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Where have all the flowers gone?: a modular systems perspective of IT infrastructure design and productivity

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WHERE HAVE ALL THE FLOWERS GONE?
A MODULAR SYSTEMS PERSPECTIVE OF
IT INFRASTRUCTURE DESIGN AND PRODUCTIVITY

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DEDICATED TO
MY PARENTS:

DR. SAMIR AND REENA DATTA

AND GRANDPARENTS:

JUGAL AND CHINMOYEE DATTA
BRAJA AND PRATIMA SAHA

"The object of all science… is to co-ordinate our experiences into a logical system"

Einstein (1922)

"It is necessary to study not only parts and processes in isolation, but also to solve the decisive problems found in organization and order unifying them, resulting from dynamic interaction of parts, and making the behavior of the parts different when studied in isolation or within the whole..."

Ludwig Von Bertalanffy (1956)

"A system is a network of interdependent components that work together to try to accomplish the aim of the system. A system must have an aim. Without an aim, there is no system. ...A system must be managed. The secret is cooperation between components toward the aim of the organization. We cannot afford the destructive effect of competition."

W. Edwards Deming (1974): The New Economics

“That all our knowledge begins with experience, there is indeed no doubt.... but although our knowledge originates with experience, it does not all arise out of experience.”

Immanuel Kant (1724-1804)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Research on IT productivity has ambiguous, as evidenced by the much debated "productivity paradox. Nevertheless, with continued increase in IT investments, fostering IT productivity has assumed primacy. This dissertation is interested in extending a disaggregated modular perspective to reveal the underlying productivity process to address the fundamental issue of whether IT adds value. This research presents a fresh outlook on IT investments and organizational productivity through the development and empirical investigation of a proposed productivity framework.

The research addresses the following question: What is the process by which IT capital outlays are transformed into organizational productivity? To answer this question, a conceptual framework of IT infrastructure productivity is proposed using a modular systems theoretical platform. The framework brings together IT capital outlays, IT management, IT infrastructure, the environment, and productivity as subsystems. Furthermore, a recursive and time-lagged approach is conceived to capture the dynamics of the system.

In order to populate and validate the conceptual taxonomy developed for the framework, two field studies are conducted in sequence. The investigation begins with a modified Delphi study where a panel of industry experts is used to identify current factors for every subsystem. The factors are used as items in the subsequent field survey of senior IT executives in Fortune firms viewed as stakeholders to the IT infrastructure productivity equation. The survey is used to collect data in order to empirically investigate the conceptual framework and its propositions.

Results from the empirical investigation failed to suggest any direct effects of IT investments on productivity. However, it did indicate the significant roles played by IT management, IT infrastructure design, and organizational environment on productivity. IT investments failed to impact productivity. However, when coupled with particular IT management styles, IT investments allowed for the creation of a unique IT infrastructure design as an organizational asset. IT infrastructure designs, in turn, sanctioned productive value, albeit contingent upon their operational environments.

The study adds to the existing body of knowledge through a holistic investigation of the relationship between IT infrastructure configurations, contingencies, and productivity. In conclusion, this research finds that the path between IT investments and productivity is veritably mediated by the creation of an IT infrastructure design as an organizational asset. In addition, the productivity process is quintessentially influenced by its contingencies: internally through the management of IT and externally by its operational environment. By systemically exploring the productivity process, this dissertation paves the path for rethinking the path towards IT value, helping all who follow understand where and how flowers may be found.

CHAPTER 1. INTRODUCTION

"It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity…"

A Tale of Two Cities-Charles Dickens

1.1. MOTIVATION

"Can organizations gain a better understanding of how discretionary information technology (IT) infrastructure investments help achieve productivity and add value?"

This very issue single-handedly continues to concern both researchers and practitioners. Investments in IT infrastructure are living in an age of "cautious optimism"- implicated by "the best of times…worst of times." While conventional wisdom remained optimistic towards IT-rich capital investments, a caution stemmed from the lack of compelling evidence in anticipated productivity gains. Fueled by expectations of efficiency, effectiveness, and veritable returns from innovative information technologies, organizations in the mid 80s experienced a distinct "bandwagon effect" of consistent and considerable IT investments to develop a discernible edge over the competition. The bandwagon effect nearly doubled IT capital investments as a share of the nation's capital stock - from 7.5% in 1980 to 13.8% in 1991 (Roach, 1993), amounting to approximately US$1 trillion expended in a decade.

The massive IT capital outlays during the 1980s, led by and large by firm-level improvements, posed a lingering contradiction. Although IT investments and capabilities were perceived as a key differentiating factor, reports on consistent returns were scarce. Lacking evidence of commensurate economic returns, studies led to a wide variability of

findings. While some firms did reveal positive impacts of IT investments, other businesses failed to derive benefits from IT.

1.2. THE "PRODUCTIVITY PARADOX"

The concept of productivity grew out of economics, defined as the ratio of outputs to inputs. In the field of information systems, IT investments have conventionally been used as the single factor input in the productivity equation. Over the years, the concept of productivity has significantly evolved. It has grown out of the trenches of assembly-line automation and time-and-motion enhancements to newer and more unique applications. For example, Lucas (1999) points out that productivity from IT has broadly shifted from operational efficiency and financial returns to encompass newer areas of value creation such as business transformation, strategic support, service quality, and managerial control. While these too constitute significant value additions, they are mostly intangible and have generally been neglected. Brynjolfsson and Hitt (1998) concur by pointing out the need to use such alternative, rather than traditional productivity measures in productivity assessments. Sadly enough, research has yet to incorporate this new-found wisdom.

It was Loveman's (1988) econometric analysis of 60 business units that began the furor about productivity from IT investments. Conducting a regression analysis of the production function using a 5-year dataset, it was found that the contribution of IT capital to productive output was extremely negligible. Strassman's (1990) examination of 38 service firms led to a disappointing discovery in terms of return on investments, therefore concluding that "there is no relation between spending for computers, profits and productivity" (Strassman, 1990: 18). Further studies reinforced the dismal claim. A 1991

research by Barua, Kriebel, and Mukhopadhyay found that IT investments failed to make a positive dent in return on assets or market share. From a cost-benefit standpoint, Morrison and Berndt (1991) found that IT costs outweighed IT benefits, forcing them to question the financial justification of IT investments-claiming trends of IT over-investments. Morgan-Stanley's chief economist, Steven Roach, (1991) found that while IT investments per information worker grew in the mid-1970 mid-1980 period, productivity of information workers fell by 6.6%. One more study by Loveman (1994) of IT investments in 60 strategic units from 20 firms reported no significant contribution to total output. Considering IT as a share of the industry's capital stock during the 1968-1986 period, Berndt and Morrison (1991) again reported that an increase in IT share led to a decrease in labor productivity. Furthermore, Barua, et al. (1995) too drew a grim picture contributing virtually no output from IT investments. The very fact that although firms found technology a crucial part of their organization, they were unable to detect consistent productive returns became dubbed as the "productivity paradox" (Brynjolfsson, 1993). Although some of the studies used second-hand MPIT (Management, Productivity, and Information Technology) data from the Strategic Management Institute (SMI) that Brynjolfsson (1993) deemed "particularly unreliable" because of its dependence on price indices, the paradox remained.

In contrast, there has been some positive evidence of productivity. Using aggregate data over the 1970-1990 period collected from a portfolio of U.S. firms, Lau and Tokutso (1992) estimated at nearly half of the growth in real output could be traced to the growth in computer capital. Similarly, Siegel and Griliches (1992) had reported a positive correlation between IT investments and productivity. Using intermediate

performance measures, there were reports of positive impacts of specific IT investments such as ATMs in Banking and SABRE reservation systems for Airlines (Banker and Johnston, 1994). A year after introducing the "productivity paradox," Brynjolfsson and Hitt (1994: 2) cautiously declared that "if there was a "productivity paradox" it disappeared in the 1987-1991 period." Taking into consideration more recent and granular data to compensate for the learning curves in implementing, the researchers attributed increased market shares to IT spending by individual firms. In context of data inconsistencies in some of the past studies, Brynjolfsson and Hitt (1996) undertook a firm-level study using a larger cross-section of firms. Using data collected from Fortune 500 manufacturing and Fortune 500 service firms, estimated production functions revealed that the marginal returns to IT capital were higher that marginal returns to non-IT capital expenditures- alleviating the paradox. Two more studies by Brynjolfsson and Yang (1999) and Brynjolfsson, Hitt, and Yang (2000) reinforced the optimism. Using data on IT capital from the Computer Intelligence Inforcorp database, Brynjolfsson and Yang (1999) reported a $5 to $20 increase in financial market valuation for every dollar increase in IT capital- revealing that marginal value of IT far outweighed its costs. The other study by Brynjolfsson, Hitt, and Yang (2000) revealed positive impacts of IT investments on intermediate performance variables such as use of teams, decision-making authority, and training- leading to higher market valuations of firms. Another recent study by Bharadwaj (2000) indicated that firms with higher IT capability outperformed other firms in terms of cost savings and increased profits.

This optimism has, however, been conflicting. In his most recent book, *The Squandered Computer*, Strassman (1997) pointed out the lack of any discernible

relationship between IT investments and firm-level productivity or performance asserting that "the era of exuberant business spending for computers will end in the next decade." Reacting as a poignant idealist whose faith in the positive potential of IT has somewhat been marred, Strassman (1997) stresses that for every IT success story, there are equivalent failures. In repudiating current claims of productivity, he adds that apparent productivity such as increased revenues per employee is more a consequence of outsourcing rather than touted IT investments. In revisiting the productivity issue in *Information Productivity,* the sequel to *The Squandered Computer*, Strassman (1999) reported contradictory findings. While U.S. industrial corporations were finally reporting an improvement in productivity metrics, Strassman (1999) pointed out that reports on the productivity gains were more a consequence of favorable interest rates than from measurable gains from IT, thus questioning the metrics used as frequently quoted indicators of productivity. As Bharadwaj (2000: 169) duly notes, "Despite the widely held belief that information technology is fundamental to a firm's survival and growth, scholars are still struggling to specify the underlying mechanisms linking IT to …performance."

Table 1 shows some of the empirical research on the two facets of the "productivity paradox." The divide over whether IT investments add to productivity lies at the crux of uncertainty faced by firms. Two decades ago, a firm-level study of 138 medical supply wholesalers by Cron and Sobol (1983) found that the productive impact of IT investments was not significant; the significant impacts were bimodal- associated with either very high or very low performance. And twenty years later, findings have been equally conflicting and patchy. Because firms are never at ease with uncertainty

Table 1. Two Facets of the "Productivity Paradox"

Study	Findings
Negative Empirical Findings	
Loveman (1988)	Negligible output from IT capital Contribution
Strassman (1990)	Lack of evidence between IT capital & productivity in 38 service firms
Roach (1991)	IT capital investments decreases information worker output
Barua, et al. (1991)	IT expenditures have no effect on Return on Assets or Market Share
Morrison & Berndt (1991)	Trends in IT overinvestment find that IT costs far outweigh IT benefits
Berndt, et al. (1992)	Increase in IT capital stock resulted in lower labor productivity
Barua & Mukhopadhyay (1993)	IT investments generated no significant output
Brynjolfsson (1993)	Firms unable to detect productivity from IT investments
Loveman (1994)	IT expenditures from 20 firms did not affect total output
Strassman (1997)	Lack of evidence between IT invetsments and Firm-level Productivity
Strassman (1999)	IT productivty a result of interest rates rather than profitability
Positive Empirical Findings	
Lao & Tokutso (1992)	Most of the growth in real output traceable to computer capital.
Siegel & Griliches (1992)	Positive relation between IT and productivity
Banker & Johnston (1994)	Productive benefits from IT investments in ATMs & SABRE
Brynjolfsson & Hitt (1994	IT spending related to increased Market Shares
Brynjolfsson & Hitt (1996)	Returns from IT capital higher than that of non-IT capital
Brynjolfsson & Yang (1999)	Marginal Value of IT outweighs its cost
Brynjolfsson, Hitt, & Yang (2000)	Positive impact of IT investments on market valuation
Bharadwaj (2000)	Investments in IT capability leads to increase profits and decreased costs

regarding investments, there has been "considerable hand-wringing among information systems (IS) professionals and some erosion of IS credibility in the board room" (Ives, 1994).

Despite a relative reduction in IT spending (Gartner Group, 2002), IT expenditures are far from dormant. IT spending by U.S. grew at 5% in 2002 and is projected to grow at 10% in 2003 (International Data Corporation, 2002). Abounding speculations of achieving productive advantages from the scale of IT investments still remains on the fore- making it one of the dominant IT research themes for the past two decades (Cron and Sobol, 1983; Strassman, 1990; Brynjolfosson and Hitt, 1993; Brynjolfsson and Hitt, 1996; Brynjofsson, Hitt, and Yang, 2000). This productivity debate has been accentuated by such capital outlays by firms intended towards developing an effective IT infrastructure in anticipation of swift and venerable returns. Yet, the lingering paradox spells that while there seems to be an apparent need for IT investments, ambiguity remains concerning both timeliness and amplitude of returns.

Even while pointing out the ambiguity, Brynjolfsson (1993: 15) nevertheless remained hopeful on the potential of IT, noting, "Although it is too early to conclude that IT's productivity contribution has been subpar, a paradox remains in our inability to unequivocally document any contribution after so much effort." Apart from the fact that a lot of the datasets used were notoriously unreliable, Brynjolfsson (1993) proposed four explanations for the paradox.

1) Mismeasurement of outputs and inputs: Mentioning that "the way productivity statistics are currently kept can lead to bizarre anomalies," Brynjolfsson points out that "mismeasurement is at the core of the "productivity paradox." Because IT

generally increases the scope and quality of work and services, much of the productive output occurs in terms of increased variety and improvements, proving it difficult to measure. Similarly, mismeasurements related to inputs resulted from the lack of a valid measure for IT stock and the underappreciated role of complementary inputs that help make IT investments worthwhile.

2) Omission of Time Lags: Brynjolfsson (1993: 17) indicates, “while the benefits from investment in infrastructure can be large, they are indirect and often not immediate.” Strategic investments in IT do not hinge upon short-term benefits but allows the firm to ride the learning curve to achieving benefits that “can take several years to show up on the bottom line.”
3) Redistribution of Benefits: IT investments can have disproportionate benefits on specific firms or even activities within specific firms without being perceptible at an aggregate industry level. This issue is quite analogous to that of measurement of productive outputs because benefits can be better traced as being distributed in terms of intermediate micro-level benefits rather than aggregate statistics.
4) Mismanagement*:* Much of the productivity paradox can be attributed to mismanagement at the firm-level. In the case that decision-making is based on outdated criteria, building inefficient systems, or merely increasing slack, productivity takes a back seat- increasing misallocation and over-consumption of IT by managers (Brynjolfsson, 1993).

Citing previous researchers, Bharadwaj (2000), too, questions the productivity paradox on methodological grounds such as the use of inappropriate measures of IT intensity, failure to acknowledge and control contingent factors that drive firm profits,

and problems related to sample selection and size. Unfortunately, there is little evidence of any systematic attempts aimed at reducing the paradox.

1.3. RESEARCH QUESTIONS

Fueled by innovations, one of the significant evolutions in the last two decades has been that of IT infrastructure. Still, not much has been done in terms reevaluating IT infrastructure as a measure of IT stock in an organization. Most past research studies have been captive to crude second hand data such as the number of PCs and peripherals, with little reference to an organization's content and communication infrastructure, albeit their growing role. While absent in research, IT infrastructure evolved to assume more convergent forms and functions. Still, not much research has been conducted beyond Huber's (1990) "computer-assisted communication technologies" and Keen's (1991) "IT architecture" categorizations.

Using propositions and corollaries, Huber (1990) revealed that as technology progressed, so did the integration and configuration of traditional IT infrastructure components. For example, the integration of once-independent infrastructure components of computing and communication technologies into computer-assisted communication is found to be efficacious at multiple organizational levels- encompassing both subunit and organizational structures and processes (Huber, 1990). Huber's convergence was furthered by Keen's (1991) "architecture" metaphor. The architecture metaphor forwarded by Keen provided a context-level classification and decomposition of the generic "IT infrastructure" construct. The decomposition of what Keen calls "corporate master architecture" into components that can be integrated not only provides a compatibility index but also initializes a discussion and examination into the issue of how

to allocate IT investments towards the acquisition and use of IT components that support the organizational architecture.

Most of the earlier empirical studies had researched IT infrastructure investments and productivity as aggregated constructs, ignoring the essential impact of their components, contingencies, feedbacks, and time lags. Robey (1977) had long bemoaned the need for a distinctive categorical and component-based approach for discerning the specific nature of IT. In a call for research, Sambamurthy and Zmud (2000: 107) presented the need for a research direction for an “organizing logic” for IT activities in response to an “enterprise’s environmental and strategic imperatives.”

Both Huber’s (1990) and Keen’s (1991) shift in the paradigmatic treatment of organizational IT stems from reviewing IT not in terms of expenditures but in terms of examining the impact of IT in terms of infrastructure design. Keen (1991) and Soh and Markus (1996) realized that the conversion of IT spending/investments (scale) into IT assets or components that could lead to output (scope), termed as “conversion effectiveness” (Weill, 1992) rested on how well an organization managed its IT. The focus in this research is to support and extend this paradigmatic shift using to understand the “organizing logic” that links IT infrastructure design to productivity. Establishing this focus requires an epistemological shift, one that focuses on facilitating the situation by privileging a decomposition and configuration of constructs over aggregation. Using a modular systems perspective to augment variance and process theories, this research disaggregates the constructs of IT infrastructure and productivity into configurable and collectively exhaustive components. It then proceeds to examine the implications of IT infrastructure configurations upon productivity while considering “strategic and

environmental" contingencies, feedbacks, and time lags. This study adds to the body of knowledge through a holistic examination of the relationship between IT infrastructure configurations, contingencies, and organizational productivity.

Using the organization as the primary unit of analysis, the dissertation is designed to understand the process of achieving IT productivity. Toward this goal, this dissertation broadly inquires:

- What is the process by which IT capital outlays are transformed into organizational productivity?

In responding to the inquiry, the study formally identifies the following subordinate research questions for empirical examination:

- How do IT capital outlays impact organizational productivity?
- How does IT management influence organizational productivity?
- How do IT infrastructure designs impact organizational productivity?
- How does the organizational environment influence organizational productivity?
- To what extent does IT productivity provide feedback for future changes in the underlying organizational productivity factors?

1.4. THEORETICAL AND PRACTICAL IMPORTANCE

Being both exploratory and confirmatory, the theoretical and practical value of this research remains legitimate and high.

This study contributes to our theoretical understanding of the relationships between investments in IT infrastructure and organizational productivity. "Attributing the inconclusiveness to conceptual limitations," Bharadwaj (2000: 170) indicates the "need for better theoretical models that trace the path from IT investments to business value"

utilizing a “process-oriented view which attempts to link the intermediate process variables to firm level performance variables.” This study does so by suspending the traditional cross-sectional variance-centric focus of much IT research to focus on the rich, time-lagged, configurable, contingent, intermediated, feedback-based process of productivity. The granularity achieved by the framework proposed in this study will help us develop semantically and empirically richer and more meaningful understanding of how IT investments are translated into productivity.

On the practitioner front, businesses and governments keep spending millions on developing and implementing their IT infrastructure in anticipation of benefits. Both success and failure stories from IT infrastructure investments abound. IT executives in organizations constantly find themselves reshaping their IT infrastructure to match IT with business objectives in an attempt to increase productivity. Faced with increasing innovative infrastructure options at multiple levels of technological convergence, knowing the productive potential of technologies remains a strategic and operational imperative. In addition, understanding managerial and environmental concerns can help provide discriminating evidence underlying successful versus unsuccessful productive ventures. Indeed, in preliminary interviews conducted for this study, IT executives voiced the need for understanding how “management culture affects infrastructure design and performance in different environments of operation.” This study brings together the essential ingredients in the productivity mix, helping IS executives clarify the role of the environment, direct IT management, create IT infrastructure designs, and ascertain requisite productivity. The immediacy and relevance of this issue makes it important for both academia and practice.

1.5. ORGANIZATION OF THIS DISSERTATION

The purpose of this research is to employ a holistic perspective to develop a conceptual framework and empirically examine the association between IT infrastructure and organizational productivity. Since this perspective explicitly recognizes the importance of contingencies such as IT management and organizational environment, it offers a significant opportunity to explore these complementing constructs that help outline the underlying productivity process linking IT investment antecedents, moderators, mediators, and productivity consequences. This constitution of the remainder of this research is as follows: Chapter 2 presents an outline of the underlying theoretical premise followed by the explication of the conceptual framework linking IT infrastructure design and productivity in light of the theory in Chapter 3. This is followed by the introduction and elaboration of the constructs as pieces of the conceptual framework in Chapters 4 through 9. Chapter 10 describes the design of this research, explicating the data sources and methodology used to address the research questions, and Chapter 11 presents the results obtained from our empirical tests. Chapter 12 discusses research findings, limitations, assumptions, and provides possible future research directions.

CHAPTER 2. THE MODULAR SYSTEMS PERSPECTIVE

"The overall name of these interrelated structures is system. The motorcycle is a system. A real system. ...There's so much talk about the system. And so little understanding. That's all a motorcycle is, a system of concepts worked out in steel. There's no part in it, no shape in it that is not in someone's mind."

