.19: Moderating effects of Environmental Dynamism on the Productivity to Performance Relationship

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.046		.000	1.000
Productivity	.176	.070	.176	2.512	.012
Dynamism	.000	.080	.000	.000	1.000
Productivity x Dynamism	.115	.086	.093	1.334	.183

a Dependent Variable: Performance

From the above models, we see that Productivity is a significant and positive predictor of Performance in both high dynamism environments as well as low dynamism environments. We also see that Productivity is more positive and more significant in low dynamism environments ($b=0.290$, $p<=0.001$) than in high dynamism environments ($b=0.176$, $p<=0.05$), in accordance with our theoretical argument. However, this difference is not significant.

We then enter both the mediator (Productivity) as well as the independent variable (IT Intensity) into the models to predict performance at high and low dynamism.

Table 5.20: Low Dynamism: Mediating Effect of Firm Productivity on the Firm IT Intensity to Firm Performance relationship

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.046		.000	1.000
Productivity	.269	.053	.269	5.054	.000
Firm IT Intensity	.057	.053	.057	1.073	.284

a Dependent Variable: Performance
b Selecting only cases for which Dynamism = 0

From the table above, we see that there is a difference between the mediating effect of firm productivity in the full sample and the low dynamism sample: In the model above, Firm productivity has a significant and positive relationship (b=0.269, p<0.001) with Firm Performance, while the independent effect of Firm IT Intensity is insignificant. Therefore, the entire variance in Firm Performance that was earlier explained by Firm IT Intensity is now completely explained by Firm productivity. We conclude that the effect of Firm IT Intensity on Firm performance if fully mediated by Firm Productivity, supporting Hypothesis 11.

In the High Dynamism sample, we see exactly the opposite of the earlier mediation model. In this model, the effect of Firm Productivity on Firm performance is insignificant while the effect of Firm IT Intensity is significant and positive (b=0.196, p<=0.01). Therefore, in high dynamism, Firm IT Intensity has a direct and positive effect on Firm Performance, and this effect is not mediated by Firm Productivity. This lends support to Hypothesis 11.

Table 5.21: High Dynamism: Mediating Effect of Firm Productivity on the Firm IT Intensity to Firm Performance relationship

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.066		.000	1.000
Productivity	.108	.075	.108	1.432	.154
Firm IT Intensity	.196	.075	.196	2.609	.010

a Dependent Variable: Performance
b Selecting only cases for which Dynamism = 1

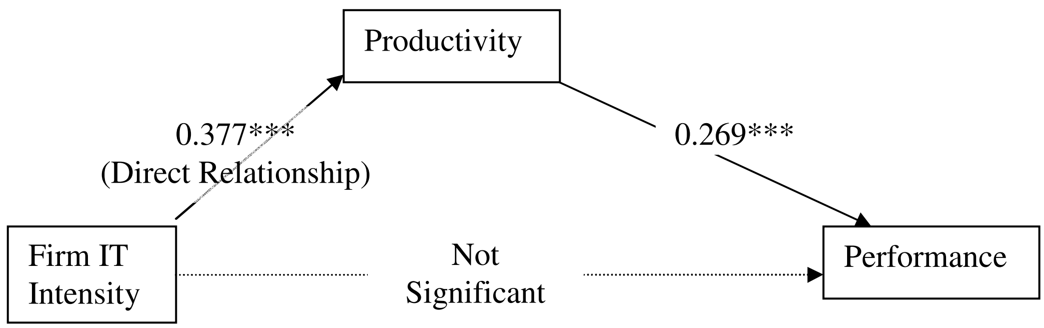

Figure 5.3: Firm IT Intensity – Firm Performance Relationship in Environments with Low Dynamism

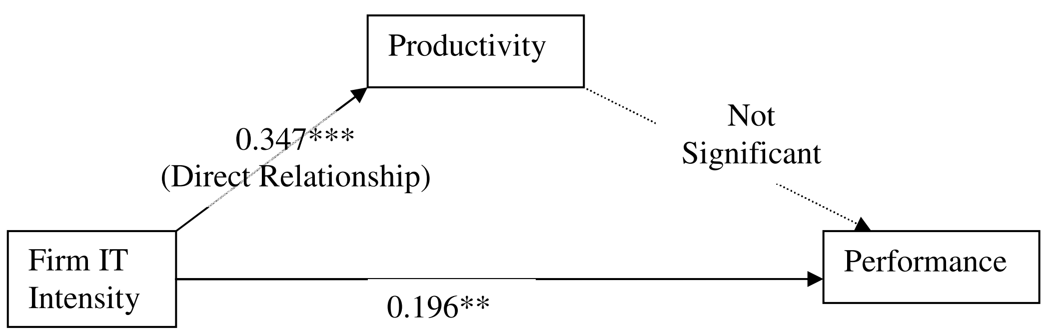

Figure 5.4: Firm IT Intensity – Firm Performance Relationship in Environments with High Dynamism