Zen and the Art of Motorcycle Maintenance: *Robert Pirsig*

2.1. FROM VARIANCE TO PROCESS THEORIES

Research on IT productivity is replete with the use of variance theories. As defined by Crowston (2000: 4), "variance theories comprise constructs or variables and propositions or hypotheses linking them. Such theories predict the levels of dependent or outcome variables from the levels of independent or predictor variables, where the predictors are seen as necessary and sufficient for the outcomes." Variance theories comprise of constructs that are related between each other through propositions and hypotheses with distinct predictor and outcome variables where the predictor is viewed as both a "necessary and sufficient" causal influence in a cause-and-effect scenario. While variance theories generally are good at explaining variations between constructs, they do not perform very well when facing transient constructs or uncertain outcomes-implicating "necessary but not sufficient" conditions (Mohr, 1982; Markus and Robey, 1988; Soh and Markus, 1996).

Markus and Robey (1988) point that process theories can alleviate the conceptual limitations of variance theories by examining the sequence of events that lead to a specific outcome (Mohr, 1982; Crowston, 2000). Contrary to variance theories that subsume predictors as sufficient and necessary conditions leading to an outcome, process theories summarize the relationships and predictions among constructs but with a greater

predilection for the events that surround rather than mere causes, focusing more on analytic instead of statistical generalization (Yin, 1993). According to Yin (1993), analytic generalization is used to draw analogies from, expand, and generalize theory, in contrast to statistical generalization that generalizes and draws analogy to samples rather than theories. Process theories help provide explanations for transient processes when "causal agents cannot be demonstrated to be sufficient for the outcome to occur" (Soh and Markus, 1996: 2). "Such a theory might be very specific," Crowston (2000: 3) remarks, "that is, descriptive of only a single performance in a specific organization. More desirably, the theory might describe a general class of performances or even performances in multiple organizations."

In conceptualizing processes in organizations, Crowston and Short (1998) refer to processes as being goal-oriented where transformation of inputs to outputs takes place through a sequence of transient activities. Citing Kaplan (1991), Crowston notes that process theories serve as "valuable aids in understanding issues pertaining to designing and implementing information systems, assessing their impacts, and anticipating and managing the processes of change associated with them. Crowston (2000: 4) goes on to say, "The main advantage of process theories is that they can deal with more complex causal relationships than variance theories, and provide an explanation of how the inputs and outputs are related, rather than simply noting the relationship."

2.2. FROM PROCESS TO MODULAR SYSTEMS PERSPECTIVE

In scenarios where researchers need to incorporate elements from variance and process theories for both analysis and synthesis, systems theory provides the essential latitude. In fact, Crowston (2000) mentions that the process view is analogous to a

system's root definition (RD), something that Checkland (1981) refers to as a concise and tightly constructed description of a human activity system. Although process theory complements variance theory by incorporating the sequence of events leading to an organizational outcome, it is limited in its scope of addressing heterogeneity and simultaneous synthesis and decomposition of a defined system. Where process theory is captive to such limitations, the modular systems perspective serves as an encompassing theoretical structure- bringing together both states and processes defining a phenomenon (Simon, 1981).

Kerlinger (1986: 221) defines theory as "a set of interrelated constructs (concepts), definitions and propositions that present a systematic view of phenomena by specifying relationships among variables, with the purpose of explaining and predicting the phenomena." While helping examine both variation and sequence of constructs, systems theory adds the elements of decomposition, modularity, flexibility, and interaction to the research analysis, logically augmenting both variance and process theories. After all, achieving a degree of "differentiation and integration" defines an effective organizational system (Lawrence and Lorsch, 1967). In our research, systems theory provides the intended and justified platform that can simultaneously incorporate differentiation and integration in a process model examining organizational systems and its environments. Herbert Simon, the Nobel laureate echoes the use of such a perspective as "The Sciences of the Artificial" (1981). In it, Simon stresses the need to characterize artificial (man-made) artifacts such as organizational systems "in terms of functions, goals, and adaptation" (Ibid: 17). An organizational system, as an artifact "can be thought of as a meeting point - an interface… - between an "inner" environment, the substance

and organization of the artifact itself, and an "outer" environment, the surroundings in which it operates” (Ibid: 23).

Scott (1961) posited "the only meaningful way to study organization is to study it as a system.” The word “Systems” is derived from the Greek word *"synistanai,"* which means "to bring together or combine.” First proposed in the 1940’s by Bertalanffy (1968: 32), systems theory "is the investigation of organized wholes...and requires new categories of interaction, transaction..." In his famous treatise on cybernetics, Ashby (1956:55) considers systems as an observer’s preferred description of a set of interrelated elements connected by an organized stream of information, maintaining “independence within a whole.” Such a system can exist at multiple levels of abstraction and complexity, moving from analysis of static structures through cybernetics, open systems, to even transcendental systems.

Boulding’s (1956) influential paper in *Management Science* was one of the seminal pieces that imported Systems theory into management. Boulding (1956:197) set out to place systems theory as a balance between the overly abstract and the overly specific:

> “In recent years increasing need has been felt for a body of systematic theoretical constructs which will discuss the general relationships of the empirical world. This is the quest of General Systems Theory. It does not seek, of course, to establish a single, self-contained “general theory of practically everything” which will replace all the specific theories of particular disciplines. Such a theory would be almost without content, for we always pay for generality by sacrificing content, and all we can say about practically everything is almost nothing. Somewhere however between the specific that has no meaning and the general that has no content there must be, for each purpose and at each level of abstraction, an optimum degree of generality. It is the contention of the General System Theorists that this optimum degree of generality in theory is not always reached by the particular sciences.”

Systems theory has thus "come into use to describe a level of theoretical model-building which lies somewhere between the highly generalized constructions of pure mathematics and the specific theories of the specialized disciplines" (Boulding, 1956:197), viewing organizations as purposive systems, emphasizing differentiation, integration, interaction, feedback, and information flow within and across the organizational boundaries with its proximal environment. As pointed by Boulding (1956:208), "General Systems Theory is the skeleton of science in the sense that it aims to provide the framework or structure of systems on which to hang the flesh and blood of particular disciplines and particular subject matters in an orderly and coherent corpus of knowledge." The organizational perspective has used the salient feature of systems theory to build their own corpus of knowledge across the following characteristics (Cummings, 1980) as seen in Figure 1.

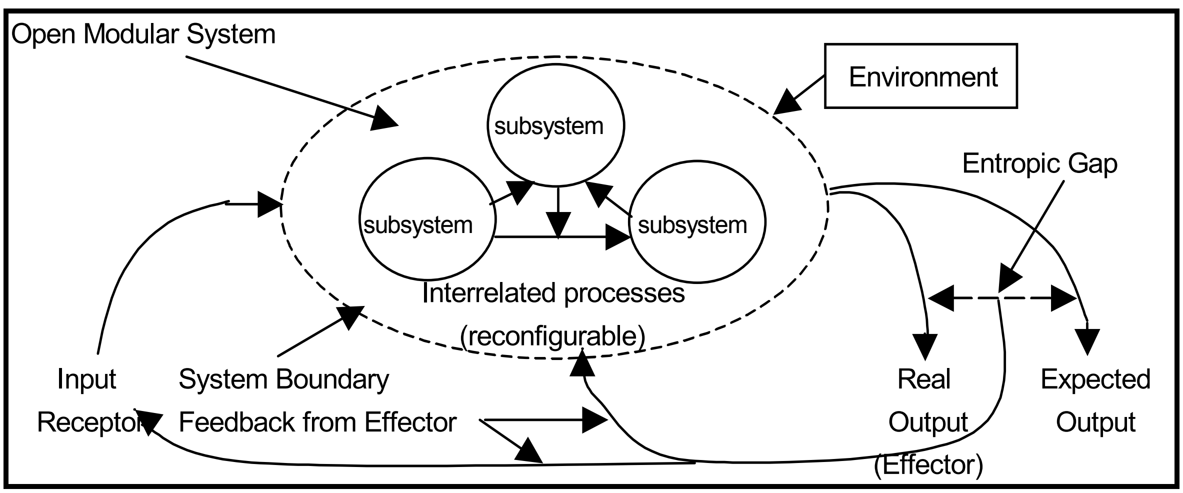


Figure 1. An Open Modular Systems Perspective

- An organization consists of a systemic process of input-throughput (or transformation)-output. A system has a receptor (for input), a processor (for reconfiguration and transformation), and an effector (for output). A systems perspective subsumes the concept of cybernetics where systems are treated only

in terms of their inputs and outputs, treating internal processes as black boxes (note its similarity to the variance theoretical perspective). Rather than using the Cybernetic black box concept, the systems perspective examines the underlying processes involved in converting resource inputs fed by input receptors, the explicit transformations by the process, and translation into outputs and performance that lead effectors to consequently provide feedback.

- Organizations are composed of multiple and interacting subsystems. Each of these subsystems may consist of smaller components that can again act as sub-subsystems. The subsystems specify the processes of a system and are conceived of as self-contained but interrelated components that a system can be decomposed into. Organizational subsystems have been conceived in different forms and categories, such as social, technical, and economic (Emery and Trist, 1960), depending upon the type of conceptualization by the researcher. While subsystems are autonomous in form, they are cohesive in function, i.e., these relatively self-contained subsystems interact with one another to serve a unified objective. Subsystems bear a semantic and functional analogy with the phrase *E Pluribus Unum*- one out of many.
- Organizational systems have semi-permeable boundaries across which they interact with their proximal external environment. The semi-permeable boundary provides the necessary linkage while maintaining autonomy by delineating the system from its environment. The boundary defines the difference between a system and its environment and is a function of the system definition. Permeability to the environment may provide sustenance or incur impediments;

and organizations need to continuously factor the impact of the environments on their own outcome or performance objectives. Information exchanges between the system and its environment occur across this boundary. Using interactive permeability, organizations react, interact, and adapt to their individual environments.

- Organizational systems have feedback mechanisms that allow for the adjustment or restructuring of organizational subsystems or components. Adapted from communications theory, feedback occurs within a system, where resources are fed into an input receptor, transformed by a configurable processor, and output by an effector. The performance of the effector is observed and information is fed back to the receptor and processor, as determined by the demands pertinent to the system. The feedback serves as a control mechanism for maintaining homeostasis, a biological phenomenon where negative feedback is used to control undesirable variations and positive feedback is used to induce desirable variations in performance, as perceived by the effector. Combined with the information and resource flow within the system along with any information scanned from the environment and organizational outcomes, feedbacks allow for continuous change and adaptation.
- Attempts are made to reduce entropy or the running down of an organizational system that results from the inability of organizational processes to recycle outputs back to the organizational processes for effective conversion and conservation. In an organizational system, an entropic gap results when differences between expected and real outcomes are deemed to be high enough by

the output effectors. A large entropic gap would imply disparity between expected and actual outcomes, which is likely to propagate if not controlled. The entropy signifies that the order from subsystem elements and process is deteriorating over time, and triggers feedbacks to the subsystem precursors. The end objective is to create a negentropic system relying on continuous feedback between inputs, processes, and outputs.

- A systems view offers a higher degree of abstraction regarding organizational systems as relational entities, providing a process-oriented, contextual view of organizations. By understanding contextual relationships among subsystems and components in organizations, it offers a holistic appreciation of the entire organizational system under examination. As Marilyn Ferguson (1980: 35) notes in The Aquarian Conspiracy, “General Systems Theory, a related modern concept [to holism], says that each variable in any system interacts with the other variables so thoroughly that cause and effect cannot be separated. A simple variable can be both cause and effect. Reality will not be still. And it cannot be taken apart! You cannot understand a cell, a rat, a brain structure, a family, a culture if you isolate it from its context. Relationship is everything.”

Systems theory therefore provides a relevant degree of abstraction from evidence gathered from reality, divulging subsystems and processes at multiple levels of analysis. Morel and Ramanujam (1999) indicate that the efficacy of systems theory comes from being able to reduce systems into smaller components, looking at their interaction and then integrating them together for a more holistic perspective. In overcoming inertia, Schilling (2000) points out how disaggregation of organizational systems remains a

prospective candidate for understanding causal mechanisms. The language of systems theory is expressed by using the criteria identified by Capra (1982):

1. From parts to the whole: In a system, the properties of the parts can be understood only from the dynamics of the whole.
2. From variance to the process: In the systems paradigm, every structured variance is seen as a manifestation of an underlying process.
3. From ontological objectives to epistemology: In systems, the epistemology - the understanding of the process of knowledge must augment our understanding of the nature of knowledge.
4. From truth to abstractions: In systems, abstractions approximating the real world are more valuable than trying to denote truth, recognizing that all scientific concepts and theories are limited and approximations under particular assumptions.

We use a modular systems perspective to map IT Infrastructure Productivity (IIP, hereafter) as an interrelated dynamic system that can be decomposed into subsystems for the purposes of analysis and synthesis. Because a system and its context co-evolve through time (Gell-Mann, 1995), there is an inherent recursive causality generated through feedback. In understanding system dynamics, feedback loops can be used to validate the continuity and provide a strong qualitative grasp of the model content and context (Ahn, 1999).

Among the attributes propounded by the systems approach, an important part of our analysis is the property of modularity, a concept that describes the degree by which a system's components can be separated and recombined - therefore "exponentially increasing the number of possible configurations achievable from a given set of inputs"

(Schilling, 2000: 4). Furthermore, it provides a context within which a system exists, thus generating relevance for multilevel elements that place demands on a system (Alexander, 1964). Modularity also provides the premise for coupling and recombination of systems or subsystems. An organizational system benefits from combination and recombination of its components to achieve optimal configuration (Schilling, 2000).

2.3. STRENGTHS AND LIMITATIONS OF THE THEORY

The primary strength of the modular systems perspective is its holism, comprehensiveness, and the rich texture it offers of a system by matching analysis with synthesis. The perspective balances both synthesis and decomposition using a recursive hierarchy. The hirerarchy marks both inter and intrarelationships among subsystems and their components as one delves deeper. Herbert Simon (1981: 121) notes: "… hierarchies have the property of near decomposability. Intracomponent linkages are generally stronger than intercomponent linkages. This fact has the effect of separating the high-frequency dynamics of a hierarchy - involving the internal structure of the components - from the low-frequency dynamics - involving interaction among components."

Systems concepts such as openness, modularity, subsystems, and feedback capture the reality and the continuity of the system. The plurality of theories subsumed by the modular systems perspective - including variance and process theories – has contributed to its ability to view organizational systems as configurable yet integrated systems. The integration of variance and process perspective under the systems theoretical umbrella provides support for the future development of a framework that can be used to surface and empirically test the process relationship leading to organizational productivity. In addition, as articulated by the modular systems perspective, by providing

a sketch detailing the process dynamics, flexibility, and subsystem reconfigurability, the theory demonstrates the significance of equifinality- a condition in which different initial conditions lead to similar effects through different process configurations. Because the modular systems perspective creates a flexible and reconfigurable standpoint for viewing systems, the same end state may be achieved through a variety of mediating process configurations, even if they use similar input conditions. This concept of equifinality provides multiple lenses to view a system, with no unique rule-of thumb configuration. Lastly, although we will use the modular systems perspective as a mid-level theory with the organization as our unit of analysis, it can also be used to examine systems at both micro (e.g., individual productivity) and macro-levels (e.g., national productivity) of analysis.

The limitations of the modular systems perspective are its late inception into the information systems discipline along with its breadth of approach. Further work needs to be done in three specific dimensions. First, although the theory has been articulated by the management discipline, the development has been sparse. For example, while Schilling (2000) used the modular systems perspective in a recent study examining organizational innovation as a system, there is little elaboration provided on what systems processes entail. Likewise, there is little discussion about feedback mechanisms depicting the continuity of organizational outcomes. The second dimension, albeit related to the first, pertains to the breadth and options offered by the modular systems theory making it difficult to utilize all available concepts offered by the theory for a comprehensive outlook.

Armed with a multiplicity of options, it becomes a difficult task incorporating the concepts surrounding systems. For example, while decomposition of systems into subsystems obviously increases granularity of examination, too much decomposition can increase opportunity costs without adding requisite value. Deciding on the optimal number of subsystems for any particular system in context will improve with further research. Lastly, while use of systems theory has been conceptually strong, there has been negligible evidence of empirical studies in the same direction. Additional empirical studies would be extremely useful for elaborating this theoretical view. Such empirical demonstrations are not only significant in terms of analyzing systems but also long due.

In summary, even with the aforesaid limitations, the modular systems perspective allows for a deeper and more cognizant understanding of an organizational process. The perspective has been limited only by its lack of use in understanding organizational systems. And this research is an attempt to enhance its presence. Considering its ability to map and configure multiple factors to achieve a synthesis of purpose, a modular systems perspective is considered to be a useful lens for this research.

2.4. THEORY ELABORATION OBJECTIVES OF THIS STUDY

Building on the strengths and addressing the aforementioned limitations of the modular systems perspective, this dissertation research uses both induction and deduction to bring to light the system parameters underlying IIP. The research develops a detailed theoretical framework and empirically tests its robustness. The research elaborates the theoretical perspective by aligning theoretical assumptions with empirical examination, integrating and illuminating systems attributes and concepts.

Much of systems theory resembles the scientific method: this research hypothesizes, designs an empirical investigation, collects and analyzes data. The purpose is to put forward a unifying theory that can be used to assess and control organizational activities as holistic systems- and linking its pursuit to the pursuit of science. To do so, this dissertation systematically develops a theory based on the following activities: (i) Defining the organizational activity of IIP as a whole system; (ii) Establishing system objectives (i.e., organizational productivity); (iii) Creating formal subsystems that serve as cohesive components; (iv) Identifying the environmental subsystem; and (v) Integrating the subsystems with the whole system.

Incorporating the potential and relevance offered by the attributes of systems theory supported by precedent research, the next section is a prologue that extends the modular systems perspective into the domain of IIP.

CHAPTER 3. IT INFRASTRUCTURE PRODUCTIVITY (IIP): A SYSTEMS PERSPECTIVE

"General Systems theory should be an important means of instigating the transfer of principles from one field to another [so that it would] no longer be necessary to duplicate the discovery of the same principles in different fields."

Ludwig von Bertalanffy (1968)

In context of IIP in organizations, systems theory provides strong evidence for understanding organizations as a purposive (human-derived) system based on relationships, structures, and interdependence, rather than constant attributes as an object (Katz and Kahn, 1966). Viewing the organization as a purposive system adds to our understanding of systems concepts at multiple levels of analysis namely, the system as a whole, the proximal environment interacting with the system, the subunits or subsystems, and their recursive reiterative qualities (Checkland, 1981).

Senge (1990), in *The Fifth Discipline*, proposes the need for "systems-thinking," a discipline for seeing the relational "structures" that underlie complex organizational situations, as a practical imperative for mapping and understanding the complex interactions in the real world. Using the concept of systems thinking, borrowed from the systems theoretical perspective, Senge highlights the use of the systems perspective in organizations. Senge essentially stressed the importance of systems as an abstraction of real-world organizational activities in terms of its relational abilities, organizational processes, systems concepts of feedback, and the identification of underlying structure (relational subsystems) providing a more thorough understanding of the system in context.

Our use of the “systems” metaphor to understand IIP in organizations is not without precedent. Morgan (1986) suggested, “By using different metaphors to understand the complex and paradoxical character of organizational life, we are able to manage and design organizations that we may not have thought possible before” (cf. Kendall and Kendall, 1993). The systems metaphor provides a more comprehensive understanding of IIP at differing levels of abstraction by coherently conceptualizing relevant interrelationships within and beyond a particular system boundary.

According to Norbert Wiener's cybernetic (systems) interpretation of organization, “a system consists generally of inputs, process, outputs, feedback, and environment,” and parts of which can simultaneously and structurally intersect with one another (Maturana and Varela, 1987). It is through the “transaction, interaction, and interrelation” that the IIP system and its elements purposively and dynamically transform inputs into purposive goal-oriented outputs. After all, “fulfillment of purpose or adaptation to a goal involves a relation among three terms: the purpose or goal, the character of the artifact, and the environment in which the artifact performs” (Simon, 1981: 17).

Traditional causal thinking underlying precedent research in IS infrastructure productivity has for long assumed isolation, external, and complete independence of antecedents, making the causal arguments far too simplistic (Cummings, 1980). Systems theory helps bridge the overly simplistic causality by introducing relational attributes across subsystems and the environment to weave a holistic fabric. Bertalanffy (1956) forwards a similar argument that isolable one-way causality is insufficient, obliging the

use of a relational, recursive, holistic systems perspective. These attributes form the basis of our understanding of IIP.

Representing IIP as a modular organizational system allows us to consider systemic properties. IIP is thus viewable as "interrelated modular subsystems connected through an organized stream of information transforming inputs into outputs. This perspective not only creates a detailed and disaggregated view of the constructs but also provides latitude to attest a numerical value to each component for facilitating measurement." We attest our view with precedent research.

In explicating the considerations necessary for systems, Churchman (1968) asserted the inclusion of the following system factors: system performance objective (outcome); system resources and components; system management; and the system's environment. In presenting their "IT interaction model," Silver, et al. (1995: 361) maintain, "the consequences of information systems in organizations follow largely from the interaction of the technology with the organization and its environment," providing an integrated and "stylized view of the dynamics of information systems in organizations" (ibid: 384). They point that such a perspective allows organizations to proactively or reactively anticipate, analyze, and/or reorganize their organizational processes. This research forwards the perspectives of Churchman (1968) and Silver, et al. (1995) as a basis for our modular systems perspective of organizational IIP.

Figure 2 depicts an aggregated view of the IIP framework from a systems perspective. This view encompasses the aforesaid system factors in the context of our theory development for the proposed framework: Organizational productivity is our system performance objective; Configurable IT infrastructure design, among others,

denotes system resources; IT management provides the organizing management logic behind the configuration of the IT infrastructure; and lastly, the organizational environment spells the qualities and attributes of the organization's operational milieu. Our research framework consists of five constituent subsystems, namely: (1) the IT infrastructure investment subsystem; (2) IT infrastructure design subsystem and its components; (3) the IT management subsystem; (4) the environmental subsystem; and (5) the productivity outcome subsystem. The figure also illustrates the interrelationships among the five subsystems. The role played by each constituent in the IT productivity subsystem is also exemplified in the context of the modular systems perspective and tabulated in Table 2.

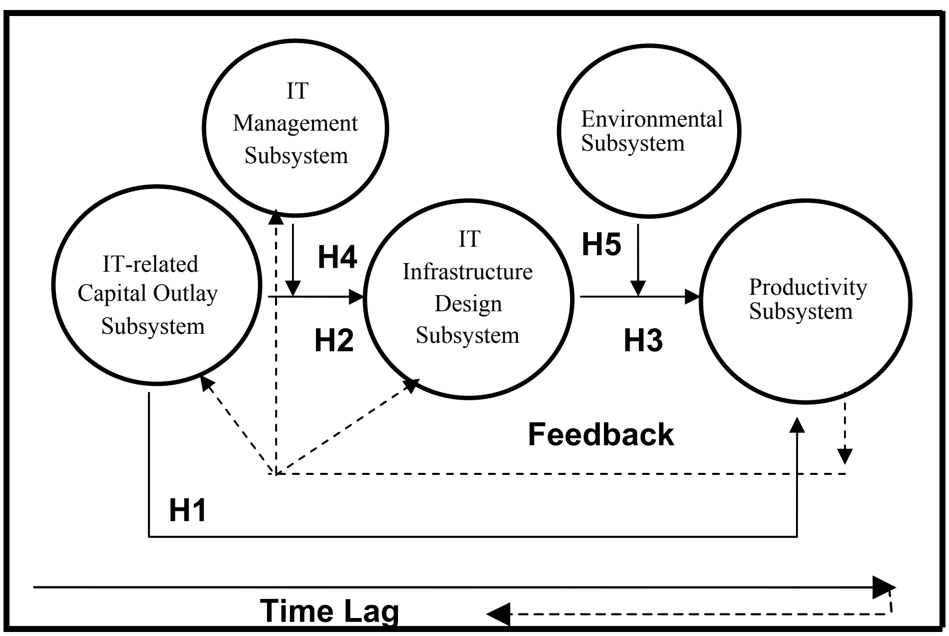


Figure 2: A Preliminary View of the IIP Research Framework

Table 2. A Systems Perspective of IIP Productivity

Term	**Definition (Organizational Context)**	**Use in Research (IT Infrastructure Productivity Context)**
Input	The Economic Inputs to a System	IT Investments/Expenditures as Capital Outlays.
Throughput	Subsystem processes within a System used to convert economic inputs into resources used as a process to achieve organizational outcomes.	IT Management (Planning & Decision making), IT Infrastructure Design & Development
Output	Organizational outomes resulting from the system's throughput or processing of economic inputs.	Organizational Productivity from IT Infrastructure Design
Feedback	Information flow from Organizational Outcomes used to Evaluate and Monitor the System for Effectiveness and Control.	Use of Current Productivity Information for Reconfiguring other Subsystems
Subsystem & Modularity	A Self-contained cohesive part of a larger System.	IT Investment Subsystem, IT Management Subsystem, Environmental Subsystem, Organizational Productivity Subsystem.
Open systems	Purposive Self-Regulatory Systems that Interact with their Environments through Interaction and Participation.	IT Infrastructure Productivity System
Boundary	Delineation between a System, Subsystem, and its Environment that maintains Scope. Can vary in terms of Permeability.	The IT-related Systems and Subsystems within an Organization.
Goal	Overall Purpose for Existence or Desired Outcomes from particular Investments.	Generating anticipated Productivity from IT Investments
Entropy	The Level of Disorder within Organizational Systems and their Outcomes	The Gap between Actual and Expected Productivity
Equifinality	Similar Objectives can be attained through varying Inputs and Processes.	Similar levels of Productivity can be achieved through multiple IT Infrastructure Design Configurations, IT Management Styles, and Organizational Environment Types.
Configurability	The Ability of a Subsystem to manifest multiple variations	Variations in IT Management, IT Infrastructure Design, Environment, and Productivity

CHAPTER 4. THE IIP SYSTEM FRAMEWORK: IT CAPITAL OUTLAY SUBSYSTEM

"Businessfolk make plenty of poor decisions when it comes to choosing computer equipment. Befuddled by a sales pitch delivered at Pentium II speed, swooning at the sight of a 16-inch flat-screen LCD display on a customers' desktop, they pitch their nickels at the high end, paying for features they'll never use. In that respect, at least, technology products resemble personal relationships: pursuing both, we tend to confuse what we want with what we need."

Leigh Buchanan (1998)

Investments in IT infrastructure provide an intuitive beginning as an essential input for future productivity. Compared to other economic inputs, IT capital expenditures have been held to be necessary and sufficient condition for achieving the requisite productive potential. As an economic input in a production function, companies had speculated that the opportunity cost of capital outlays in IT was lower than capital outlays in alternate resources. In the past few decades, hundreds of companies have bankrolled billions of dollars out of sheer belief and anticipation of productive returns, but with limited results. But not all capital outlays end up as investments. As discussed in Chapter I, much of these capital outflows grew out of a bandwagon effect, and referring to them as "investments" becomes a case of semantic *faux pas.*

` Organizations have popularly and conveniently used the term "investments" to characterize their IT expenditures. Yet, one should note that "investments" and "expenditures" have particular connotations. Expenditure, according to Webster's Dictionary, is "a process of expending or disbursement," while investment is defined as "the outlay of money usually for income or profit (productivity)." The difference between expenditures and investments reflects that of the generic and the specific, respectively.

Expenditures do not claim a return or a purpose but investments do. While expenditures denote scale of capital outlays, investments define the scope or the purpose behind the outlay. It is this distinction that separates expenditures and investments and lies at the heart of the productivity paradox. Firms that have expended IT capital without a purpose have rarely been able to usurp any productive value form information technology. Nevertheless, “investments” rather than “expenditures” remain at large the semantic currency of choice for all capital outflows aimed at acquiring, deploying, allocating, or developing IT infrastructure in organizations. For outlays committed without a sense of direction or purpose, the term investments remain a solecism. The bandwagon effect of process automation, reengineering, business restructuring and enterprise integration that began over two decades ago has taken a toll on businesses that have considered hype over prudence, failing to consider their pitfalls and constraints along their promises. And such instances are more than a mere few. A 1998 study by Standish Group International, a Massachusetts-based research firm, reported that only 26% of all IT-related outlays can be justified as investments- 28% are written off as failed expenditures; and 46% are considered “challenged” investments- waiting to be written off from going over budget, over schedule, and failed or botched deliverables. Here are some cases that portray the distinction between IT investments versus IT expenditures.

One such case of IT capital outlays gone awry concerned the candy giant Hershey’s 1999 fiasco. Fueled by the hype of integrated enterprise systems (ES), Hershey Foods committed a capital outlay of $112 million towards an integrated order-processing and distribution system without much heed towards the timing or the purpose of such a large-scale integration. Already months behind deadline, Hershey was anxious to “go

live" simultaneously across the entire enterprise. The systems went live during the peak seasons on Halloween and Christmas. Problems with integrating inventory data led to unanticipated shipment delays, resulting in a failure to stock retailers' shelves during the Halloween and Christmas candy rush- leading to a 12% ($150 million dollars) drop in revenues. Led by the promise of systems integration, the candy giant had tried to integrate the infamously complex Enterprise Resource Planning (ERP) Software by SAP R/3, Customer Relationship Management (CRM) software from Manugistics, and Supply Chain Management (SCM) software by Siebel.

Another case concerned the CONFIRM reservation system developed by AMRIS, an IS spinoff from American Airlines (AMR), for Marriot, Hilton Hotels, and Budget Rent a Car that ended up expending 4 years and $125 million as a technology writeoff. More than four years after its initiation in late 1987, CONFIRM was sure to miss its implementation deadline by more than two years. AMR brought a civil suit against its clients on the grounds of breach of contractual agreements and lack of understanding and specifying the scope of the project. Marriot countersued on the basis of failure to deliver the project and botching up its problems. The result was the demise of the CONFIRM system and AMR took a writeoff of $109 million. The reason was more than a mere failure of AMRIS as an agent in its contractual obligations. Equally to blame were the clients who lacked a clear understanding of what they wanted the project to do and achieve, therefore falling a victim to "scope creep."

Our technology-driven history is replete with IT investments turning into expenditures when outlays were driven by hype rather than purpose. Competitive hype in the early 1990s led Greyhound to develop the "TRIPS" reservation and bus dispatch

system. The inability of Greyhound to understand the limitations of the system developed led to serious glitches upon attempting to change prices. The $6 million project crashed and agents were forced to write tickets by hand- resulting in $61.4 million loss in a single quarter and the resignation of its CEO and CFO. Other highlighted *expenditures* include Norfolk Southern's Integration fiasco, Whirlpool, Macy's, Toys-R-Us', Agilent technologies' ERP glitches, among many others. All of the aforesaid have a few common denominators: failing to understand the scope of the system, not being able to anticipate pitfalls and constraints, lack of direction and purpose, and hype from bandwagon effects- each complementing the other in precipitating investments into expenditures (Hammer and Champy, 1993).

Sparsely evidenced yet sharply in contrast are some notable examples of IT capital outlays that can be considered as investments. Walmart's reengineering efforts towards developing an inventory tracking and replenishment system were well-timed and justified. The retail giant used its existing infrastructure and inventory management competencies to build an inventory system that allowed suppliers real-time inventory access for dynamic reordering, reducing purchasing order costs, inventory holding costs, and potential stock-outs. Similar exemplars include IBM Credit's reengineering of its credit application system that reduced its application time by a fifth of the normal time; Kodak's innovative use of CAD/CAM (Computer-Aided-Design/Computer-Aided-Manufacturing) technologies resulted in faster product development; Cigna reduced its labor overhead while increasing its business by creating decentralized scaleable client-server systems that could dynamically price products and services by location. Again, these aforesaid exemplars share the common attributes of having a clear sense and

purpose in their IT related capital outlays through logical anticipation- translating their capital outlays into investments rather than expenditures.

Companies need to rethink their capital outlays before characterizing them as investments rather than expenditures. After all, "it is not prudent to set the corporate information technology budget by some arbitrary rationale" (Strassman, 1997: 21). The term "IT investments" has long been a semantically popular alternative to IT-related capital outlays. It has also been regarded as a necessary and sufficient input for productivity although the aforementioned cases evidence the variability in both the findings and semantics. Most normative analyses on the value of IT have designated all IT related capital input as investments- leading to conflicting findings as revealed by the infamous "productivity paradox." The paradox reiterated that even carefully considered investments did not spell necessary productivity. Some did reveal productivity gains…and some did not. However, as Brynjolfsson (1993) realizes, if the measures of productivity are well cognizant of the breadth of value-addition, IT investments are likely to produce the desired gains. Brynjolfsson (1993) indicated that if productivity mismeasurements were reduced and time lags were implied, increases in IT investments would lead to requisite productivity. The same approach has also been resorted to by several other productivity researchers (Lucas, 1993; Brynjolfsson & Hitt, 1993; Devaraj & Kohli, 2000). This has led to a general assumption that all IT related capital outlays provide a "sufficient and necessary" condition for productive output. In lines of referent literature, productivity can thus be postulated to be directly proportional to the level of IT investments. However, because of the conflicting evidence of some capital outlays ending up as investments while some ending up us expenditures, the term "capital outlay"

remains the most semantically justified. Nevertheless, the reader should note that the terms "IT-related Capital Outlays" and "IT Investments" are used interchangeably in parts of this dissertation, partly because of the conventional popularity of the latter terms and its recurrent is within referent literature used as precedents in this research.

Still, convention has generally held that companies need to spend more money on IT in order to increase productivity. The presumption is that the higher the spending, the more the returns. On such a premise, it is further proposed:

> H1: The level of IT-related capital outlays in an organization is positively and significantly related to higher levels of productivity.

CHAPTER 5. THE IIP SYSTEM FRAMEWORK: THE PRODUCTIVITY SUBSYSTEM

"Management must accept that there exists no set of accounting ratios or simple formulas that show the business value of IT."

Shaping the Future- Peter Keen (1991)

5.1. THE CONCEPT OF "LOCUS OF VALUE"

Previous research examining the impact of information technology investments on organizational performance has employed a wide range of productivity outcomes and measures. While Chan (2000) and Devaraj and Kohli (2000) have conducted comprehensive reviews of existing productivity literature, little evidence remains of any systematic yet comprehensive and exhaustive classification of productivity. Turner and Lucas (1985) achieved this objective to a certain extent by classifying productivity in terms of functional objectives- transactional, informational, and strategic. However, the classification was limited in determining the level of analysis for any specific type of productivity (e.g. even if an organization achieves transactional productivity, where or at what level of analysis is the productivity traceable?). We incorporate their understanding to develop a productivity framework by the disaggregation and classification of the productivity construct based on the degree of standardization, level of analysis, and focus.

In our attempt to disaggregate and classify organizational productivity as a consequence of its specific IT infrastructure, this research utilizes the concept of "locus of value" (Kauffman and Weill, 1989). Locus of value relies on a process oriented perspective of IT payoffs where the focus is on "that primary level of analysis at which

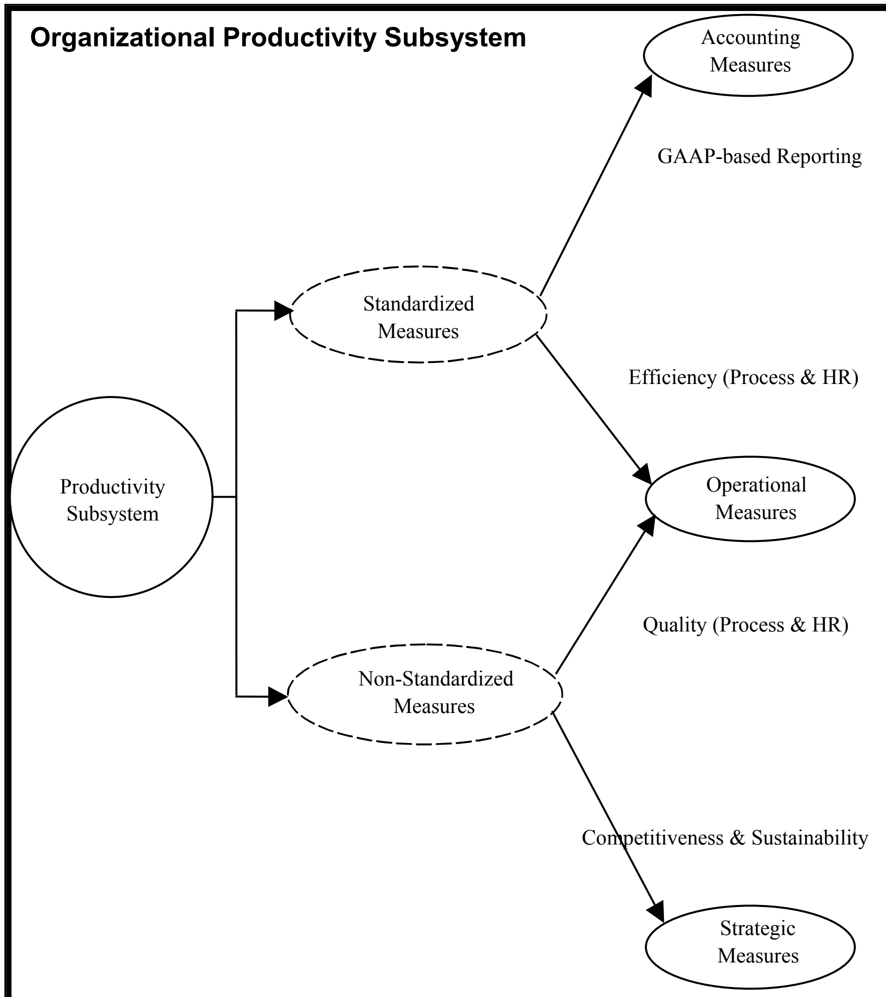
flows of IT become discernible for the investing firm" (Davern and Kauffman, 2000: 126). Central to this perspective is the belief that the impacts of IT must be measured at multiple points within an organizations' value chain. For example, the locus of value of an automated transaction process system would most likely be discernible through increased financial performance (cost effectiveness technological substitution for labor) and operational efficiency. In comparison, the locus of value for a CRM (Customer Relationship Management) system would generally be discernible in terms of higher operational quality and better strategic decision making ability. Again, the locus of value for a web-based electronic-commerce presence is likely to be discernible through increased financial productivity (higher revenues, lower cost of maintenance) and operational quality (faster customer service and streamlined shopping experience). These observations extend our understanding of both IT infrastructure and organizational productivity, bringing to light the need for examining productivity from capital outlays towards particular IT infrastructure at the level at which the infrastructure is implemented and used. Because a firm's value chain occurs over a spectrum rather than at a particular level or within a specific process, an organization's infrastructure may have "multiple loci of value nested within different levels of analysis" (Davern and Kauffman, 2000: 128).

One of the earliest evidenced research on IT productivity can be traced to the King and Schrems (1978). Two and a half decades ago, King and Schrems discussed the productive benefits of IT along efficiency considerations. Their classification mainly surrounded transactional benefits such as record-keeping and calculating efficiencies. The research that followed generally utilized either financial or efficiency measures of

productivity- leading to the much-debated “productivity paradox” as discussed in Chapter 1. Bailey and Pearson (1983) were among the first few to shift their perspective towards operational quality rather than efficiency by developing a measure for IT-related user satisfaction. However, it was Parsons’ (1983) work followed by Porter and Millar’s (1985) research that first raised awareness that IT could be used to leverage a firm’s strategic and competitive presence- affecting competition, altering organizational structures, and spawning new businesses. Unfortunately, empirical research has generally failed to systematically and comprehensively capture necessary productivity dimensions and measures. The Nobel Laureate, Robert Solow, had remarked “Computers are showing up everywhere except in our productivity statistics." As Chan (2000) points out, in the search for “hard” incriminating evidence, researchers have foregone the finer and intermediate productive benefits, leading to the paradox. “Mismeasurement is at the core of the “productivity paradox”…due to deficiencies in our measurement and methodological toolkit,” Brynjolfsson (1993: 76) bemoans, and “researchers [ought to] be prepared to look beyond conventional productivity measurement techniques.”

5.2. THE PRODUCTIVITY SUBSYSTEM FRAMEWORK

Viewing productivity as a function of its locus of value, the proposed productivity framework serves as a unifying umbrella encompassing the necessary productivity dimensions (Figure 3). Our framework moves away from a “black box” approach and begins by classifying productive benefits in terms of standardization. “Standardized metrics” comprise of measures commonly used to quantify productivity in conventional financial/accounting and operational/process efficiency dimensions. On the contrary, “non-standardized metrics” comprise of measures that focus on productivity in



Metrics	Referent Literature
Return on assets	Rai et al. 1997, Tam 1998
Return on investment	Jelassi and Figon, 1994
Return on sales	Tam, 1998; Mahmood and Mann, 1993
Operating costs	Desmaris et al. 1997
Profitability	Hitt and Brynjolfsson, 1996
Book value of assets	Tam, 1998
Labor expenses	Dewan and Min, 1997
Labor productivity	Brynjolfsson 1993
Total documents processed	Teo, Tan, and Wei 1997
Administrative productivity	Rai, Patnayakuni, and Patnayakuni, 1997
Capacity utilization	Barua et al. 1995
Inventory turnover	Mukhopadhyay et al.1995
Inventory and stockout levels	Lee and Clark, 1999
Premium income per employee	Francalanci and Galal, 1998
Reduction in training time	Desmaris 1997
Improved information exchange	Sheffield and Gallupe, 1993-94
Quality improvement	Wilcocks and Lester, 1997
Service quality	Myers, Kappelmann, and Prybutok, 1997
Improved work environment	Teo and Wong, 1998
User satisfaction with IT systems	Yoon, Guimaraes, and O'Neal, 1995
Improved operating effectiveness	Henderson and Lentz, 1995-96
Quality of new products	Barua, Kreibel, and Mukhopadhyay, 1995
Decision-making improvements	Belcher and Watson 1993
Customer satisfaction	Anderson, Fornell and Rust, 1997
Changes in organizational structure	Lucas, Berndt, and Truman, 1996
Relative market share	Kettinger, Grover, and Segars, 1994
Improvements in performance	Vandenbosch and Huff, 1997
Development of new markets	Hess and Kemerer, 1994
Improved customer convenience	Nault and Dexter, 1995

Figure 3. The Organizational Productivity Spectrum[1]

[1] Thanks to Harold Lagroue for filling in the metrics and the referent literature from Chan (2000).

dimensions of operational/process quality and competitiveness/sustainability. Accounting measures and Strategic measures represent the two poles in the productivity spectrum. While strategic measures are completely non-standardized and vary by competitive landscapes, accounting measures are completely standardized and compiled using protocols prescribed by GAAP. In between are operational measures that can be viewed as quasi-standardized in objective and use. For example, while operational efficiency measures based on process and HR efficiency are standardized (e.g. throughput), operational quality measures based on process and HR quality are non-standardized (e.g. quality improvements, employee satisfaction).