From the two results above, we have strong support for Hypothesis11. The effect of Firm IT Intensity on Firm Performance is completely mediated by Firm Productivity in Low Dynamism environments. In environments with High Dynamism however, there is no mediating effect of Firm Productivity; Firm IT Intensity has a direct impact on Firm Performance.

Table 5.22: Results of Hypotheses Tests for Moderating Effects of Environmental Dynamism

Hypothesis	Result
H8: Firm IT Intensity will have a more positive relationship with Firm Productivity in environments with low dynamism than with high dynamism.	Not Supported
H9: Firm Productivity will be more positively related to Firm Productivity in environments with low dynamism than with high dynamism..	Not Supported
H10: Firm IT Intensity will have a more positive relationship with Firm Performance in environments with high dynamism than with low dynamism.	Not Supported
H11: The relationship between Firm IT Intensity and Firm Performance will be more positively mediated by Firm productivity in low dynamism than in high dynamism	Strongly Supported

The strong support for hypothesis 11 is a very significant finding. It lends strong credence to the two-order effect model, as we now have strong support that IT indeed impacts performance through two different effects. In addition, the strong support for hypothesis 11 also demonstrates the efficacy of the first and second order effect contingent on environmental dynamism. The first-order effect is better as an IT investment strategy in environments with low dynamism, as the variation in firm performance can be completely explained by the impact of IT on productivity. The second-order effect is better as an IT investment strategy in environments with high dynamism, as this directly affects performance whereas the productivity improvements do not. We also see that although we derived hypothesis 11 from hypothesis 8 through 10, hypothesis 11 is the only one supported and the hypotheses we base this on are not. We will discuss the implications of this in detail in our conclusion section.

5.4 Moderating Effects of Environmental Munificence

We first test the moderating effects of environmental munificence on the Firm IT Intensity to Firm Productivity relationship.

Table 5.23: Low Munificence: IT Intensity (time 1) to Productivity (time 2)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.057		.000	1.000
Firm IT Intensity	.139	.064	.139	2.184	.030

a Dependent Variable: Productivity
b Selecting only cases for which Munificence = 0

Table 5.24: High Munificence: IT Intensity (time 1) to Productivity (time 2)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.045		.000	1.000
Firm IT Intensity	.521	.047	.521	10.982	.000

a Dependent Variable: Productivity
b Selecting only cases for which Munificence = 1

Table 5.25: Moderating Effect of Environmental Munificence on the Firm IT Intensity to Firm Productivity Relationship

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.054		.000	1.000
Firm IT Intensity	.139	.060	.139	2.302	.022
Munificence	.000	.072	.000	.000	1.000
IT x Munificence	.383	.078	.296	4.903	.000

a Dependent Variable: Productivity

From the results above, we see that Firm IT Intensity in time 1 is significantly and positively related to Firm Productivity in time 2 in both environments with low munificence as well as environments with high munificence. However, in environments high in munificence, the influence of firm IT intensity is more positive and more significant (b=0.521, p<=0.001) than in environments low in munificence (b=0.139, p<=0.05). We also see that the difference between the two slopes is highly significant, as indicated by the interaction effect (0.521 – 0.139 = 0.383, p<=0.001). This lends strong support for Hypothesis 12.

Table 5.26: Low Munificence: IT Intensity (time 1) to Performance (time 3)

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.057		.000	1.000
Firm IT Intensity	.159	.063	.159	2.511	.013

a Dependent Variable: Performance
b Selecting only cases for which Munificence = 0

Table 5.27: High Munificence: IT Intensity (time 1) to Performance (time 3)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.052		.000	1.000
Firm IT Intensity	.201	.055	.201	3.678	.000

a Dependent Variable: Performance
b Selecting only cases for which Munificence = 1

From the above results, we see that Firm IT Intensity has a significant and positive relationship with Firm Performance in both high munificence as well as low munificence environments. In addition, the relationship is more positive and more significant in high munificence environments (b=0.201, p<=0.001) than in low munificence environments (b=0.159, p<=0.05), in accordance with Hypothesis 13. However, this difference is not significant, as shown by the interaction term in the model above. Therefore, we have no support for Hypothesis 13.