- Standardized Measures: Standardized measures are conventional metrics that are easily quantifiable and are compliant to some preset standard or convention. These metrics generally have historical precedence and are available as secondary data at multiple-levels of analyses. Standardization allows these metrics to be used as benchmarks for meaningful comparisons.
    - Accounting measures (GAAP-based Accounting and Financial reporting): GAAP-based accounting and financial measures are designed to provide a reliable body of quantifiable factors by which organizational productivity and performance can be credibly evaluated. Although, in the wake of recent financial scandals, critics are questioning the value-relevance of these metrics, they still serve as “hard evidence” for stakeholders, analysts, and researchers. As fixtures in financial statements and corporate analyses, accounting measures have been used to understand productivity articulated by financial statements. Because financial statements reflect

direct and immediate impacts of an investment or an asset (e.g. saving money, increasing revenues, downsizing), the focus of accounting measures remain transactional (Mirami and Lederer, 1998). Examples of popular accounting measures include ROA (return on assets), ROE (return on equity), ROI (return on investment) (Hitt and Brynjolfsson, 1994).

- Operational Efficiency measures (Process and Human Resource (HR)): Operational efficiency measures are used to gauge the efficiency of key business and HR processes. Efficiency is deeply ingrained in economizing, i.e., reducing costs of continuing operations through mechanisms such as increasing throughput, labor output, decreasing spoilage and errors to inventory turnover. Operational efficiency is marked by its ability to deliver significant cost advantages from its operational use of processes and HR. Related measures conform to metrics developed from the economics of operations and remain both standardized and conventional; they are easy to measure, simple to quantify, and available at their particular level of analysis. Some examples of operational efficiency measures include inventory turnover, capacity utilization- that Barua et al. (1995) refer to as "lower-level impacts."

- Non-Standardized measures: Contrary to standardized measures, non-standardized metrics do not follow any particular canons of conformance. Non-standardized metrics, because of their detachment to any conforming criteria, therefore offer a multidimensional perspective of productivity. While these dimensions deliver a richer and closer examination of productivity in its different

shapes and forms, they lack the ease of definition that is historically preceded in standardized measures. As non-standardized measures do not form a part of the reporting currency, the dimensions are generally reported and revealed through first-hand data collection.

- Operational Quality (Process and HR): As discussed earlier, operational measures have a split-personality. On one hand, operational efficiency heavily relies on standardized economic attributes, while operational quality measures are largely non-standardized, referring to the reliability of business processes and human resource services. Operational quality allows unambiguous differentiation between different instances of the quality aspect at its relevant locus of value (Lott and Rombach, 1993). Operational quality is achieved through the definition of quality goals, monitoring processes that can help achieve that quality, and reviewing whether the quality goals have been met. Examples of such measures include service quality improvements (Myers et al., 1997), work environment improvements (Teo and Wong, 1998) and improvements in information exchange (Sheffield and Gallupe, 1993).
- Strategic measures: Strategic measures are non-standardized variables of interest that are deemed to be "necessary" for superior strategic positioning of an organization. Tallon et al. (2000) point out that strategic measures hinge on how much an organization has been able to enhance its strategic position in the market- creating a value-proposition for their customers. Strategic measures try to reflect an organization's competitive

advantage reliant on factors such as customer service enhancement, identification of new opportunities, and product/service value-enhancement (innovation). Strategic metrics are used by executives to enhance their organizations' strategic orientation and discernible at an organizational level of analysis. Examples include increased innovations in goods or services (Barua, Kreibel, and Mukhopadhyay, 1995), development of new markets, and strategic decision-making (Hess and Kemerer, 1994).

5.3. PERCIEVED PRODUCTIVITY

The locus of productive value is a function of a time lag due to IT learning effects. Franke (1987) followed Brynjolfsson (1993) suggest that transforming technology into productivity is time-intensive. While neither found immediate effects of technologies, both remained optimistic about the future potential of IT- noting that there are no preset time lags and variances are large and disparate by the type of technology and its use.

The fact that there are no prescribed time lags between IT-related capital outlays and productivity poses a serious concern for researchers trying to incorporate a fixed time lag within their research for effectively tracing the potential of IT. For example, strategic payoffs from an infrastructure investment in forecasting systems would take a longer time than operational efficiency payoffs from IT infrastructure in an order-processing system (Devaraj and Kohli, 2000). Furthermore, because IT infrastructure capital outlays are recurrent, linking productivity to a particular infrastructure would be confusing. A specific productivity may not be relevant to a specific IT infrastructure but could be a

cumulative result of different infrastructures. This problem of recurring capital outlays and variable time lags makes the assessment of productivity a difficult an extremely subjective phenomenon- especially when considering multiple organizations.

Addressing this issue, Tallon, et al. (2000: 148) note, "in the absence of objective data on IT payoffs, executives' perceptions can at least help to pinpoint areas within the corporation where IT is creating value." While there has been some reference to exaggeration of payoffs by the respondent, perceived productivity by top IT executives has been shown to correlate highly with real productivity (Venkatraman and Ramanujam, 1987; Parker and Benson, 1998; Tallon, et al., 1998). IT executives' perceptions of productivity turn out to be more effective in assessing IS effectiveness compared to realized value compared to values assessed at any given point of time. It includes the necessary time lags and allows discerning of productivity from particular IT infrastructures.

Furthermore, perceived productivity permits an *ex ante* assessment of IT value. A study by Ventakraman and Ramanujam (1987) found that perceptive evaluations of IT productivity by senior executives were highly correlated with the realized objective performance. Similar support was provided by Dess and Robinson (1994) who found that executives' "self-reported" evaluations of productivity accurately reflected true productivity. In the words of Venkatraman and Ramanujam (1987: 118), "perceptual data from senior managers…can be employed as acceptable operationalizations of [productivity]." Several other researchers have incorporated the notion of perceived productivity in various shapes and forms. They include Tallon et al.'s (2000) perceived business value, Sander's (1984) perceived usefulness of DSS tools, Franz and Robey's

(1986) perceived usefulness of MIS, and Davis' (1989) perceived usefulness and ease of use of IT, just to name a few.

IT executives serve as essential candidates in the perceived assessment of productivity. "Executives are ideally positioned to act as key informants in…assessment of IT impact" because, as Tallon et al. (2000:148) reveal, "First, as direct consumers of IT, executives can rely on personal experience when forming an overall perception of IT impacts. Second, as…[IT] executives become more involved in IT investment decisions, they are increasingly exposed to the views of peers and subordinates regarding the performance of previous IT-related capital outlays." Following the cue, this research uses senior IT executives to perceptively assess IT productivity. The choice of such IT executives as organizational informants will again be substantiated in a later chapter on research design.

IT executives' perceived assessment of productivity is accentuated by the latitude provided by a disaggregated view of productivity. Explicating productivity as a spectrum provides an IT executive the ability to illuminate the perceived locus of value for particular IT infrastructure technologies. The classification scheme allows organizational informants to systematically measure productivity perceivable and traceable across multiple levels of analysis within an enterprise. Furthermore, the classification schema can be employed to assess how capital outlays in a particular IT infrastructure can be related to one or more specific dimensions of productivity. The corresponding impact of IT-related capital outlays on specific productivity categories echoes the fact that impacts from IT can have "multiple loci of value." The rational-economic paradigm had relegated the more tacit, long-term benefits of investing in IT in favor of being couched in short-

term benefits. Our productivity framework shifts our cognitive perspective by adopting a different value-based lens for assessing IT capital outlays.

Chan (2000: 231) remarks, “perhaps part of the challenge associated with technology evaluations is the need to let go of narrow, one-dimensional, win/lose pronouncements, and to accept instead mixed, multidimensional, multistakeholder, explicitly value-based assessments.” The dimensions incorporated in our classification bring to the fore a value-based assessment that firms can utilize to distinguish IT value impacts related to infrastructure. A systematic partitioning of productivity into operational metrics also assists in “explicitly identifying appropriate boundaries or limits of the impacts to be investigated” (Chan, 2000: 231). Understanding the constraints posed by the boundary allows us to accurately pin the impact of a particular technology to one or more dimensions of productivity. Distinguishing the locus of productivity can therefore be immensely beneficial for both practitioners and researchers desperately trying to understand the economic impact from investing in a particular IT infrastructure.

CHAPTER 6. THE IIP SYSTEM FRAMEWORK: IT INFRASTRUCTURE DESIGN SUBSYSTEM

"Convergence creates new forms of capabilities by combining two or more existing technologies to create a new one that is more powerful and more efficient."

Opening Digital Markets- Walid Mougayar (1998)

6.1. IT INFRASTRUCTURE

The construct of "IT infrastructure," albeit having undergone prolific research, remains esoteric and in "realms of conjecture and anecdote" (Duncan 1995, p.39). The esoteric quality of the construct has made it difficult to correctly assess its nature and significance, creating conjectural evidence about its efficacy. While researchers such as Keen (1991) describe a firm's IT infrastructure as a major organizational resource and a source for competitive advantage, a failure to understand what constitutes the IT infrastructure will likely lead to a misapprehension of its potential.

Much of this misapprehension has resulted from an aggregated treatment of IT. Given the dearth of systemic or systematic demarcation among technologies that make up an IT infrastructure, an objective assessment remained difficult. A systemic perspective required a paradigmatic shift- affirmed by Robey's (1977) call for a component-based approach for discerning the nature of IT infrastructure. Defining IT infrastructure in terms of component technologies that "transmit, manipulate, analyze and exploit information, in which a digital computer processes information integral to the users' communication or task." Huber (1990: 48), the call was first answered by Huber (1984) where he viewed IT infrastructure as "C^2 –technologies" comprising of components related to "communication" (transmit information) and "computing" (to manipulate,

analyze, and exploit information). While Huber's definition does refer to the technologies as serving to analyze and transmit "information" (content), it fails to include "content" as a distinct technological component whose prowess would be evident in the 1990s.

The 1990's revealed the growing importance of "content" oriented database technologies for managing data and information as an additional "leverageable" component of the IT infrastructure (Keen, 1991; Silver, Markus, and Beath, 1995). King (2001: 211) notes that a content-centric perspective of IT infrastructure "identifies relevant data, acquires it, and incorporates it into databases designed to make it available to users in the needed form." In a recent survey conducted by *CIO* (2002), demand for content related storage and database technologies are expected to rise by 39%, with 22% of the IT budget allocated to such technologies. As Pawlowski (2000: 1) confirms, "One of the dominant IT themes for organizations over the past decade has been the movement towards shared information systems and databases."

The three technological components of content, computing, and communications were first brought to light together in Keen's (1991) IT architecture categorizations. Keen (1991) referred to these three distinct components as "a technical blueprint for evolving a corporate infrastructure resource that can be shared by many users and services." The reference parallels Weill and Broadbent's (1998: 332) view of IT infrastructure as "the enabling base for shared IT capabilities." According to Keen (1991), the three elements of an organization's IT infrastructure comprises of (1) processing systems (computing), (2) telecommunications (network), and (3) The data (content). Six years later, this component perspective was further adopted by Tapscott (1997), categorizing *data and information architecture* as content, *IT processing systems*

architecture as computing, and *telecommunications (networks) architecture* as communication. As Bharadwaj (2000: 172) notes, "IT assets which form the core of a firm's overall infrastructure comprise the computer and communication technologies…and databases."

In addition to pointing out the technological categorizations, both Keen (1991) and Tapscott (1997) realize that these infrastructure categorizations are in the process of technological convergence. An infrastructure is no longer the sum of isolated technological domains of communications (network-based resources), computing (system-based resources), and content (information-based resources). As researchers such as Keen (1991), Tapscott (1997) and Sambamurthy and Zmud (2000) posit, technological domains are slowly converging in the face of the digital economy. This new reality is that of technological convergence- complementing the isolated technological components. While isolated technologies still maintain their presence in an IT infrastructure, especially, at the operating level, there is a growing presence of technological convergence at both operating and application levels- creating options for configurable variety.

Technological convergence begets configurable variety. Because of newer and more innovative application-level technologies, configuration synergies are no longer constrained by the lock-ins associated with previously isolated and proprietary infrastructure. IT infrastructure design today closely resembles organizational design (Crowston and Short, 1998: 13), a concept that "explores the relationship between configurations of…technologies to outcomes." Because an IT infrastructure design consists of configurable technological components existing at various levels of

convergence, organizations have the latitude to decide on particular infrastructure configurations to address specific productivity objectives. It is worthwhile noting that, in most cases, greater convergence leads to less flexibility in configurations because it would be more difficult to “pull” apart, even at an application level.

The choice of a component-based configurable IT infrastructure design is implicated and reified by referent literature. In providing a conceptual and clarified framework for IT infrastructure, Kayworth, et al. (1997) look at it as an amalgamation of physical artifacts: system platforms (computing), databases (content), and telecommunications (communications)- echoing Keen’s (1991) and Tapscott’s (1997) componentization. Building upon the referent literature, we develop our own infrastructure design schema as a dynamic intersection of the three technological components. We diagram the dynamics using a Venn diagram because of its ability to link multiple entities (in our case, technological components) by shared (intersecting) characteristics and attributes. Using a Venn diagram, the intersecting schema for our IT infrastructure design allows us to incorporate the components onto a single plane while allowing us to view infinite configurable varieties marked by infinite levels of convergence. Because IT infrastructure is considered an IT asset, organizing the infrastructure remains an organizational imperative (Soh and Markus, 1996). Decomposing IT infrastructure into intersecting technological components of communications, content, and computing allows us to organize the IT infrastructure to reveal the following configurable categories as seen in Figure 3. They are:

(i) Non-Convergent IT Infrastructure Technologies: Basic infrastructure technologies based on Content (A), Computing (B), and Communications (C).

(ii) Partially-Convergent IT Infrastructure Technologies: Shared infrastructure technologies based on the convergence of Computing and Content (D), Computing and Communications (E), and Content and Communications (F).

(iii) Highly-Convergent IT Infrastructure Technologies: Integrated infrastructure technologies based on the convergence of Content, Computing, and Communications (G).

Each of these configurable categories consists of three dimensions: two distinct and one derived. One of the two distinct dimensions is the technical infrastructure (physical core operating and/or application-level technologies). The second is the human resource infrastructure (personnel who use, maintain, and support each particular technical infrastructure configuration). The third and derived dimension is that of services and procedures (derived from the interaction of human and technical infrastructure). The collectively exhaustive IT infrastructure subsystem (Z) is shown in Figure 4a where A, B, C, D, E, F, G $\subset$ Z. We shall discuss each of these dimensions in the following paragraph.

6.2. THE TECHNICAL DIMENSION

1. **Non-Convergent IT Infrastructure Design:**

   a. Content (Data/Information-based Resources) (A): The content component includes data and information under organizational governance. It includes data and information in multiple formats of text, graphics, audio, and video. Keen (1991) defines content as resources needed to organize data for the purposes of cross-referencing and retrieval- through the creation of information or data repositories as content for organizational accessibility

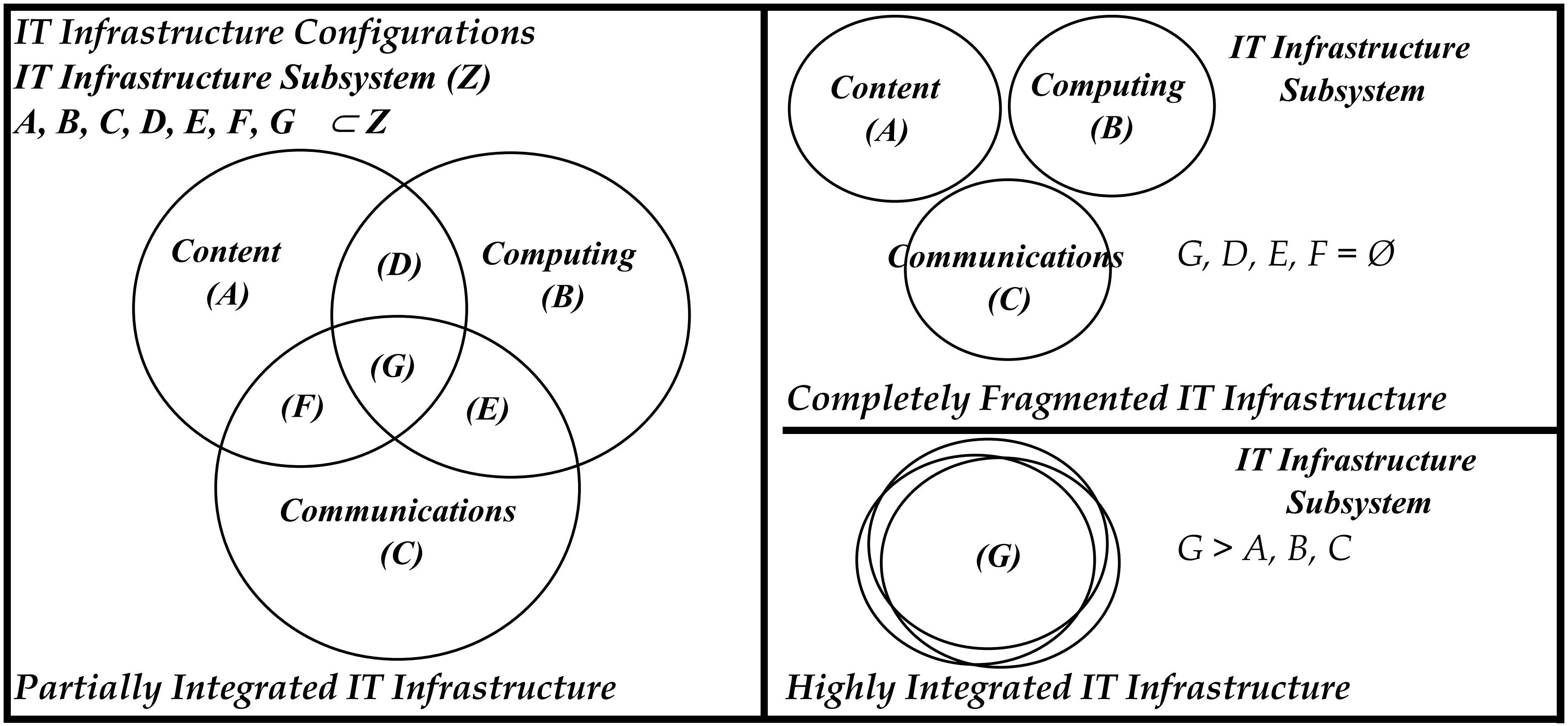


Figure 4a. Sampled Configurations of the IT Infrastructure Design Subsystem

Most of the organizational content is managed by relational or object-oriented databases acting as repositories of information. Content technologies involve both operating-level and application-level assets dedicated towards the acquisition, allocation, management, and development of the data/content infrastructure.

Operating-level technical assets include Magnetic-media storage (Disk Drives, External/Removable storage devices, Virtual Tape), Optical-media storage (CD, DVD, Holographic Storage, Magneto-optical, Optical jukeboxes, Optical library); Application-level assets include applications focused on Data Creation and Manipulation (Spreadsheets, Text/Graphic Editors, Statistical software).

b. Computing (Processor-based Resources) (B): The computing component involves processor-based resources focused on input-output, control, and processing. Keen (1991) refers to computing as comprising operating systems environments, applications software, and technical standards for the hardware for operation and multi-vendor compatibility. Computing technologies involve both operation-level and application-level assets dedicated towards the acquisition, allocation, operation, management, and development of the computing infrastructure.

Operating-level assets include hardware such as Processors (Intel, AMD, Motorola), Processor-based systems (Sun, Unix, PC, Apple), Mobile-devices (PDAs-Pocket PCs, PalmOS, Cellular Phones, Pagers), Input Devices (Keyboards, Mice), Output Devices (monitors, printers),

Operating Systems (Windows 9x, Linux, Unix, Apple OS). Application-level assets include Developmental Software (Compilers, Debuggers, Programming Tools), System Administration Software (Backup/Recover, Emulators, Disk/File Access, System Monitoring, User Management) and other General Applications providing system operation and support.

c. Communications (Telecommunications/Network-based resources) (C): The communication component involves network-oriented resources that support organizational communications. Keen (1991) refers to communications as resources that provide organizational connectivity using networking standards over which voice and data is transported within and across organizations. Content technologies involve both operation-level and application-level assets dedicated towards acquisition, allocation, optimization, management, and development of the networking infrastructure.

Operating-level assets include Physical Hardware Technologies (Telephones, Faxes, Backbone, Routers, Switches, Bridges, Gateways, Hubs, wired and wireless Modems, etc.), Directory services (ADSI, DEN, X.500/LDAP, NDS), connectivity technologies (ATM, T1/T3/E1, DSL, ISDN, Gigabit Ethernet, Digital audio/video, VPN, Optical networking), Network architecture (MAN, WAN, LAN, Client/server, Peer-to-Peer). Application-level assets include applications pertaining to Network administration (Network Solutions, Traffic management, Remote/Automated administration, Print/Fax, Domain controllers, Clustering/Load balancing), Network protocols (VoIP, DHCP, HTTP,

PPP/SLIP, DNS, SMTP, TCP/IP, IMAP, POP3, SNMP), and Network Troubleshooting.

2. Partially-Integrated IT Infrastructure Design

a. Content and Computing (Information and Processor-based Resources): ($D = A \cap B$: The convergence of content and computing gains significance especially in the light of the complexity of information and data stored within an organization. This component refers to technologies that address and help integrate content (data and information) using computing (processor) power. Because there has been a significant shift towards multiprocessor workstation computers and dedicated content providing workstations with dedicated processor resources for database management, this component category involves technological assets focused on the acquisition, allocation, and development of the common integrated infrastructure.

Operating-level assets would primarily include computing (system) hardware resources that provide access to stored content as Storage Access Devices (Tape/JAZ/ZIP Drives, CDR/CDRW/DVD Drives, Storage Media Adaptors) and Direct Access Storage (DAS) (where each server has dedicated storage). Application-level assets include applications pertaining to Content Manipulation and Administration (OODBMS, RDBMS, Compression, Data-vaulting, User Access, File Sharing, Hierarchical Storage Management, File sharing, Resource virtualization, Archiving, Backup/Recovery, Hard Disk management), Heterogeneous Storage

Integration (Storage Domain Managers, Data migration and synchronization), File Service Optimization (Data ONTAP software), and Content Processing (Data Warehousing, Data Mining, Data query processing).

b. Computing and Communications (system and network-based resources) ($E = B \cap C$): The convergence of system and network resources is gradually becoming evident as processor resources are being linked and shared over popular network protocols. This component refers to technologies that address and help integrate computing (system processors) and communications (networks) and involves technological assets focused on the acquisition, allocation, and development of the shared processor resources. These are found in high end computing systems forming computing clusters by connecting processors and workstations over networks based on load distribution to optimize processes and resources such as the massively parallel LINUX clusters or Sun UltraSPARC III based computing clusters.

Operating-level assets include technologies pertaining to Secure Systems-Access (Biometrics, Token and Smart Card technology, Firewall Server Hardware), Thin Clients and Terminals, Network Operating Systems, Distributed Processing (parallel processing, distributed computing, Shared memory multiprocessors, Grid Computing). Application-level assets include technologies such as Distributed Application Performance Monitoring, Collaborative Computing, Heterogeneous System Connectivity Protocols and Software (CORBA,

COM+/DCOM, Java RMI, Middleware interoperability, Samba, Tivoli NetView, Tanit IRIS, Compaq TIP).

c. Content and Communications (information and network-based resources) ($F = A \cap C$): With distributed data over networked environments, the need for information integration has grown steadily (Rudensteiner, et al., 2000). Distributed and networked databases and storage remain at the heart of the convergence of content and communications. Networked content has led to increasing reviews on the efficacy of multiple information integration techniques such as on-demand approach to integration or tailored information repository construction (Rudensteiner, et al., 2000). Technologies supporting the convergence of content and communications pertain to distributed data/information and content delivery and management. This component refers to technologies that address and help integrate content (data and information) over communication (networks) resources and involves technological assets focused on the preparation, deployment, and management of content over large networks, e.g. Cisco's Content Delivery Networks (CDN).

Operating-level technologies include technologies related to E-Commerce, Storage Consolidation, Network-Attached Storage (NAS), Distributed Databases, Storage-Area Networks (SAN) (SAN Controller, SAN Integration Server), IP Storage. Application-level technologies include applications supporting Data Consolidation, Networked Content Protection (Virus Protection, Access Protection), Data Recovery, Disaster Tolerance, SAN managers, SAN/NAS Convergence, Interfaces and

Standards (CGI, Fiber Channel, ESCON, SCSI, HIPPI, iFCP, iSCSI, FCIP).

3. Highly-Integrated IT Infrastructure Design

a. Content, Computing, and Communications (Information, System, and Network-based Resources) ($G = A \cap B \cap C$): The convergence of content, computing, and communications by merging information, system, and network-based resources has been a growing trend, especially with the proliferation of enterprise-wide systems and applications. The component refers to technologies that address and help integrate content (data and information), computing (system processing), and communications (networks) and involves technological assets focused on the acquisition, allocation, and development of a highly integrated infrastructure, supporting enterprise systems. Enterprise Application Integration (EAI) is an example that combination of processes, software, standards, and hardware resulting in the seamless integration of two or more enterprise systems allowing them to operate as one. Convergent content, computing, and communication technologies involve both operation-level and application-level assets dedicated towards developing, managing, and integrating content, computing, and communications. For example, Enterprise system technologies can link distributed databases in a parallel processing environment connected over client-server networks.

Operating-level technologies include assets related to Enterprise Systems, CRM, Network Servers (Application servers, Web servers,

Wireless servers, Web servers, Mail servers, Proxy servers), E-server clusters (using distributed processor and system resources to provide content across wide area networks (WANs)). Application-level assets include technologies supporting Integration Security (Hitachi TPBroker, Veracity, FreeVeracity, Gradient DCE, UniCenter, Tivoli SecureWay), Business Process Integration (BPI) (Workflow, Process management, Process modeling), Groupware and Collaborative Communication (Lotus Notes, Document Exchange), Distributed Data Management (SQL server, Oracle 9i), Application Integration development (XML, ASP, LDAP, Panther for IBM WebSphere), Application Integration Standards (UML, EDI), Application Integration Adaptors/Wrappers (bTalk adaptor for SAP, BEA eLink for PeopleSoft, OpenAdaptor), Enterprise Resource Planning Suites (Baan, Microsoft Great Plains, Oracle, SAP R/3).

6.3. THE HUMAN RESOURCE DIMENSION

The previous section dealt with the physical assets that comprised the technical dimension for each infrastructure configuration. Because physical IT assets "can be purchased or duplicated fairly easily by competitors," Bharadwaj contends, "physical IT resources are unlikely to serve as sources of competitive advantage." What, however, helps leverage IT infrastructure configurations as an organizational asset is the incorporation of the human resource element that makes up the human resource infrastructure. The human resource infrastructure builds on the education, training, experience, relationships, and insights of personnel supporting a particular infrastructure configuration (Bharadwaj, 2000). Each of the aforesaid 7 infrastructure configurations

consists of distinct technical and human infrastructure dimensions. While physical IT assets are replicable, human resources are unique in terms of their skills and capabilities. Following the footsteps of researchers such as McKay and Brockway (1989), we regard IT infrastructure as a fusion of technical and human assets. The shift in perspective could be attributed to the socio-technical dimension first offered by Kling and Scacchi (1982). The authors introduced the importance of people "behind the terminal" representing the "mortar" that binds all technical IT components (McKay and Brockway, 1989).

We refer to the human infrastructure as the "mind behind the machine." It is this human infrastructure that enhances the physical infrastructure in terms of optimizing and innovating work processes through efficient use of technology. Kayworth, et al. (1997) substantiate the notion by pointing out that technical artifacts along with human assets can provide differentiated value by enhancing IT performance. Both assets have to work in unison to augment their individual resource potential within each IT infrastructure subsystem component (Figure 3). Possessing both technical and managerial IT skills, the human resource infrastructure brings to the table an eclectic mix of intangible assts that provide a unique concoction as a result of the situatedness between the man and the machine. It is through interaction between the technical and human infrastructure that "value-innovation" procedures emerge (Sambamurthy and Zmud, 2000). Bharadwaj (2000: 174) posits, "it is clear that human IT resources are difficult to acquire and complex to imitate, thereby serving as sources of competitive advantage." Because the human resource infrastructure pertaining to a particular IT infrastructure is so difficult to imitate, human resources have the potential to create "causal ambiguity" as a differential sustainable advantage for firms.

6.4. IT INFRASTRUCTURE SERVICES DIMENSION

The Merriam-Webster defines services as “the work performed by one that serves.” In the context of IT infrastructure, the human resource infrastructure interacts with their relevant technical/physical infrastructure to provide us with necessary services. In the words of Broadbent et al. (1996: 176), “The base level IT components are converted into useful IT infrastructure services by the human IT infrastructure composed of knowledge, skills, and experience. This human IT infrastructure binds the IT components into a reliable set of shared IT services.” Functionally, “IT infrastructure services” is a derived dimension resulting from the use of the technical infrastructure by the respective human resource infrastructure.

Infrastructure services are wide ranging and contingent upon the “who, what, and how” of infrastructure technologies and configurations. The “who” refers to the human resources; the “what” refers to the technology surrounding a particular infrastructure configuration; and the “how” refers to the way a particular technology is put to use for specific services. For example, human resources supporting less-convergent components can provide services such as Database Maintenance and Management, Network Maintenance and Management, Systems Maintenance and Management; human resources supporting partially-convergent components can provide services such as E-commerce Training and Consulting, Security Training and Consulting, Storage Training and Consulting; while human resources supporting highly-convergent components can provide services related to Deployment, Training, Integration, and Support of integrated Enterprise systems. In addition, there exist common or shared services such as help desk support across different levels of convergence. While the set of IT infrastructure services

is relatively stable over time (Weill et al.. 1995), the way the services are administered can be a source for ascertaining the necessary productive potential.

The two distinct dimensions of IT technical and human resource infrastructure along with the derived dimension of IT services infrastructure are diagrammed in Figure 4b.

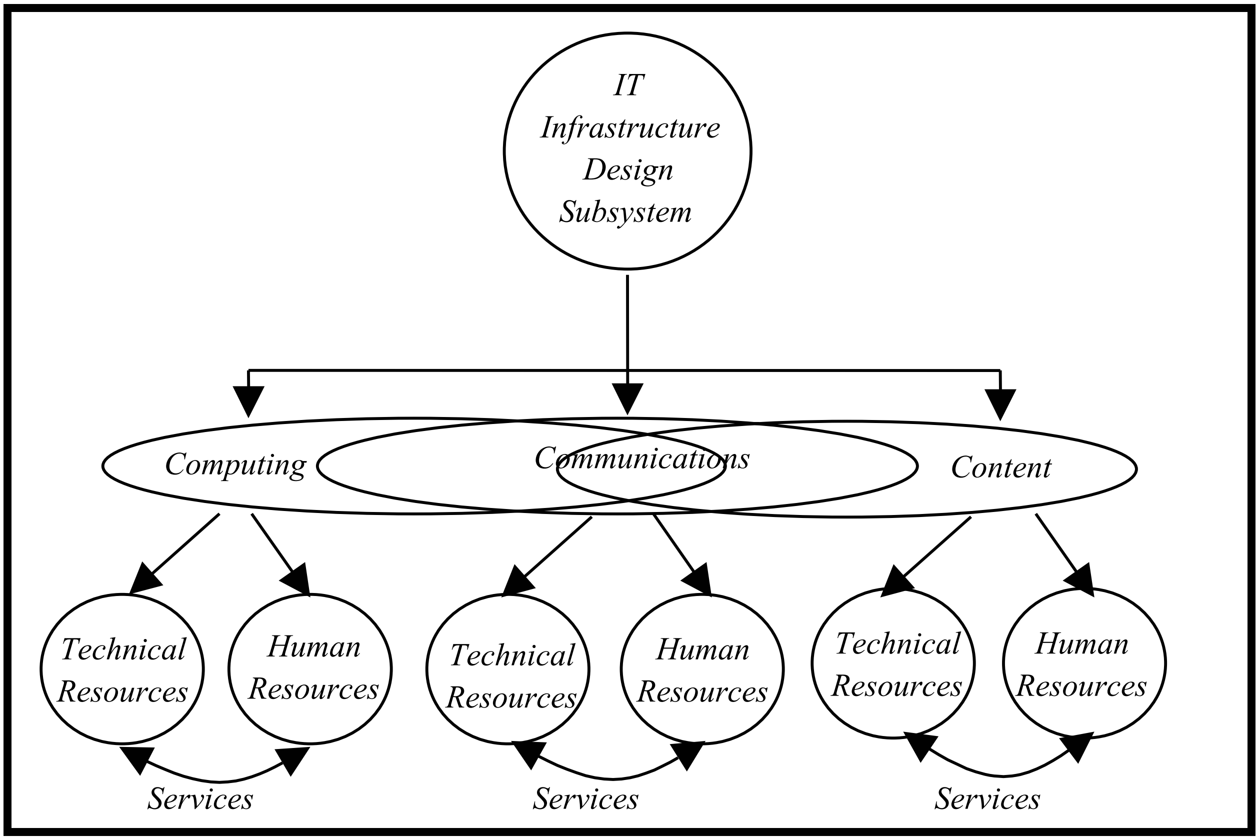


Figure 4b. Technical, Human Resource, and Services Dimensions of the IT Infrastructure Design Subsystem

While convergence is an evolving trend, we need to realize that IT infrastructure configurations are unique and vary across industry and firm and that no specific configuration serves as a panacea for productivity ailments. It remains imperative to note that an organization incorporates a portfolio of infrastructure technologies with multiple levels of convergence. The infrastructure portfolio provides a unique mix of technical

infrastructure, human resources, and services- consequently creating an eclectic mix of assets. However, greater technological convergence incurs higher levels of infrastructure expenditures. Evidence offered by the industry allows us to infer that the scale of capital outlay for infrastructure technology grows in line with infrastructure convergence. For example, less-convergent network and storage devices incur lower capital outlays than partially-convergent technologies such as data mining applications and SANs. Similarly, partially-convergent technologies incur lower budgetary allocations than highly-convergent technologies such as ERP and CRM. This motivates us to hypothesize:

> H2: The level of IT investment in an organization will be significantly and positively related to the level of convergence of its IT infrastructure design.

There is a general consensus that a rational consequence of IT infrastructure convergence is the increased diffusion of information across the firm (Broadbent and Weill, 1991)- supporting better strategic decision-making activities (Cotteleer, 2002). For example, Brauerei Beck and Co.'s, one of the world's leading beer exporters, incorporation of a highly convergent ERP and CRM related infrastructure design from SAP helped them achieve a strategic and competitive advantage with faster value-enhancements in products and services.

> H3a: A highly-convergent IT infrastructure design will be significantly and positively associated with higher levels of strategic productivity compared to other productivity measures.

On the other hand, the utilization less-convergent infrastructure designs such as Amoco Corporation's 1994 use of ATM (Asynchronous Transfer Mode) technology

helped in generating considerable revenues for increasing financial returns- which leads us to forward the argument that a less-convergent IT infrastructure has focused more upon satisfying financial productivity concerns.

> H3b: A less convergent IT infrastructure design will be significantly and positively associated with higher levels of financial productivity compared to other productivity measures.

Partially-convergent infrastructure designs have a greater propensity for generating productive value at a more operational level. For example, Federal Express Corporation's infrastructure design objectives of 1992 were a convergence of content and communications. Their large scale investments in optically-scanable handheld devices led to considerable rise in operational quality through streamlined package routing and reliable service outcomes.

> H3c: An IT infrastructure design based on the convergence of content and communications will be significantly and positively associated with higher levels of operational productivity in terms of operational quality compared to other productivity measures.

Similarly, the use of distributed computing technologies such as the computational grids used by SETI (Search for Extra Terrestrial Intelligence) has increased operational efficiency by upping operational productivity by reducing human-related observational errors and increasing calculations using idle CPY time across a network of subscribers. Convergence of computing and communications has resulted in increased operational efficiency where SETI can process and sift through signals transmitting immense quantities of radio-waves.

H3d: An IT infrastructure design based on the convergence of computing and communications will be significantly and positively associated with higher levels of operational productivity in terms of operational efficiency compared to other productivity measures.

Finally, infrastructure designs based on the convergence of computing and content seem to yield a high level of operational productivity. As an example, Wal-Mart's investments in a comprehensive data mining solution have resulted in both operational efficiency and operational quality through better analysis of customer demand and their purchasing behavior, respectively. A better understanding of customer demand has helped Wal-Mart plan and manage its inventory- leading to lower stock-out scenarios while catering to seasonal demands. Additionally, analyzing purchasing behavior has resulted in smarter shelving and pricing strategies for creating a heightened shopping experience.

H3e: An IT infrastructure design based on the convergence of computing and content will be significantly and positively associated with higher levels of operational productivity in terms of operational efficiency and operational quality compared to other productivity measures.

As can be seen, information flow increases in line with technological convergence. As increased information occurs with partial infrastructure convergence, value-addition shifts from financial to operational dimensions. Mirani and Ledere (1998) regard such value-added benefits as informational- where reliance is on streamlining the efficiency and quality of operations. As convergence increases, information access and diffusion increases simultaneously, creating enterprise-wide informational support. With

information available on an enterprise-level scale, productivity shifts from operations to a more strategic dimension. The strategic dimension of productivity is exemplified in terms of increasing strategic advantage, competitiveness, strategic alliances, and customer-relationship management, among others. Thus, as the IT infrastructure scope shifts from low a high level of convergence, so does the nature of productivity shift from a financial to a strategic context.

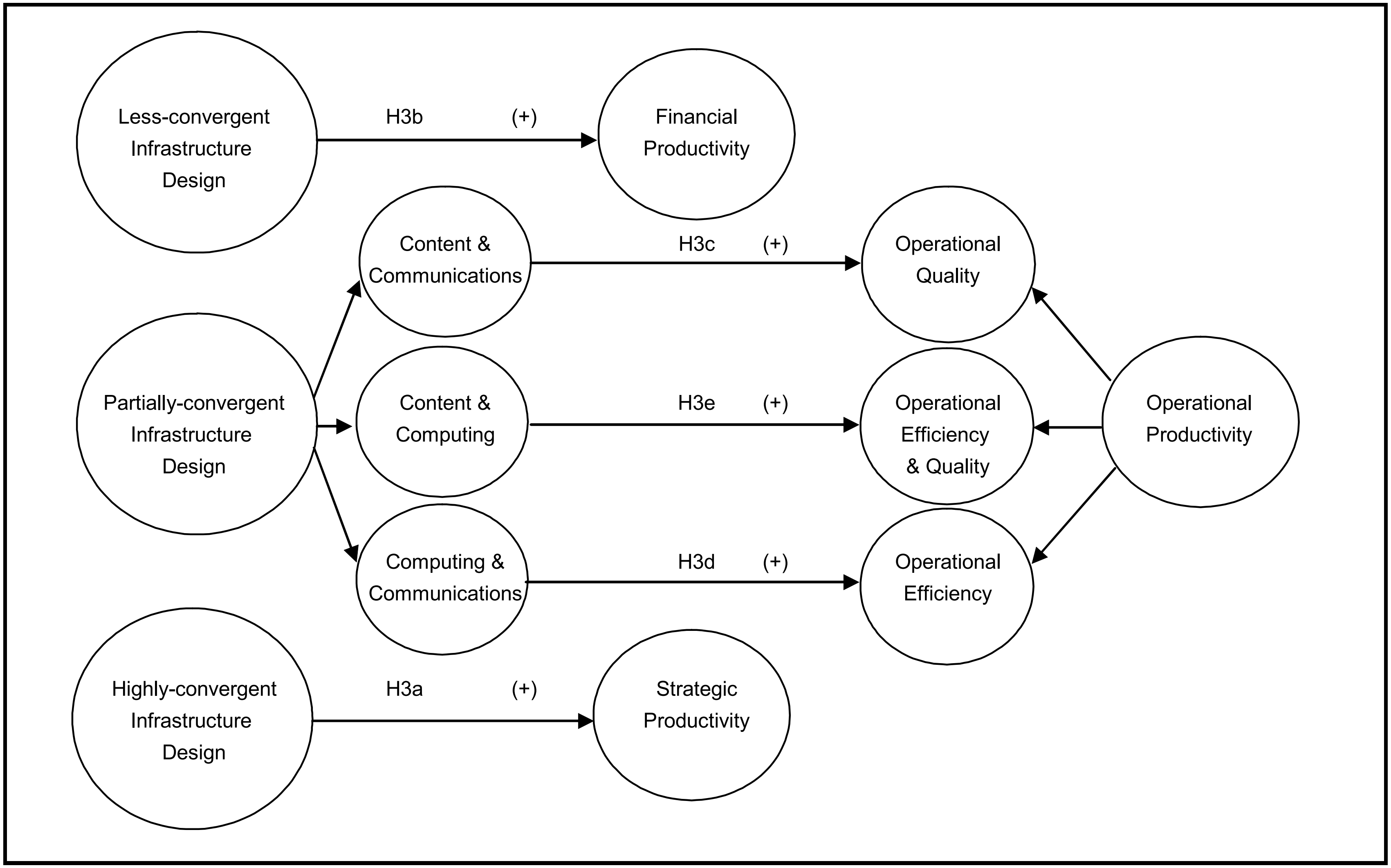


Figure 5. Proposed Relationships between IT Infrastructure Design and Productivity

CHAPTER 7. THE IIP SYSTEM FRAMEWORK: IT MANAGEMENT SUBSYSTEM

"It is not the technology that creates a competitive edge, but the management process that exploits technology."