Table 5.28: Moderating Effects of Environmental Munificence on the IT Intensity to Performance relationship

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.059		.000	1.000
Firm IT Intensity	.159	.065	.159	2.446	.015
Munificence	.000	.078	.000	.000	1.000
IT x Munificence	.041	.084	.032	.492	.623

a Dependent Variable: Performance

Next, we test the moderated mediation hypothesis. That is, we test the moderating effect of environmental munificence on the mediating effect of productivity on the IT Intensity to Performance relationship.

Table 5.29: Low Munificence: Productivity (time 2) to Performance (time 3)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.057		.000	1.000
Productivity	.132	.064	.132	2.070	.039

a Dependent Variable: Performance
b Selecting only cases for which Munificence = 0

Table 5.30: High Munificence: Productivity (time 2) to Performance (time 3)

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.050		.000	1.000
Productivity	.333	.052	.333	6.350	.000

a Dependent Variable: Performance
b Selecting only cases for which Munificence = 1

Table 5.31: Moderating Effects of Environmental Munificence on the Productivity to Performance relationship

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.057		.000	1.000
Productivity	.132	.064	.132	2.067	.039
Munificence	.000	.076	.000	.000	1.000
Productivity x Munificence	.202	.082	.156	2.443	.015

a Dependent Variable: Performance

From the above models, we see that productivity has a significant and positive relationship with Firm performance in both environments with low munificence as well as environments with high munificence. We also see that this relationship is more positive and more significant in environments with high munificence (b=0.333, p<=0.001) than in environments with low munificence (b=0.132, p<=0.05), in accordance with our reasoning. In addition, we see that the difference between the slopes of these two models is significant (0.333-0.132=0.202, p<=0.05). This indicates that productivity is more strongly related with performance in environments with high munificence. This lends strong support for hypothesis 14, and our theoretical claim that productivity may be a more important differentiator in environments with higher munificence than environments with lower munificence

Finally, we enter both Firm IT Intensity as well as Firm Productivity in the models to predict Firm Performance.

Table 5.32: Low Munificence: Mediating Effect of Firm Productivity on the Firm IT Intensity to Firm Performance relationship

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.057		.000	1.000
Productivity	.112	.064	.112	1.755	.081
Firm IT Intensity	.144	.064	.144	2.254	.025

a Dependent Variable: Performance
b Selecting only cases for which Munificence = 0

In environments with low munificence, we see that Firm IT Intensity is positive and significant (b=0.144, p<=0.05), while Firm Productivity is not significant. This indicates that Firm IT Intensity directly affects Firm Performance and is not mediated by Firm productivity in environments with Low Munificence, lending support for Hypothesis 15.

Table 5.33: High Munificence: Mediating Effect of Firm Productivity on the Firm IT Intensity to Firm Performance Relationship

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.000	.050		.000	1.000
Productivity	.314	.062	.314	5.102	.000
Firm IT Intensity	.037	.062	.037	.598	.550

a Dependent Variable: Performance
b Selecting only cases for which Munificence = 1

We see exactly the opposite result in environments with high munificence. Here, the effect of Firm IT Intensity is small and not significant, while the effect of

Productivity is positive and highly significant (b=0.314, p<=0.001), lending strong support for Hypothesis 15.

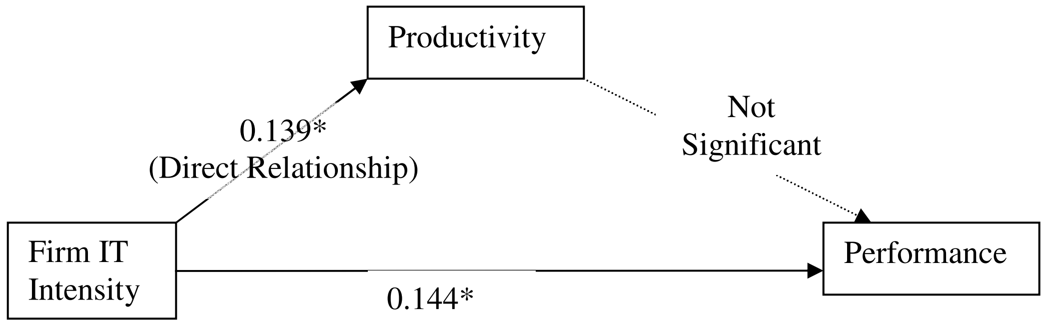

Figure 5.5: Firm IT Intensity – Firm Performance Relationship in Environments with Low Munificence