Shaping the Future- Peter Keen (1991)

A considerable corpus of past normative research on the value of IT subsumed the notion that if the magnitude of capital outlays is both necessary and sufficient condition for productivity, similar inputs should generate similar outputs, a common presumption in the standard production theory (e.g. the Cobb-Douglas function). However, reality holds a different view. As evidenced in our aforementioned cases, the size of capital outlay (input) is not a sufficient precondition for securing productivity. Lee and Menon (2000) note that variances in productivity can be attributed to the facts that identical levels of IT capital input does not produce the same level of output across two firms because of allocative inefficiencies that occur when resources (e,g, capital) are allocated at a suboptimal level. According to the authors, allocative efficiency is a function of IT management decision-making who decide on obtaining the best allotment of scare resources (IT-related capital outlays, in this case) among alternative activities and uses.

The importance of IT management in achieving productivity cannot be overstated. Researchers such as Broadbent and Weill (1997), Davenport and Linder (1994) realize the IT-related capital outlays need effective management. It is IT management that increases allocative efficiencies by effectively converting IT-related capital outlays into organizationally coherent IT assets, a phenomenon Weill and Olson (1998) refer to as "conversion effectiveness." Weill's (1992) conversion effectiveness concept is rooted in the need for effective management of IT in order to acquire, allocate, and develop

effective and efficacious IT assets from given IT-related capital outlays (Soh and Markus, 1996). To be precise, it is never "how much" one has expended that counts, but "how" one has expended it. While capital outlays denote the "how much," IT management distinguishes the "how." In the process, IT management joins the select club of scarce resources that organizations need to use for building assets and harnessing their productive potential (Weill and Broadbent, 1998).

As a scarce resource, the nature of IT management holds the clue for converting IT expenditures into IT assets. In treating IT management as the key moderator in converting IT expenditures into value-added IT assets (Soh and Markus, 1996), conversion effectiveness becomes an integral part of management quality and commitment. Sambamurthy and Zmud (1992) acknowledges that IT management is all about aligning technological and business objectives, matching technology and capital investments for greater productivity. The role of IT management in aligning technological and business objectives forms the basis for "conversion effectiveness" a concept deeply rooted in contingency theory, where outcomes are influenced by and large by value-conversion contingencies (Lucas, 1999). As a value-conversion contingency that that is internal to a firm, IT management in the function of the degree of technological and business alignment, influencing the accrual of value in different ways (Davern and Kauffman, 2000). Because IT management is an internal contingency and therefore controllable, understanding its demeanor becomes an important parameter for ascertaining its influence. After all, "If payoffs from IT investment are a function of …alignment, then any attempt to increase IT business value must consider the extent to which IT is aligned with the business…" (Tallon, et. al, 2000: 154). The words echo thoughts by Strassman (1997:4) who remarked, "if the consequences of… computer

projects are clearly linked with a firm's planning and budgeting commitments… then computer investments have a chance of becoming catalysts of organizational change instead of discrete expenses."

In The Squandered Computer, Strassman (1997) relates the need for alignment as a precursor to developing IT assets for realizing productive returns- attributing the lack of productive returns from IT-related capital outlays to misalignment by management. "Alignment is not ex-post-facto reasoning," as Strassman insists, "Alignment is the fullest understanding of the futurity of present decisions and present commitments of funds!" (Ibid: 32). Conceptualizing IT management as a process of aligning business and IT infrastructure domains to achieve competitive advantage, Sambamurthy and Zmud (1992) refer to how IT management can enhance the acquisition or development of existing and future IT infrastructure resources. According to Sambamurthy and Zmud (2000), IT management positions an enterprise to exploit business opportunities by aligning competencies for value innovation and solutions delivery. IT alignment thus becomes a core constituent in IT management effectively linking "business and technology in light of dynamic business strategies and continuously evolving technologies" (Luftman and Brier, 1999: 110).

According to Reich and Benbasat (2000), IT alignment has a strategic and a social research dimension. Strategic alignment is more normative concerning documentation, planning, and the distribution of control within an organization- measuring the extent to which IT strategies matched business objectives. Social alignment is more formative, concerning participation, communications, and cohesion between IT and business executives.

a. Strategic IT Alignment Dimension (Normative): The importance of strategic alignment has been documented since the late 1980's (Brancheau and Wetherbe, 1987; Niederman, et al., 1991) and continues to be ranked among the most important issues faced by business executives (Rodgers, 1997). Reich and Benbasat (1994: 84) define strategic alignment as, "the state in which IT and business objectives are consistent and valid." Strategic IT alignment indicates the need to orient IT resources and strategy to business level strategies (Chan and Huff, 1993). Because strategic alignment is viewed as the degree to which IT resources and strategies are cohesive with the business strategy, such an alignment dimension "considers the strategic fit between strategy and infrastructure as well as the functional integration between business and IT" (Luftman and Brier, 1999: 110). Strategic alignment has a normative and formal demeanor. The essence of strategic alignment lies in the fact that activities and functions in organizational levels need to be guided by formal strategic planning. Such a normative strategic planning relies upon developing and utilizing formal detailed artifacts that can provide a constant direction- from individual skills to business level visions. The need for strategic alignment through proper planning gains credence in developing IT infrastructure as an organizational asset. With the ever-growing IT management onus on acquiring, configuring, developing, and allocating IT infrastructure, strategic alignment provides a strategic purpose for developing IT infrastructure as an asset. Once strategically aligned, IT management can create meaningfully differentiable IT infrastructure assets, given an IT capital outlay.

b. Social IT Management Dimension (Formative): Reich and Benbasat (1994: 83) define social alignment as “the level of mutual understanding and commitment to business and IT mission, objectives, and plans by organizational members.” Reich and Benbasat (2000) forge a robust defense for understanding IT alignment by looking beyond the strategic artifacts of plans and structures to investigate the mutual understanding of IT and business objectives. The social dimension augments the rational model of normative strategic alignment. The reliance of strategic alignment on formal artifacts is complemented by social alignment by elaborating the role of communications and connections among the human entities that cohesively interact to create IT assets by effective infrastructure design. The concept of social alignment sustains itself from a more formative strategic dimension through its dynamism rooted in world-views, and investigable through the understanding of the mutual relationship between IT and business executives (Reich and Benbasat, 1994). Social alignment builds on effective communication and connections. As Luftman and Brier, (1999: 37) note, "for alignment to succeed, clear communication is an absolute necessity.” The process of communication relies on the interactions and exchanges between IT and other managers to reach a mutual understanding (Boynton et al., 1994)- relying on formal and informal communication mechanisms (e.g., meetings, written or verbal communications). Connections are evidenced by better participation of IT management in business planning (Lederer and Burky, 1989)- related to “the ability of IS and business executives, at a deep level, to understand and be able to participate in the others' key processes and to respect each other's unique contribution and challenges” (Reich and Benbasat, 2000: 112). This ensures that

the plane of thought and action between IT management and the rest of the organization are both at par and convergent.

Given the two dimensions of IT management as explicated by the strategic and social dimensions, the combinations can be defined as a 2x2 combinatorial matrix, subsequently forming four categories as shown in Figure 6. They are:

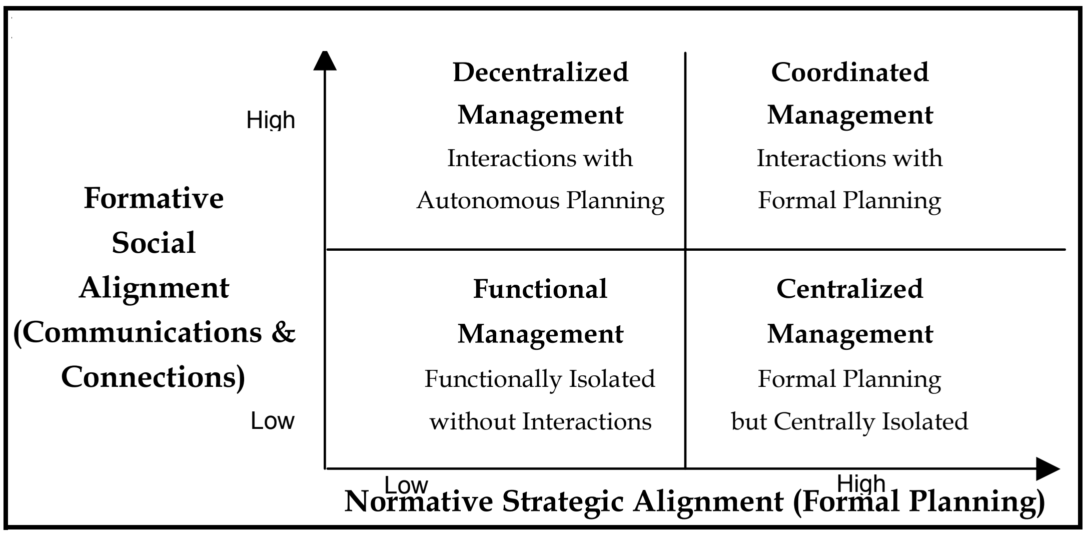


Figure 6. IT Management Subsystem Categories

- Functional Management: Functional IT management is characterized by a high degree of isolation- marked by low strategic and social alignment (the bottom-left quadrant in Figure 6). In such a scenario, IT management is captive to functional units that are unique in nature and activities performed. The level of segregation of activities is high and disparate, independent of the modus operandi of any other function. IT management is therefore functionally isolated without any preset goal or formal planning that is in congruence with organizational objectives.

  Functional IT management isolate IT as an isolated body within the organization- managed by department-centric functional heads with a focus on functional

rewards and outcomes independent of enterprise-wide ramifications. Here, only the IT department serves as the focal point for IT management without much ado about the organization. Isolated in its management and objectives, the onus is only on serving its own needs rather than that of the organization. This management style is neither reliant on participative communication nor formal organizational-level planning, infrastructure design considerations too remain primarily functional. The infrastructure design, in this case, remains hidebound- relegated to non-convergent designs that generally serve application level developmental objectives. This allows us to propose the following hypotheses.

> H4a: Given a specific level of IT-related capital outlays in an organization, a functional management style will significantly and positively result in a less-convergent IT infrastructure design compared to any other infrastructure design.

- Coordinated Management: Coordination is defined as a body of principles about how factors can work together harmoniously to achieve a unified purpose, collectively focused on delivering a common output (Malone, 1990). Coordinated management is characterized by a combination of high strategic and social alignment (top-right quadrant in Figure 6). Normative strategic alignment along with formative social alignment marks a high level of planning and objectivity along with increased participation between IT management and other managers. The result is a common and cohesive focus on the development, allocation, or acquisition of an IT infrastructure design that is in line with the organizational processes and objectives. In analyzing multiple organizations, Weil and Olson (1989: 11) posit that an “integrated coordination of IT investments is necessary”

for IT management. Coordinated management thereby stresses on achieving an IT infrastructure that supports entire organizational processes in unison. As IT infrastructure design develops to accommodate organizational goals, objectives, and complexity, a coordinated management style brings the essential actors together for a unified organizational purpose. Because this management style is reliant on both formal planning and participative communication, infrastructure design objectives simultaneously hinge towards a content, communication, and computing related convergence. The convergence is aimed at increasing planning and participation, leading us to the following hypothesis:

H4b: Given a specific level of IT-related capital outlays in an organization, a coordinated management style will significantly and positively result in a highly convergent IT infrastructure design compared to any other infrastructure design.

- Centralized Management: Centralized IT management results from a combination of high strategic alignment with low social alignment (bottom-right quadrant in Figure 6). A centralized governance structure consists of one or more people having exclusive authority to make the management decisions for the benefit and sustenance of the firm. Centralization entails elaborate and explicit formal planning where IT management decision-making is not reliant upon communications or connections with other departments within the organization. Centralized IT management has been effective in terms of explicating goals and plans, consolidating resources, and reduction of management inefficiencies (Ulrich, 1999). In this case, the onus is on partial integration of the IT infrastructure for a one-way (top-down) flow of decisions. There is little reliance

on participative decision-making as management processes organizational data (content) to deliver a set of strategic propositions for the enterprise to follow and function. Because there is less reliance on participative communication and more on processing organizational content for prescribing a modus operandi, infrastructure design objectives hinge more towards enhancing content-related convergence, processing and delivering results. We therefore propose the following hypothesis:

> H4c: Given a specific level of IT-related capital outlays in an organization, a centralized management style will result in a partially convergent IT infrastructure design compared to any other infrastructure design.

- Decentralized Management: Decentralized IT management is a combination of a low degree of strategic alignment (autonomy) and a relatively high degree of social alignment (participation) (top-left quadrant in Figure 6). This is characterized by the low centralized planning and control. According to Turban, et al. (2000), because decentralized units are more responsive to business demands and there is a greater support for the delegation of authority, communication and participation is high, albeit relative strategic autonomy. While decentralization signals operational flexibility through facilitation, collaborative democracy, and participative communication (Davenport, 1998), it also drives operational costs higher. In such a case, IT management in every unit largely treats their specific unit as a cost or profit center, trying to reduce operational overheads and develop ad-hoc infrastructure strategies that tactically serve to sustain the operations of individual business units. With a lack of formal planning,

too much autonomy to formulate budgets and allocate resources may present confusion in organizations that may result in an unwieldy mix of de-concentration and decentralization of activities. While communication and connections remain extant because of the affiliation with the parent, IT management grows narrow and too operational in objective and scope. IT management, in this instance, focuses on limited top-down planning by a centralized parent body, focusing on achieving greater autonomy. Because of the decentralized management structure, the infrastructure design serves to connect business units for seamless communication and participation. In such instances, an IT infrastructure design serves to deliver shared IT resources across the enterprise- heavily reliant upon communication-related convergence, distributing system or data resources. This leads us to the following hypothesis:

> H4d: Given a specific level of IT-related capital outlays in an organization, a decentralized management style will result in a partially convergent IT infrastructure design compared to any other infrastructure design.

While each of the dimensions offers an understanding of IT alignment, we believe that IT management is a socio-strategic process where the dimensions are interwoven. IT alignment has a normative strategic aspect (planning and structure) and also a formative social aspect (understanding, communication of IT and business objectives). However, none of them are independent and rely upon the other for IT alignment. The high degree of intertwining between the two dimensions offers a rich ground for contending that it is the interaction of the two dimensions that constitute the IT alignment construct. Chircu and Kaufmann (2000) elaborated on the need to reduce barriers to “conversion

effectiveness" by effectively weaving social and strategic dimensions. The intricate relationship reduces "conversion" barriers by explicating policies, plans, and strategies that encompass decision-makers and functional units to understand, and develop a consensus on the allocation, acquisition, and development of IT infrastructure assets directed towards an organizational goal.

According to Strassman (1997), aligning IT with business objectives is realizable upon meeting multiple requirements. These requirements consist of prudent anticipation of returns from infrastructure design, mutual evolution of objectives, planning, reducing resistance, and understanding how a particular capital outlay can help create an infrastructure asset for future benefits. After all, "to achieve alignment, one must first identify the sources of misalignment" (Strassman, 1997: 37). By discriminating management styles based on alignment types, it becomes easier to discern alignment from misalignment. In doing so, IT management becomes a salient candidate influencing the conversion of IT-related capital outlays into an effective IT infrastructure design.

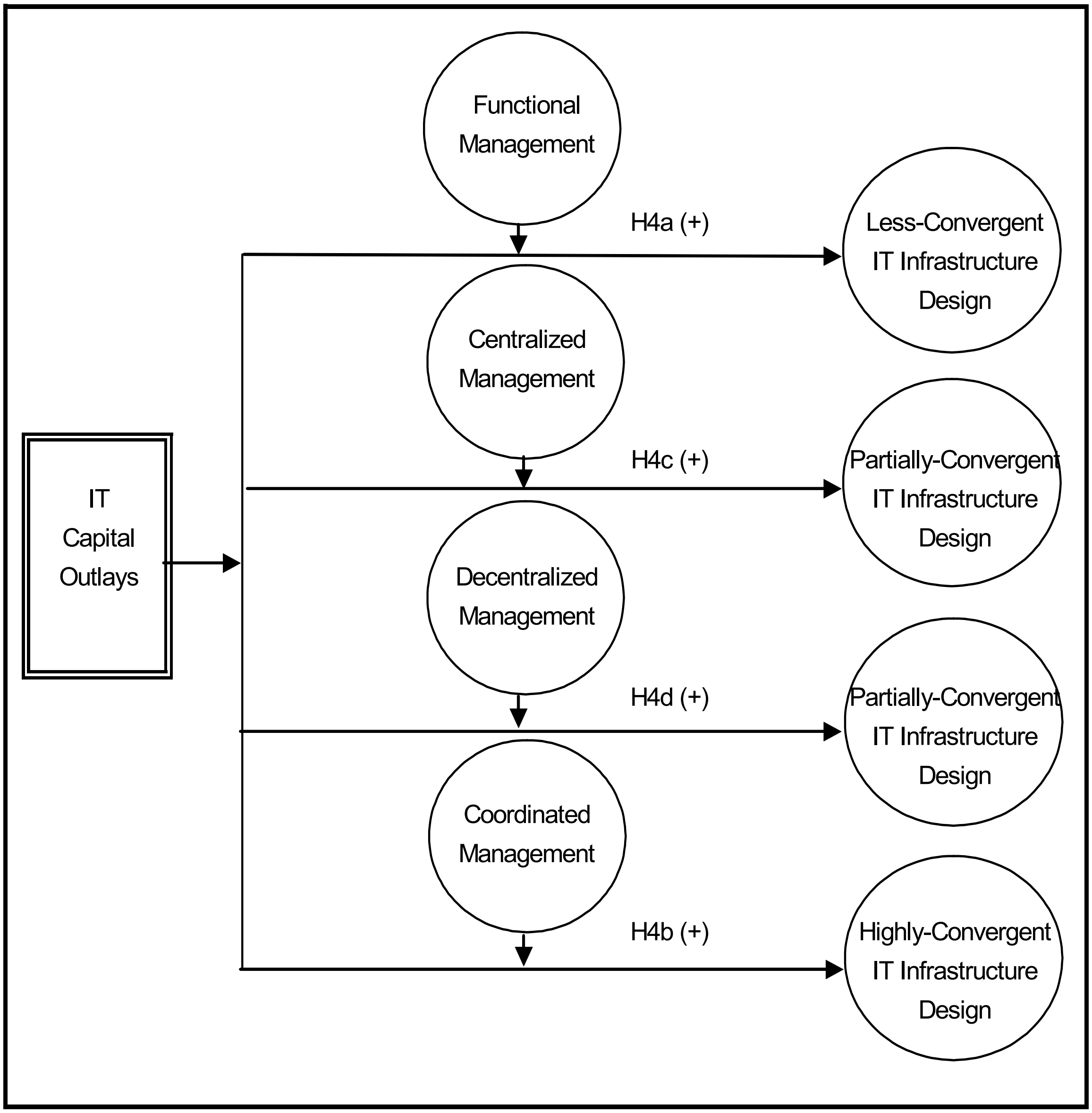


Figure 7: Propositions based on the Moderating Influence of IT Management on IT Infrastructure Design

CHAPTER 8. THE IIP SYSTEM FRAMEWORK: THE ENVIRONMENTAL SUBSYSTEM

"Business as usual has been rendered largely ineffectual by the growing complexity of the business environment."

Shaping the Future- Peter Keen (1991)

The systems approach to IIP in organizations begins with the postulate that organizations engage in various modes of exchange with their environment (Katz and Kahn, 1966). To conceptualize organizations as systems is to emphasize the importance of its environment, upon which the maintenance, survival, and growth of an open system depends. Davern and Kauffman (2000) implicate the environment as the other value-conversion contingency (the first being IT management- an internal contingency) external to the system that can influence the accrual of value in several ways. Accordingly so, the external environment plays a key role as a contingent factor in achieving IIP. As Argyris (1972: 87) so aptly and humorously remarks, “Tell me what your environment is and I shall tell you what your organization ought to be.”

From Schumpeter’s (1948) “waves of creative destruction” to Nadler and Shaw’s (1995) “wicked environment characterized by discontinuous change,” the environment has always brought with it a “wide range of potential surprise” (Landau and Stout, 1979). Our use of systems theory treats organizations as systems constantly adapting to and evolving with the environment, marked by an effective “anticipation of surprise” (Burns and Stalker, 1961). This variability of the environment and its influence on organizational productivity can either inhibit or promote the flow of value for an investing entity trying to justify its IT investment (Davern and Kauffman, 2000).

Duncan (1972) defines the environment as the relevant factors outside the boundary of an organization that impact organizational functions. Factors outside the firm boundaries are always in constant interaction with the organization- imposing on them opportunities, constraints, and adversities. As Sadler and Barry (1970: 58) note, “an organization cannot evolve or develop its ways that merely reflect the goals…since it must always bow to the constraints imposed on it by the nature of its relationship with the environment.” The constraints are as varied as organizations and environments are- forcing firms to revamp themselves to adapt to this “artificial selection.” Consequently, “different environmental conditions…require different types of…structural accommodation for a high level of performance to be achieved” Child (1972: 3).

Environmental influences decrease the perfect use and exploitation of technology- only in a completely insulated and closed system can organizations realize returns from technology (Thompson, 1967). Chan (2000: 231) aptly relates, “If IT evaluation approaches are designed with static, closed systems in mind, they may be inadequate,” Disparate environments are therefore culpable for disparate productivity for two similar firms in dissimilar environments. Because organizational productivity varies by environments, preemptive strategies in response to environmental changes are generally associated with superior performance (Miller and Friesen, 1986). For example, productivity pursuits via low cost (operational efficiencies) are appropriate in a stable and predictable environment while differentiation strategies (strategic competitiveness) are appropriate in a dynamic and uncertain environment (Miller, 1989). According to Lawrence and Lorsch (1967: 352), “the most effective organizations achieve a degree of differentiation and integration… compatible with environmental demands,” something that we purport that our IIP framework accomplishes. After all, comprehension of a

“system” cannot be achieved without a constant study of the forces that impinge upon it (Katz and Kahn, 1966).

Organizational environment can be conceptualized as constituting of a task environment and a general environment (Dill, 1958). A task environment is defined by its nearness and has a direct influence on the organization. Made up of entities closely linked to the focal organization (organization that is the point of reference), this mix of current and potential competitors, suppliers, and customers together constitute the task environment (Daft, 2001; Dess and Beard, 1984). A general environment, on the other hand, is relatively less proximal to the focal organization, affecting it indirectly through political, economic, and socio-demographic factors. While the general environment is a significant aspect, our research seeks to examine the impact of the more proximal task environment on IIP.

As referred to earlier, a task environment consists of environmental elements that directly affect the focal organization (Gross, Mason and McEachern, 1958) in terms of influencing the achievement of organization goals and objectives, using similar resources, competing directly with the organization, or transacting with it as customers and suppliers (Starbuck, 1976). In short, the entities that constitute the task environment for the focal organization are likely to readily and most directly influence organizational value-added outcomes. Asserting that the task environment offers considerable variation and a more direct influence, this research uses it as a proxy for the organizational environment. After all, the task environment qualifies as a more immediate conversion-contingency whose variability can build or erode organizational productivity.

Following Lawrence and Lorsch (1967), we denote productivity as being dependent on a firm’s ability to adapt to and learn from the influences exerted by its

environment. Duncan (1972) who is generally credited with initiating the study of perceived environmental uncertainty suggested that the level of uncertainty could be described along two dimensions in the moderating environmental subsystem variable. First, every firm faces and dynamically interacts with its environment (Lawrence and Lorsch, 1967). Second, organizations face varying degrees of heterogeneity in terms of goals and markets (Burns and Stalker, 1961). This implies that firms in different environments will face varying degrees of contingencies and consequently IIP, *ceteris paribus*. This parallels the classical contingency theory that asserts that the productive potential of an organization is contingent upon the amount of congruence or goodness of fit between environmental and structural variables (Burns and Stalker 1961; Lawrence and Lorsch 1967; Lee and Xia, 2003).

Previous classical contingency theorists (e.g. Judge and Miller, 1991) have posited that the magnitude and direction of change in firm performance is contingent upon the complexity and dynamism of industry environment. Because the constraints and contingencies posed by the relatively uncontrollable environment are heterogeneous, an accurate assessment can reduce organizational dependence on the elements of the task environment. Duncan’s (1972) seminal work on organizational environments rests on two essential dimensions: environmental complexity and environmental dynamism, both of which had been supported by Emery and Trist (1965:21) who confirm that, "the environmental contexts in which organizations exist are themselves changing, at an increasing rate, and toward increasing complexity," as reified in a future study by Lee and Grover (1999).

a. Environmental Dynamism: Environmental dynamism represents the *degree of change* in an organizational environment and, especially, the unpredictability of such change (Daft, 1998; Dess and Beard, 1984). In his seminal paper on organizational environment and performance, Child (1972: 3) refers to the notion of dynamism in terms of variability, calling it "the degree of change which characterizes environmental activities relevant to an organization's operation." Therefore, as dynamism or variability increases, so does the propensity for uncertainty and ambiguity. Because a prescribed pattern of changes cannot be anticipated with any level of certainty in these highly dynamic environments, organizations face a need to be extremely aware and responsive of any sudden environmental shifts. Dynamism can be characterized by uncertainty and unpredictability regarding the actions of competitors, and the rate of change and innovation in the industry (Miller and Friesen, 1983). As environmental dynamism refers to the *rate of change* within the environmental elements in terms of volatility in customer demand, technology, practices, and product/service sustainability (Miller and Friesen, 1982), increases in unpredictable change contributes to uncertainty because organizations do not know on what assumptions they should organize their IT infrastructure.
b. Environmental Complexity: Complexity refers to the heterogeneity of environmental elements relevant to the organization (Child, 1972). Duncan (1972) describes environmental complexity in terms of the heterogeneity in and range of environmental factors that a firm faces. According to Child (1972: 3), "the greater the degree of complexity, the more a profusion of

relevant environmental information in likely to be experienced" along with the dedication of increasing organizational resources directed at "monitoring of diversified information." Complexity is thus determinable by the number of heterogeneous "external entities" and/or their heterogeneous behavior that firms need to comprehend to stay responsive and adaptive. As organizations in a given industry expand their product and market activity, the variety of inputs and outputs with which they must cope increases environmental complexity. Emery and Trist (1965: 21) relate, "The environmental contexts in which organizations exist are themselves changing, at an increasing rate, and toward increasing complexity." The complexity of an organization thus becomes directly related to the organization's information-processing needs (Galbraith, 1977). As information-processing needs grow manifold, an organization faces resource shortages to cope with the tremendous need for information, therefore increasing unpredictability and uncertainty- consequently affecting its productive performance (Wiersma and Bantel, 1993). The unpredictability of the external environment has been viewed in terms of elements in the external environment about which information needs to be processed by an organization. As the number of elements grows, so does the scale and scope of information. Galbraith's (1977) use of goal diversity (products/services, markets served…), supplier diversity (Landry, 1998), and customer diversity (Anderson and Narus, 1998), competitor diversity (Miller and Friesen, 1982), among others, constitute some of the elements that have been found to be significant elements adding to environmental complexity.

Based on the degree (low/high) of environmental complexity and environmental dynamism that firms are contingent upon, our research presents a 2x2 combinatorial matrix as shown in Figure 8a. The 4 distinct outcomes from the combinations of these dimensions provide a preliminary insight on the types of environments that may be created by the interaction of these two dimensions. The types are:

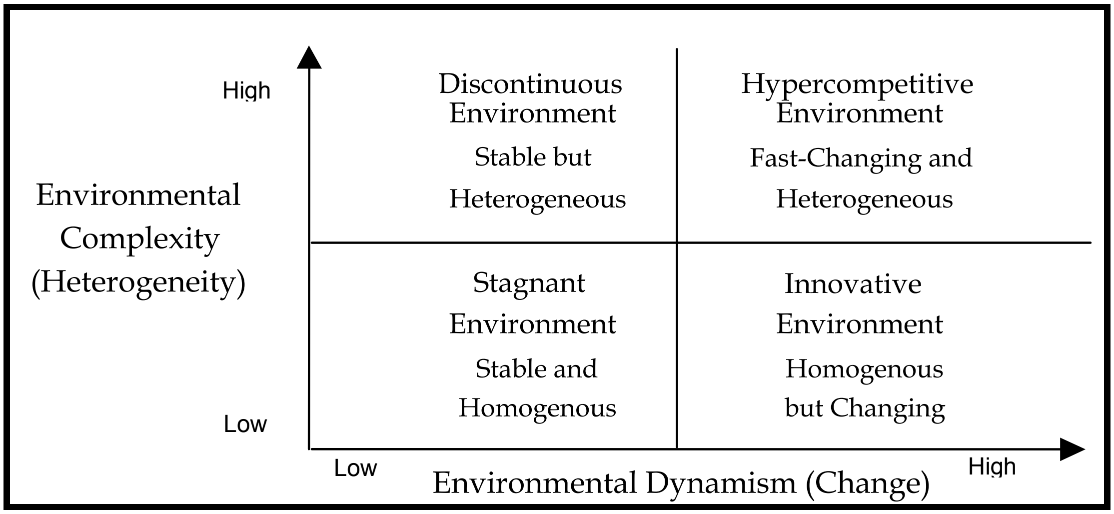


Figure 8a: Organizational Environment Subsystem Categories

- Stagnant Environment: A stagnant environment is generated by an unchanging, stable environment consisting of homogenous entities. From a complexity perspective, because entities in the environment are non-diversified, information-processing is extremely low. With a fixed and homogenous set of customers, suppliers, competitors, and goals, the organizational environment provides no challenges through heterogeneity. Similarly, from a dynamism perspective, the environment is extremely stable, offering no variation or environmental shifts. This creates an environment marked by a lack of competition, low innovation, and little or no changes in customer demand (highly predictable demand). Industries marked by monopolies, extreme maturation, or high degree of

nationalization (e.g. the consumer products industry in the former USSR) may create such stagnant environments. In such a "no-frills" environment, organizations try to focus on financial outcomes by trying to reducing expenses and increasing financial report-based returns (Mirani & Lederer, 1998).

H5a: Given a specific IT infrastructure design, organizations facing a stagnant environment will positively and significantly rely more on financial productivity measures compared to other productivity metrics.

- Uncertain Environment: In extreme contradiction to stagnant environments are uncertain environments, marked by tremendous heterogeneity and extreme rates of change. Salmela, et al., (2000) reveals that environmental dynamism and complexity considerably increases uncertainty and the risk of IT investment failure. In such conditions, environments show a high degree of flux. Complexity is high in terms of high degree of heterogeneity in markets, products, customers, suppliers, and competitors. Dynamism is high in terms of a fast-changing and volatile demands, rivalry, practices, and cannibalization of products and services. Here the high frequency of change along with tremendous resource consumption for information-processing leads to an environment that is volatile and uncertain. Such environments are marked by extremely fragmented market demands, very low entry barriers, tremendous product/service turnover, and lack of vertical or horizontal alliances or long-term contracts. In such an environment, organizations try to expend their efforts in reducing heterogeneity by better identifying their markets, suppliers, customers, and goals through more accurate, reliable "quality" information. As D'Aveni (2001) recommends, firms facing

uncertain environments should try to focus more on operational timing, know-how, and information quality- productive attributes explicable in terms of operational quality

H5b: Given a specific IT infrastructure design, organizations facing an uncertain environment will positively and significantly rely more on operational quality compared to other productivity metrics.

- Innovative Environment: An innovative environment is the result of low environmental complexity (low heterogeneity) and high environmental dynamism (fast-paced change). In this category, the environment faces a homogenous set of markets, suppliers, customers, and competitors, thus creating a well-defined environment. However, within this well-defined environment is the evidence of constant change in demands, technology, competition, and practices. Such an environment necessarily seeks innovations in both products and processes so as keep abreast of the changes. However, because the environment is well-defined, organizations can rely upon their markets, product competencies, supplier and customer base to better and more effectively innovate. The well-defined homogenous market provides the added advantage of innovation in a less goal-diverse context. Such an environment is characterized by a robustly identified niche in the market- whose attributes are well-comprehended by the organization. This environment is present in industries catering to specific market segments leveraging upon competition, innovation, and alliances. Organizations leveraging their presence through competition, innovation, and alliances focus more towards achieving strategic productivity that will provide them sustenance and growth.

H5c: Given a specific IT infrastructure design, organizations facing an innovative environment will positively and significantly rely more on strategic productivity compared to other productivity metrics.

- Discontinuous Environment: A discontinuous environment results from a combination of low environmental dynamism (lack of change) yet high environmental complexity (overly heterogeneous market base). The lack of changes in customer demand, technology, products, and practices results in a lack of innovativeness. Because price elasticity of demand is low, the need to compete to deliver better substitutes is little. In addition, because income elasticity for specific goods or services is meager, the need to produce enhanced varieties through innovations is also marginal. Competition is acute but regressive- captive to price wars rather than meaningful differentiation. This problem is accentuated with growing heterogeneity where customers, competitors, and suppliers are diverse, fragmented, and fleeting. Determining a niche is extremely difficult in such a scenario. Because of such extreme heterogeneity, information-processing needs are continuous and overwhelming. This consumes tremendous organizational resources along with increasing transaction costs associated with dealing with multiple and undefined environmental entities and policies. Such an environment is extremely disruptive as tremendous organizational resources are allocated to process information and transact with multiple, undefined entities, with little or no focus on sustenance through competition, alliances, and innovations. Industries in discontinuous environments have little technological focus, are labor-intensive, lack innovation and competition, while having to deal

in undefined markets with a large base of customers, suppliers, competitors, along with poorly defined goals. Faced with such an environment, organizations try to increase productivity in terms of operational efficiency for their static product/service line. Dotcoms dabbling in commoditized products and services experience such a discontinuous environment- a fleeting and capricious customer base driven only by prices, failing and volatile supplier relations, and "run-of-the-mill" services. Lacking any discernible content that could serve as a differential and meaningful advantage, these dotcoms try to cater to a fleeting market through price-wars with their "dime-a-dozen" competitors. With a high degree of complexity and heterogeneity, customers, suppliers, and markets are constantly in flux, forcing the organization to rely upon its own operational efficiencies to reduce costs in order to sustain itself in a vicious cycle of "price wars." Aggressive cost-cutting then remains the only alternative that allows the organization from slowing eroding all profits. In such instances, operational efficiencies seem to be the only alternative that can help decrease costs and sustain itself in a volatile base of customers and suppliers.

H5d: Given a specific IT infrastructure design, organizations facing a discontinuous environment will positively and significantly rely more on operational efficiency compared to other productivity metrics.

Environmental demands that firms face have been a primary aspect of numerous studies, commonly proposing that organizations should achieve an environmental fit by matching internal processes to external settings for better performance (Burns and Stalker, 1961; Lawrence and Lorsch, 1967). In order to achieve environmental fit, Aldrich (1979) and Weick (1979) have argued about the need for "loose coupling" in

organizations, where elements within the subsystem “are only weakly connected to each other and therefore free to vary independently.” Our IIP framework allows for changes in coupling. It can accommodate a loosely coupled structure built on less convergence and greater flexibility; a highly coupled structure to achieve standardization and control, and infinite configuration of couplings in between. Simon (1981: 66) confirms, “The outer environment determines the conditions for goal attainment - if the system is properly designed, it will be adapted to the outer environment, so that its behavior will be determined in large part by the behavior of the latter…” Altogether, the contingent IIP framework provides for a more responsive and elastic conceptual platform that incorporates time lags, dynamic feedback, and contingencies- both internal and external. These issues are discussed this in the next section.

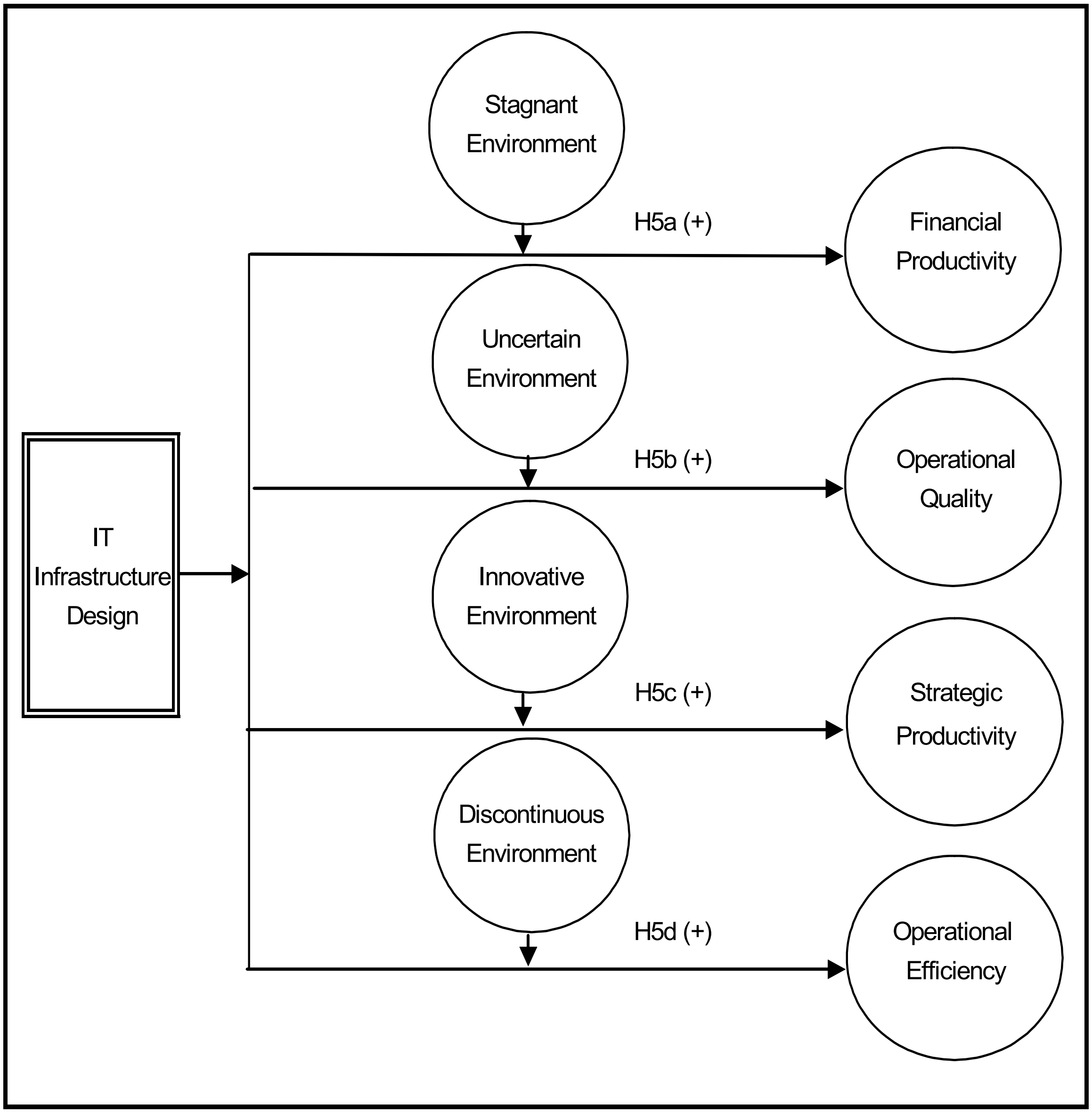


Figure 8b: Propositions based on the Moderating Influence of the Environment on Organizational Productivity

CHAPTER 9. THE IIP SYSTEM FRAMEWORK: TIME LAGS, FEEDBACK, AND THE CONCEPT OF EQUIFINALITY

"A 'system' can be defined as a complex of elements standing in interaction. There are general principles holding for systems, irrespective of the nature of the component elements and the relations of forces between them. ...In modern science, dynamic interaction is the basic problem in all fields, and its general principles will have to be formulated in General Systems Theory."

Ludwig von Bertalanffy (1962)

Over the few previous sections, this dissertation proposed a theoretical framework for the IIP system as a two-phase process. It began with the transformation of IT-related capital outlays into IT infrastructure design-contingent upon IT management; the IT infrastructure design then served as a precursor to organizational productivity contingent upon the external environment. Still, there remain three consequential issues that we inquire in this section: First, is the IIP system static- i.e., does the system come to a rest after productivity is achieved? Second, are IT infrastructure design and productivity immediate consequences of IT-related capital outlays? Third, is there an underlying heuristic that can spell the perfect concoction of investment, management style, infrastructure design, and environment for greater productivity? Answering these questions requires a shift in paradigm and perspective. In answering these inquiries, the proposed framework moves away from the conventional by introducing concepts of productivity feedbacks, time lags, and equifinality, respectively.

9.1. PRODUCTIVITY FEEDBACKS

Considering the IIP system as “static” robs the system of its essential dynamics. The modular systems perspective allows for the incorporation of the concept of feedback. Feedback, as Umpleby (1965) defines it, concerns the information flow from the results

of a process that can be used to change one or more process constituents. Feedback provides a recursive, cyclical, and causal process where the output information triggers changes in other parts (subsystems) of the system in context. Feedbacks in the proposed IIP system framework stem from the derived productive value that serves as a trigger- informing other system constituents of its entropic deviations. Therefore, a level of productivity achieved from a particular infrastructure may not match organizational objectives. This information concerning the productive deviations flows back into the system- triggering changes in capital outlays, infrastructure design, and/or IT management. Feedback supports the flow of information back to the system- allowing the system to adjust and reconfigure its subsystems for increased system flexibility and responsiveness. This results in reciprocal interdependence- leading to increased coordination and mutual adjustment while the modularity of the subsystems allow for dynamic reconfiguration.

According to Stacey (1996), system dynamics involve a circular causality that flows via feedback loops across mutually interdependent subsystems. System theorists have recognized the importance of "feedback" for the survival of the system (Miller, 1955) and for maintaining a "steady state" or "homeostasis" (Katz and Kahn, 1966). In describing homeostatis, Simon (1981: 116) remarks that even for an open system (e.g., IIP) “quasi independence from the outer environment may be maintained by various forms of passive insulation, by reactive negative feedback, by predictive adaptation, or by various combinations of these [forms of feedback mechanisms].”

The concept also provides an intuitive and qualitative grasp of the content, context, and description of the organizational dynamics (Ahn, 1999). As Chan (2000: 231) notes, an organization is “a dynamic system with feedback loops” where

"approaches designed with static, closed systems in mind…may be inadequate." Because a system receives feedback in the form of information, feedbacks from productivity can reconfigure process subsystems- elevating the effectiveness of the system over time.