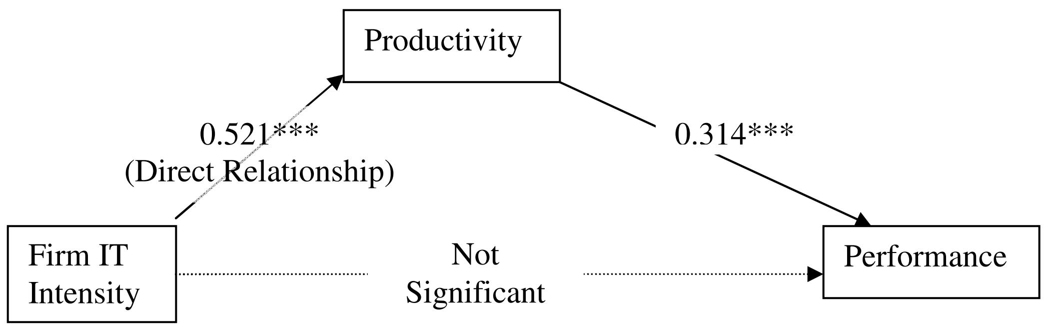

Figure 5.6: Firm IT Intensity – Firm Performance Relationship in Environments with High Munificence

From the results of above, we conclude that environmental munificence moderates the mediating effect of Productivity on the IT-Performance relationship. In environments with high munificence, the effect of IT Intensity on Firm performance is completely mediated by Firm productivity. In environments with low munificence, the effect of IT Intensity on Firm Performance is direct and is not mediated by Firm productivity. These results lend strong support to Hypothesis 15.

Table 5.34: Results of Hypotheses Tests for Moderating Effects of Environmental Dynamism

Hypothesis	Result
H12: Firm IT Intensity will have a more positive relationship with Firm Productivity in environments with high Munificence than low Munificence.	Strongly Supported
H13: Firm IT Intensity will have a more positive relationship with Firm Performance in environments with high Munificence than low Munificence.	Not Supported
H14: Firm Productivity will have a more positive relationship with Firm Performance in environments with high Munificence than with low Munificence.	Supported
H15: The relationship between Firm IT Intensity and Firm Performance will be more positively mediated by Firm productivity in low Munificence than in high Munificence	Strongly Supported

The similarities between these findings and those on environmental dynamism indicate that we have found further support for the two-order effects of IT. In addition, the strong support for hypothesis 15 clearly demonstrates the efficacy of following different investment strategies based on the munificence of the environment. Specifically, using the technology effect as an IT Investment strategy is more effective in environments with high munificence. As demonstrated by hypothesis 15, the entire variation in firm performance caused by IT can be attributed to this effect. This goes to show that building productivity through the technology effect may help firms handle internal and external growth without adding the expenses of hiring, training, and managing resources, and this may be the critical factor in differentiating between the performances of firms in environments with high munificence.

In addition, the test for hypothesis 15 shows the efficacy of using the information effect as an IT investment strategy in environments with low munificence.

In environments that are low in munificence, or ‘hostile environments’ investing in IT that focuses on the information effect may help firms identify and meet threats before other firms. This may be the important differentiating factor in hostile environments.

CHAPTER 6

CONCLUSION

This chapter is organized into three sections. In the first section, we discuss the results and interpretations of our hypothesis tests. In the second section, we detail the implications and contributions to academic research. In the third section, we outline the contributions and implications for practitioners. In the fourth section, we discuss the limitations of the study and the directions that future research should take.

6.1 Discussion

In this section, we interpret the results for the hypotheses tests. As with the earlier chapter, we organize these into the research questions.

6.1.1 The Two-Order Effect Model

From the tests of the base two-order model through hypotheses 1, 2 and 3, (Table 6.1) we find support for the two-order effects of IT.

Table 6.1: Results of hypothesis tests for the two-order effect model.

Hypothesis	Result
H1: Firm IT Intensity in time 1 will have a positive relationship with Firm Productivity in time 2	Strongly Supported
H2: Firm IT Intensity in time 1 will have a positive relationship with Firm Performance in time 3	Strongly Supported
H3: The relationship between Firm IT Intensity in time 1 and Firm Performance in time 3 will be mediated by Firm productivity in Time 2	Supported

As with previous studies, we find a significant and positive relationship between firm IT intensity and firm productivity (H1). We also find a significant and positive relationship between firm IT intensity and firm performance (H2). This result is a significant contribution over previous studies which do not find a link with profitability; for example, Hitt & Brynjolfsson (1996) find a strong positive effect with productivity but a weak negative effect on profitability.

The methodological rigor of our study may be a sufficient improvement on previous studies to enable us to discern this significant and positive effect which was not found by previous studies. Basing our measures of the independent, dependent and mediating variables on the theory that IT empowers employees, allowed us to choose the measures where the effect is most discernable, instead of arbitrary choices in previous studies. Operationalizing the independent and dependent variables as z scores, allows each firm to be measured relative to its competition addressing the assumption of similarity of IT investment across industries and years, and also removes the sensitivity to price deflators. In addition, the time lags used provide sufficient time for the theorized first and second order effects to occur, further improving our ability to discern this relationship. One finding that has some similarity with previous studies is that firm IT intensity has a stronger relationship with firm productivity than with firm performance. This is also consistent with our reasoning that firm performance is a more downstream variable than productivity.

More importantly, we see that even though IT has a strong effect on productivity, and productivity has a strong effect on performance, there is another effect of IT on performance that is not explained through this productivity improvement. This is consistent with the theory that IT has two-order effects. We find further support for the two-order effect model through the moderating effects of information intensity, environmental dynamism, and environmental uncertainty on this mediated model.

6.1.2 Moderating Effects of Information Intensity

Table 6.2: Results of Hypotheses tests for moderating effects of Information Intensity

Hypothesis	Result
H4: Firm IT Intensity will be more positively related to Firm Productivity in sectors with high information intensity than those with low information intensity.	Supported
H5: Firm IT Intensity will be more positively related to Firm Performance in sectors with high information intensity than those with low information intensity.	Strongly Supported
H6: Firm Productivity will be more positively related to Firm Performance in sectors with high information intensity than those with low information intensity.	Strongly Supported
H7: The relationship between Firm IT Intensity and Firm Performance is more positively mediated by Firm productivity in environments with high information intensity than environments with low information intensity	Supported

Our results on the moderating effects of Information intensity adds to our understanding of information intense industries. As theorized, we find a difference in how productivity impacts performance in industries that are high in information intensity and industries that are low in information intensity.

We theorized that IT will impact information intense industries through the first-order effect, similar to the manner in which advances in mechanical technology impacted manufacturing industries over the twentieth century. Manufacturing industries have products that are more based on physical materials than information, and advances in mechanical technology improved productivity through innovations like automation and mass-production. Most firms in these industries needed to adopt these innovations to improve their productivity, as the ones that do may not be able to survive in the industry. In information intense industries such as banking and insurance, information is a greater part of the product than physical materials, and operational workers need to process much larger amounts of information on the daily, routine activities. It is here that Information Technology stands to make a tremendous impact. While this impact has begun to show, IT has not yet reached the level of maturity that mechanical technology has reached in manufacturing industries. Therefore, in information-intense industries, firms that adopt IT should see much larger gains in productivity, and those productivity gains should translate into larger gains in performance, as compared to firms in less information-intense industries. This is strongly supported by our hypothesis tests. In information-intense industries the relation between Firm IT intensity and firm productivity is significantly more positive, and the relation between firm productivity and for performance is significantly more positive than in less information-intense industries. While these relations are as theorized, the size of the relations in information intense industries is very revealing. Firm IT intensity has a coefficient of 0.614 to firm productivity, and firm productivity has a relation of 0.717 to firm performance. This goes to show how strong an impact firm productivity has on firm performance in information intense industries, and adds to our understanding of the differences between these industries with industries lower in information intensity. We predict that as the adopting firms become more adept at developing the necessary organizational culture, structure and strategy to utilize the IT applications to their full potential in improving the productivity of their information workers, productivity should improve across the industry, and less productive firms will not be able to survive. After this period, firm IT intensity will have less of an effect on firm productivity, and firm productivity will have less of an effect on firm performance. Then, firms will have to compete more based on the second-order effect of IT.

In firms in less information-intense environments, we see that there are two paths to increased firm performance from firm IT intensity, through firm productivity, as well as a direct path. This is consistent with our theory and Porter & Millar's (1985) prediction that these firms will inject more information into the processes in their value chain. This enables the firms to compete based on productivity improvements through the first order effect, as well as through performance improvements through the second-order effect.

These findings also lend strong validity to our two-order effect model. Specifically we theorized that the first-order effect of firm IT intensity to firm productivity is primarily driven by the automate effect (Zuboff, 1985) of IT on information work (figure 3.1). In information intensive industries, by definition, there is much more information to be processed by information workers in their daily routines, and consequently, there is a greater potential for IT to contribute, as there is much more to automate. Through our results, we see that this link is indeed much stronger, lending strong credence to our two-order effect theory.

6.1.3 Moderating Effects of Environmental Dynamism

From the moderating tests (Table 6.3), we see that even though the moderating effects of environmental dynamism on the effects of firm IT intensity on firm productivity and firm performance are not significant, the effects are in the direction theorized. The coefficient of firm IT intensity is higher for environments with low dynamism in predicting firm productivity, while the coefficient of firm IT intensity is higher for environments with high dynamism in predicting firm performance.

Table 6.3: Results of Hypotheses tests for Moderating Effects of Environmental Dynamism

Hypothesis	Result
H8: Firm IT Intensity will have a more positive relationship with Firm Productivity in environments with low dynamism than with high dynamism.	Not Supported
H9: Firm Productivity will be more positively related to Firm Productivity in environments with low dynamism than with high dynamism..	Not Supported
H10: Firm IT Intensity will have a more positive relationship with Firm Performance in environments with high dynamism than with low dynamism.	Not Supported
H11: The relationship between Firm IT Intensity and Firm Performance will be more positively mediated by Firm productivity in low dynamism than in high dynamism	Strongly Supported

It is only when we test the moderated-mediation hypothesis that we get a clearer picture of the complexity involved. Here, we see that in environments with low dynamism, the variance in firm performance from firm IT intensity can be entirely explained by the effect of firm IT intensity on firm productivity. On the other hand, in environments with high dynamism, it is not the effect of firm IT intensity on firm productivity that explains the variance in performance, but the direct effect of firm IT intensity on performance.

To understand this, we have to interpret the strong support for the moderated-mediation test in conjunction with the lack of support for the moderation tests for the direct effects. Even though the first order-effect may not be significantly different between environments with low dynamism and environments with high dynamism, it is only in environments in low dynamism that this first-order effect translates into an improvement in performance. In addition, even though firm IT intensity does not have a significantly different effect on firm performance between environments with low dynamism and environments with high dynamism; in low dynamism environments, this improvement in performance comes mainly through the first-order effect, while in high dynamism environments, this improvement comes mainly though the second-order effect.

In addition, we are able to contribute back to the industrial economics and organizational strategy literature that we based our theory on. The productivity dilemma literature (Benner & Tushman, 2003) theorized that the effect of productivity on performance is more positive for environments with low dynamism than environments with high dynamism, but we were not able to discern this with our moderation test. Although we see that the coefficient for firm productivity on firm performance is higher for low dynamism environments than high dynamism environments, this difference is not significant. It was only when we included the effects on firm IT intensity with our moderated-mediation model that we were able to find evidence of this effect. In environments with low dynamism, firm productivity still has a significant and positive relationship with firm performance, even with the inclusion of firm IT intensity into the model. However, in environments with high dynamism, the inclusion of firm IT intensity into the model renders the effect of firm productivity on firm performance insignificant. Therefore, we see that the moderating effects of environmental dynamism on the productivity-performance relationship that the productivity dilemma literature theorized was hidden by the lack of inclusion of firm IT intensity in the relationship. This not only contributes back to the organizational economics and organizational strategy literature, but also highlights the importance of IT – it has now become a highly significant predictor of firm performance, and may be needed in models that attempt to analyze the effect of other variables on firm performance.

6.1.4 Moderating Effects of Environmental Munificence

From the hypothesis tests, we see the effect of firm IT intensity on firm productivity is significantly more positive in environments with higher munificence than environments with lower munificence. As this relationship is highly significant, we have strong support for the theorized moderating effect of environmental munificence on the first-order effect of IT. Through the first-order effect of IT on productivity, firms can handle an increase in revenue without a corresponding increase in employees. This becomes more pronounced in environments that are highly munificent, as firms are experiencing high growth in revenue, along with a corresponding growth in internal and external information. However, the first-order effect of IT may not be as important in environments that are low in munificence, as these firms may be experiencing negative growth.

Table 6.4: Results of Hypotheses tests for Moderating Effects of Environmental Munificence

Hypothesis	Result
H12: Firm IT Intensity will have a more positive relationship with Firm Productivity in environments with high Munificence than low Munificence.	Strongly Supported
H13: Firm IT Intensity will have a more positive relationship with Firm Performance in environments with high Munificence than low Munificence.	Not Supported
H14: Firm Productivity will have a more positive relationship with Firm Performance in environments with high Munificence than with low Munificence.	Supported
H15: The relationship between Firm IT Intensity and Firm Performance will be more positively mediated by Firm productivity in low Munificence than in high Munificence	Strongly Supported

In addition, we see the relationship between productivity and performance is significantly higher in environments with high munificence than environments with low munificence. This goes to show that productivity is very important when firms are experiencing growth, but other factors may be more important when firms are in a decline.

We see that environmental munificence does not significantly moderate the relationship between firm IT intensity and firm performance. This demonstrates that firm IT intensity can make a contribution to firm performance in both environments that are high in munificence as well as environments that are low in munificence. However, from the moderated-mediation model, we discern a difference in how it contributes. From the moderated-mediation analysis, we see that in environments with high munificence, the entire variance in firm performance explained by firm IT intensity is completely mediated by the first-order effect of firm IT intensity on firm productivity. However, in environments with low munificence, the variation in firm performance comes from the second-order effect of firm IT intensity on firm performance, and the effect of firm productivity is not significant. Therefore, we can conclude that in environments that are highly munificent, we see that firm IT intensity contributes to firm performance through the first order effect, while in low munificence environments, firm IT intensity contributes to firm performance through the second-order effect.

6.2 Contributions to Research

This study makes an important contribution by opening up the black box of IT Business Value and theorizing a two-order effect model: the first-order effect involving the automation impact of IT, and the second-order effect which revolves around the use of information in decision making. By theorizing that IT value does not come solely from cumulative improvements in productivity similar to previous technological advances, but instead through two different impacts, we improve upon earlier simplified models with direct links between IT and Performance. The theoretical analysis of mediating and moderating relationships of the two-order effects lead us to the moderated-mediating model, a complex but parsimonious representation of how IT provides value. We make another important contribution by validating this model and finding strong support for the two-order effect of IT, and the moderated-mediated model.

In addition, we add to our understanding of industry information intensity. In particular, we find a very significant difference in the productivity-performance link depending on information intensity. In information intense industries, firm productivity explains over 70% of the variance in firm performance. This is much less, under 25%, in industries that are lower in information intensity. This may be due to the amount of information that information workers in information-intensive industries need to process in daily activities, affecting their productivity. Consequently, the firms that can increase their productivity in these industries can have a huge advantage over their competitors. Interestingly, this finding provides strong support for the two-order effect theory of our base model, as we see from our hypothesis tests that the first order effect of firm IT intensity on productivity is indeed significantly more positive in information intensive industries, as IT has a lot more to contribute to performance through automating the huge amounts of information processed on a daily basis by the employees in these firms.

We also make important contributions back to the organizational economics and organizational strategy literature by shedding more light on the productivity-performance relationship. The productivity dilemma literature theorized that productivity has a bigger effect on performance in environments with low dynamism, yet we did not find evidence of this in the moderating test. However, when we factor in firm IT intensity, we are able to discern this effect. This shows that researchers studying the productivity dilemma need to factor in firm IT intensity for empirical tests. In addition, we find that the productivity-performance link has strong variations with industry information intensity and environmental munificence. Productivity dilemma researchers may also need to take these factors into account.

Finally, we have made very important contributions to research by improving upon the methodology of earlier studies by explicitly incorporating the theorized time lags between the independent and dependent variable, in order to better discern the effects. In addition, we address the methodological limitations of earlier studies that compared IT investment figures across industries and time, by converting the independent and dependent variables to z scores of their particular industry and year. This ameliorates the problem by comparing a firm to its competition, as well as the sensitivity to price deflators.

6.3 Contributions to Practice

By finding strong support for the moderated-mediation model, we are able to make specific recommendations for the type of investment in IT depending on the industry information intensity, environmental dynamism and environmental munificence.

In industries that are more information-intensive, firms should never ignore the basic and fundamentally important role of the first-order effect of IT. Through the first-order effects, firms in information-intensive industries can improve the productivity of the information workers who have to handle much larger amounts of information in their daily activities. The strong relation between productivity and profitability in these industries indicate that automating business processes of information workers can be a crucial factor in determining firm performance relative to competitors. In industries that are lower in information intensity, however, both the first-order and second-order effects are important, and firms may need to consider the environmental dynamism and munificence while deciding what types of information systems they need to invest there is budget on.

In environments with high dynamism, firms should pay special attention to IT that focuses on the second-order effect, i.e., focusing more on ‘informating’ effects by providing information to strategic decision makers to reduce state, effect and response uncertainty. Firm in highly dynamic environments should not be preoccupied with traditional applications of information technology that merely ‘automate’. In low dynamism however, firms should pay more attention to IT that focuses on the first-order effect; i.e. focusing more on the ‘automating’ effects of IT for improving the productivity of employees through faster and automated transaction processing, communication, and supporting systems.

In a similar vein, in environments that are high in munificence, firms should pay special attention to the first-order effect to improve the productivity of their information workers so that they can handle the higher internal and external growth without a corresponding increase in the expenses of hiring, training, and managing human resources. In environments where munificence is low, however, firms should focus on the second-order effect by providing strategic decision makers information about emerging hostilities and threats so that they can deal with them expediently.

Through the moderated-mediating model, we find strong support for the efficacy of following these strategies. Therefore, by making firms aware of these relationships and the need to follow different IT investment strategies contingent on the environment and the industry, we make an important contribution to practice.

6.4 Limitations and Future Directions

The limitations of using secondary data in research apply to this study as well. Correlations between the data on IS budgets between different databases such as Harte-Hanks, Computerworld and IDG, improve our confidence in the dataset. Our confidence in InformationWeek’s data is further increased as the data for InformationWeek is available publicly and has been used before in a number of published scholarly journal articles, including eminent IS journals. Matching between two datasets always has an increased risk of incorrect matches. We addressed this problem by matching between the two datasets on two criteria – the revenue as well as the name. The revenue reported by the company to InformationWeek is reportedly validated by InformationWeek against public sources, and the majority of companies had an exact match on revenue with the Compustat database. In addition, we left out all firms where we could not get an exact match on revenue between InformationWeek and Compustat, and we also removed all companies where we could not verify any name change through public company history. This increases our confidence that the firms matched are the same.

In addition, we have addressed a limitation of earlier studies, the sensitivity to price deflators. As IT depreciates at a faster rate than other capital, differential price deflators for IT and other dollar figures in the analysis need to be applied. Due to the difference in estimation of these deflators, the results may vary depending on the choice of price deflators. With our operationalization of the independent, dependent and mediating variables as z scores, the choice of price deflators will not affect the position of these companies relative to each other in that year, and therefore will not affect our results.

There is a risk of firms appearing in different years may affect the results. However, as this dataset has been used before by other studies, this risk may be low.

Another limitation of using panel data is that it does not give us richer insights into the type of IT used. We do address this limitation to a certain extent by measuring our independent, dependent and mediating variables on a per-employee basis, we are able to discern the effects of productivity and performance benefits that stem from improving individual information and knowledge workers, improving upon previous studies that used aggregate IT budgets and firm-level outcomes to measure these effects. However, case studies, surveys and field experiments may be able to give us additional insight into the specific type of IT used. As research grows through triangulation, the limitation of secondary data must be supplemented by other studies that use other methods of analysis. In particular, studies using other methodologies may gather data on the specific type of IT used, for example, transaction support systems, decision support systems, communication systems, and executive information systems, and how these impact the organization through the first-and second-order effects of IT. In addition, future research can look at more complex models such as the interaction of the moderators on the mediating model, i.e. industry information intensity, environmental dynamism and environmental munificence may interact to affect the two-order model or the moderated mediating effects.

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BIOGRAPHICAL INFORMATION

Vishnu Vinekar is a doctoral candidate at the University of Texas at Arlington. His research interests lie in IT value, systems development, outsourcing, and IS project/process management. He has published in the journal *Information Systems Management* as well as various conference proceedings. He won the best paper award at the 2006 Americas Conference in Information Systems and the University of Texas at Arlington's 2007 Schkade Fellowship Award for Excellence in Research.