9.2. TIME LAGS

Although time lags have an intuitive presence in organizations, it has rarely surfaced in research related to IT productivity. Translating IT-related capital outlays into infrastructure design entails time. So does generating productivity from a particular IT infrastructure design. Hershey's ERP debacle grew out of a disregard for the time lag that surrounds an IT infrastructure investment. Research is replete with tales where a rush for immediate results from IT resulted in a miscomprehension of the actual benefits of the implemented technology. Both Mahmood and Mann (1997) and Brynholfsson and Hitt (1998) suggest that the accrual of productivity can be better traced if firms take into consideration the effects of inherent time lags required to reap benefits from IT-related capital outlays. In addition to noting that because technologies generally do not manifest immediate impacts, managers need to rationally account for the necessary time lags, Brynjolfsson (1993) also offers the learning-by-doing model as a theoretical support for time lags. "According to models of learning-by-using, the optimal investment strategy sets short term marginal costs greater than short-term marginal benefits," Brynjolfsson (1993: 12) adds, "This allows the firm to "ride" the learning curve and reap benefits analogous to economies of scale. If only short-term costs and benefits are measured, then it might appear that the investment was inefficient." Answering the issue of how long it takes for a firm to ride the learning curve, Devaraj and Kohli (2000) note that the magnitude of the time lag varies by industry and maturity of the IT infrastructure within an organization- with averages ranging between two and two-and-a-half years

(Brynjolfsson, 1993). This dissertation incorporates the essence of a time lag by linking the most recently committed IT-related capital outlays at time “t-i” to proposed IT infrastructure design at time “t”; the proposed IT infrastructure design at time “t” is then linked to perceived organizational productivity at time “t+i.”

9.3. EQUIFINALITY

Equifinality is a systems concept that manifests a behavior that is oriented towards reaching a final objective regardless of the conditions, attributes, and subsystem characteristics. As maintained by this concept, the initial condition, i.e., the amount of capital outlay, does not matter in the productivity equation. Equifinality is a conceptual systems condition where different initial conditions can lead to similar effects. Because this principle allows for a system to get to the same end (or goal) from various different routes, different subsystem configurations can be used to achieve requite productive results. In the context of the IIP system, equifinality provides the conceptual latitude allowing us to consider that multiple combinations of contextual characteristics may result in different but equally effective productive outcomes. There are no heuristic “perfect” configurations leading to productivity- as there can be multiple, albeit converging, means to a common end.

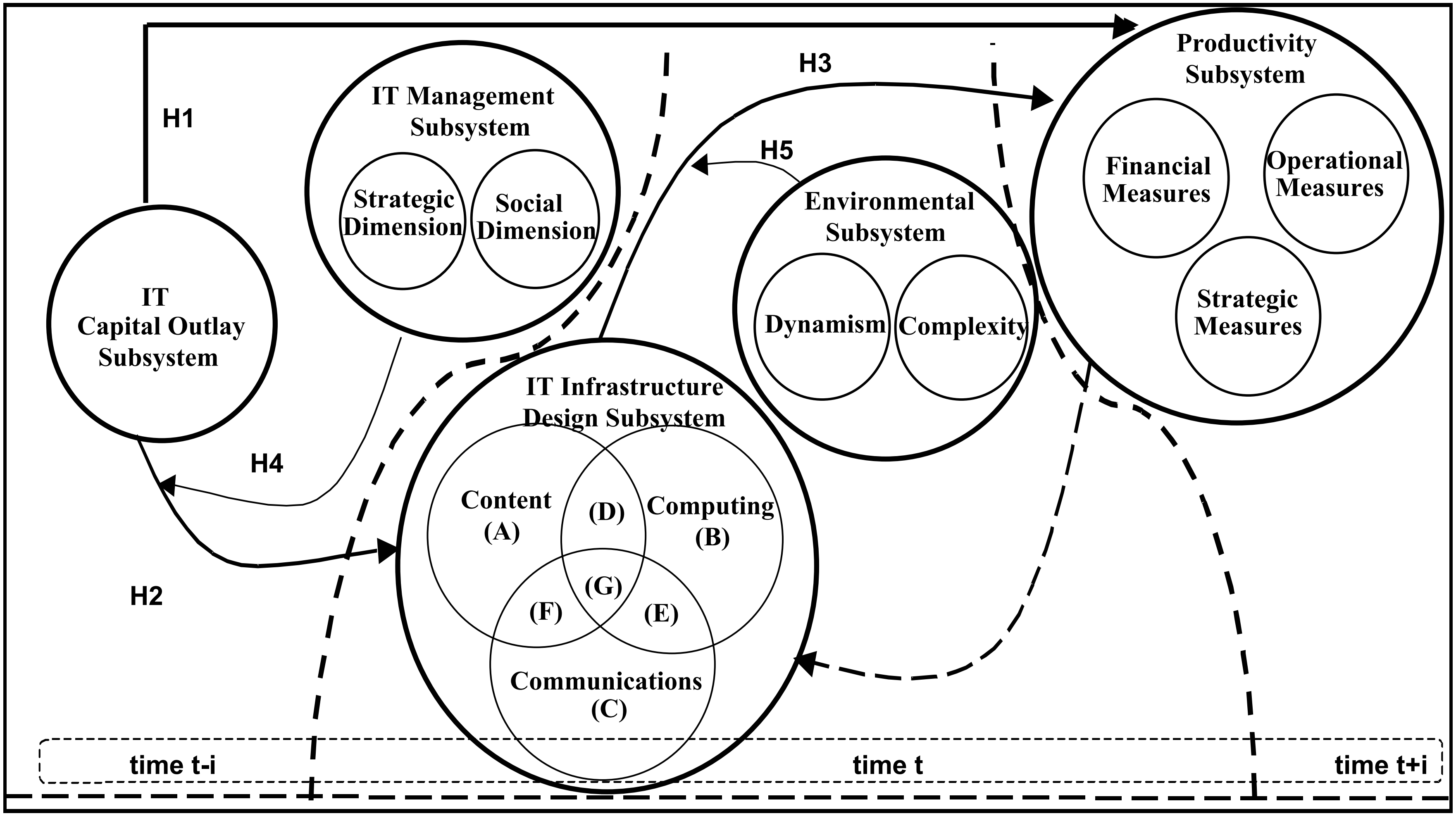


Figure 9: A Detailed View of the IIP Theoretical Framework and Proposed Hypotheses

CHAPTER 10. RESEARCH DESIGN, METHODS, AND SETTINGS

"Concepts without percepts are empty; percepts without concepts are blind."

Immanuel Kant (1724-1804)

This chapter presents the design of an empirical field study based on the IIP theoretical framework developed in the prior chapters. The following pages describe the key issues concerning the methodological rationale, design rationale, sample recruitment, and the administration of the field study. Data preparation, instrument reliability, and validation efforts are discussed as well.

10.1. METHODOLOGICAL DESIGN AND RATIONALE

This section presents the research design and rationale that this dissertation uses to test and validate the hypotheses developed in the previous sections. This chapter discusses and develops the rationale behind the epistemology and research design. Also discussed are factors related to the process of data collection, instrument reliability, and validity.

This research is both rationally and empirically driven. Rationalism, a 17^{th} century philosophical movement that traces its roots in Descartes and the later “Cartesians,” proposes that foundational concepts and frameworks can be deciphered through reasoning, where innate ideas including causality can be axiomatically deduced. Rationalism places a strong emphasis on deductive reasoning as the salient feature that drives understanding of events and phenomena. In our study, rationalism, with its deductive reasoning, provides a rational platform for idea creation and framework development. Empiricism, on the other hand, takes its cues from Francis Bacon in the 18^{th} century, draws from a philosophical foundation that rests on the premise that

knowledge is essentially a product of observation and experience that does not disavow innate ideas but favors ideas drawn from experience. Empiricism augmented deductive reasoning with inductive validation, leading to an approach that has gained wide acceptance in the social science, and providing the basis for observation and analysis to support reasoning. Invoking Kantian traditions, Hirschheim (1985: 18) provides a refreshing synthesis between rationalism and empiricism:

> "Kant outlined the problems associated with the empiricism of Locke and Hume, and the rationalism of Descartes, Spinoza, and Leibniz. He believed the former placed primacy on experience to the detriment of understanding; the latter was the reverse. Neither could therefore provide a coherent theory of knowledge. For Kant, knowledge is achieved through a synthesis of concept (understanding) and experience. He termed this synthesis 'transcendental', which gave rise to the philosophy of 'transcendental idealism'. In this philosophy, Kant noted a difference between theoretical and practical reason. The former dealt with the knowledge of appearances (realm of nature); the latter with moral reasoning (issues)."

Hirschheim's invocation of Immanuel Kant's "transcendental idealism" bridges the conventionally separate epistemologies- from combatants to complements. A similar blending of the rationalism and empiricism into a single, unified method is also evidenced in Newton's "hypothetico-deductive model of science" (Toulmin, 1980). This research incorporates the complementing characteristics of the two ontological traditions to empirically observe the relational and causal attributes hypothesized in our rationally-derived IIP framework. It is the synthesis of the two forces that add value. Citing the contributions of Wold (1975) and Ackermann (1985), Falk and Miller (1992: 3) reject "naive empiricism, which rests on strictly inductive approach, and holds instead that the work of science is an interplay between ideas about the world and our observations. Such a position is consistent with the modern philosophy of science, which views science as

the union of theory and empirical observations."

Positivism is the underlying epistemological paradigm for this dissertation. Positivism maintains that methods incorporated in natural science are legitimate methods of use in the social sciences in terms of manipulation of formal theoretical propositions. According to Lee (1991), the positivist approach involves the manipulation of deduced theoretical propositions found in the explanation's own "objective" foundational premises using the rules of formal (logical relation of propositions) and hypothetico-deductive logic (syllogistic progression from theorizing to testing). Positivism seems to be a suitable epistemic candidate in supporting our research efforts. The proposed IIP framework is tied to a positivist tradition because, as Myers (1999) indicates, it involves constructs and relationships that can be objectively defined and measured, while remaining independent of the observer's instruments. As positivism requires, this dissertation aims at testing theory and "increasing predictive understanding of phenomena," (Myers, 1999) through formal propositions, quantifiable measures of variables, hypothesis testing, and drawing inferences from a stated sample (Orlikowski and Baroudi, 1991).

In the context of this dissertation, the blending has been systematic. While the previous sections dealt with a rational approach toward generating the IIP theoretical framework and hypotheses, this section forth will deal with an empirical investigation and validation of the theory. The empirical investigation relies on conducting two separate epistemic techniques: a Delphi approach is used to populate the theoretical constructs in IIP taxonomies and transforming these constructs into operationalizable, objective, factors. Once the factors are determined and prioritized, it is followed by a

field study in the form of a survey that used the objective factors generated by the Delphi to test the research propositions.

10.2. RESEARCH DESIGN RATIONALE

As discussed in the previous chapters, our IIP research framework follows the concept of "locus of value," i.e., understanding attributes at multiple levels of analyses, from organizational processes to organizational environments. Multiple levels of analysis in organizational research has been found to be "uniquely powerful and parsimonious" in capturing the complexities of organizational realities (Klein, et al., 1994: 223). Moreover, the modular systems perspective gives this research credence by inductive and deductive analysis of multilevel organizational factors that impact the process and variance of the IIP system framework.

This research study's use of a positivist epistemology also strikes a balance between induction and deduction. In moving from the general to the specific, deductive reasoning uses theoretical standpoints to develop frameworks and extend arguments through propositions and hypotheses concerning a specific context (e.g., IIP). Inductive reasoning, on the other hand, uses observations of a particular phenomenon to argue a case and perhaps even ratify or change theoretical deductions – thus moving from the specific to the general (Grover and Malhotra, 1998). As Babbie (1989: 409) describes it, "a middle ground involving symbiotic interaction between deductive and inductive approaches, theory building and testing, and exploratory and explanatory research, is probably the best representation of the scientific research cycle" (Ibid: 409).

A field study was judged to be the most pertinent method in the IIP context. Until we can objectively define our understanding of the nature and IT infrastructure and

productivity, an alternate method (e.g. experimental design) would be ineffective because the factors manipulated in the treatment would themselves be suspect (Murphy, 2000). In addition, because a field study could surface underlying factors behind essential constructs, it would serve as a useful platform for more granular studies (e.g. case studies) that could use the IIP framework to richly examine and add to the issue.

10.3. A SUMMARY OF THE RESEARCH DESIGN

The efficacy of any research begins with a robust theoretical premise as a precursor to empirical investigation. As Newsted, et al., (1998: 122) confirm, "a carefully constructed theory is a precursor to the actual use of an instrument." This research therefore maintains the need for a rationally derived theoretical premise. It has done so by developing a theoretical framework specified in terms of construct domains, relationships, and hypotheses (Newsted, et al., 1998).

The onus in this section is on the development and use of relevant instruments for examining our framework in context. With a strong theory as a precursor, the methodological development follows three distinct phases: (i) Survey Item Identification and Validation, (ii) Survey Development and Administration, and (iii) Analysis of Data. Our use of methodology is based on positivism studied using empirical qualitative and quantitative methodologies. Figure 10 provides an overview of the research design and methods for the IIP study. The conduct of this entire research involves the use of primary data collection techniques from first-hand sources.

The dissertation research design is a two-instrument field study of CIOs (Chief Information Officers) and senior-level IT management at several organizations. Each of the instruments has a distinct connotation. A Delphi-based technique is used to develop

the first instrument to generate qualitative data; this is followed by a survey instrument to

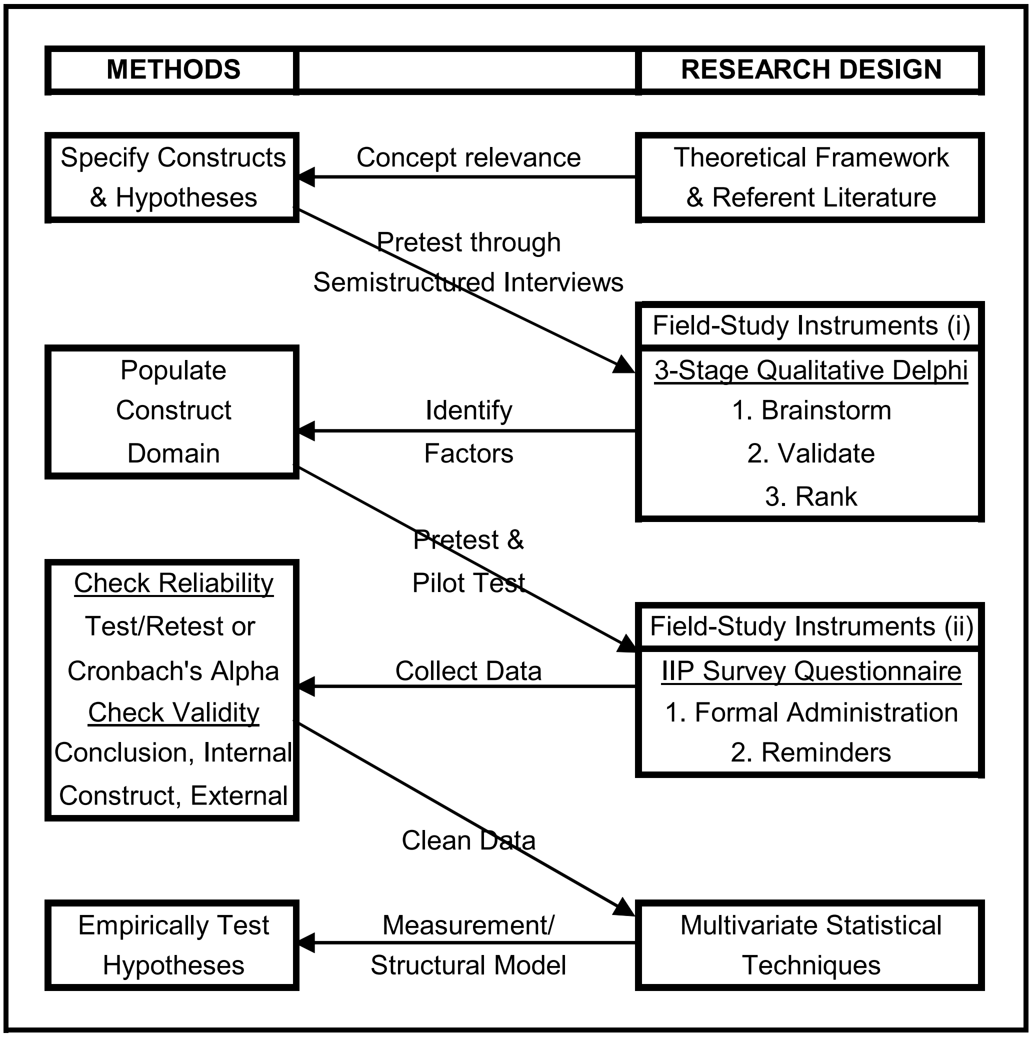


Figure 10. A Systematic Description of the Research Design and Methodology

generate quantitative data. The first instrument, the qualitative Delphi-based questionnaire (DQ), uses responses collected from a small sample (n_1= 31) of IT executives and CIOs, to identify objective factors for populating the theoretical constructs. The identified factors from the first instrument are then used to populate the second instrument, the IIP survey questionnaire, as items in the survey. The second instrument uses a much larger sample (n_2= 217) to collect quantitative responses for the

survey items. The samples used for the first and second instruments were kept independent to reduce any response biases. Both survey instruments were approved by the Human Subjects Committee (HSC).

The instruments are described below at a greater detail.

10.3.1. INSTRUMENTS, DATA COLLECTION, AND ADMINISTRATION:

The recruitment of respondents for the field studies was the most time-consuming activity. Because subjects were all senior IT executives, getting the subjects to participate was the biggest hurdle in the process.

A. THE DELPHI TECHNIQUE

Developed by the Rand Corporation in the 1950's, the Delphi technique is a method for the "systematic solicitation and collation of judgments on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions derived from earlier responses" (Delbecq, Van de Ven, and Gustafson, 1975: 10). This technique does not require that participants be co-located or meet face-to-face, thereby making it useful to conduct surveys asynchronously while maintaining confidentiality (Gould, 2000).

Delphi is a group decision mechanism that needs qualified experts who have deep understanding of the issues of concern (Delbecq, et al., 1975). The Delphi study is a qualitative technique that can effectively combine factor research with research on IIP to generate an authoritative list of factors for each of the constructs (Schmidt, et al., 2001). Using an expert panel, this technique can elicit important factors through iterative and controlled feedback.

The Delphi study is generally a positivist tradition, developing an objective list of

factors derived from divergent ideas and issues. As with positivism, reality is assumed to be objective, thus stressing on systematic and canonical analysis for identifying non-random phenomenon, prescriptive and nomothetic in its outcome. Schmidt, et al. (2001) refers to the Delphi technique as also having “exploratory and explanatory” dimensions. While the explanatory dimension arises from the reification of previously identified factors within referent literature and theory, the exploratory dimension identifies current factors that remain unidentified in referent literature. The ability to successfully validate and generate factors through consensus by the Delphi panel of experts increases both face and construct validity.

Just as theory and referent literature serve as precursors to the specification of construct domains, the Delphi technique is used as a similar precursor to survey design in our study. Administered as the Delphi-based Questionnaire (DQ), the technique provides a premise for generating consensus on factors pertaining to individual constructs identified in the IIP framework.

A.1. THE DELPHI-BASED QUESTIONNAIRE

The DQ is a 5-page, self-administered questionnaire consisting of 8 open ended questions (Refer to Appendix I) that was emailed to senior IT executives and CIOs as an editable text attachment (.doc and/or .txt format). Form-fields were provided for exemplifying factors for each construct, namely IT-related capital outlays, IT management, IT infrastructure design, organizational environment, and organizational productivity. With the exception of the IT infrastructure design construct, all form-fields were open ended. Given the complexity posed by the preponderance of IT in every type and form, the respondents were asked to match a prescribed technology to one or more

infrastructure categories, namely content, computing, and communication technologies[2]. An example was provided in the questionnaire as a cue for respondents. In addition, open form-fields were made available at the end prompting researchers to identify any infrastructure technology they perceived as missing.

A.2. DELPHI QUESTIONNAIRE ADMINISTRATION

The DQ was iterative and was asynchronously administered between November 2002 and March 2003. The instrument was administered in three phases over four-and-a-half months. As Delbecq, et al. (1975: 83) note:

> "Delphi is essentially a series of questionnaires. The first questionnaire asks individual to respond to a broad question…Each subsequent questionnaire is built upon responses to the preceding questionnaire. The process stops when consensus has been approached among participants."

Participants were recruited using a Knowledge Nomination Resource Worksheet (KNRW). All prospective respondents were asked to complete the questionnaire and email back the responses for each phase. Every email subject-heading carried the name: LSU IIP Delphi # (indicating the Delphi phase) along with the word "URGENT" in capitals. The email body specified the return date for the questionnaire and explained the importance of that specific Delphi phase. All emails were sent as plain text. The DQ text document filename was the same as the email subject-heading. The text attachment for the DQ instrument used an Arial font, regular font-type, and a 12 font-size with 1" margins. Because the DQ was emailed, there was no anonymity. However, because the Delphi technique is a multiphase process that relies on reiterative questionnaire administration for brainstorming purposes, maintaining anonymity does not remain an issue. Still, participants were explicitly advised regarding issues regarding the privacy

[2] Grateful acknowledgements to Dr. Tom Shaw for providing this insightful format

and use of the information provided. Every phase of the Delphi explicitly had a question requesting the informed consent of the participant. Upon completion, all respondents were emailed the final list of factors that they had identified and ranked.

The Knowledge Nomination Resource Worksheet (KNRW) was used to recruit respondents for the Delphi technique. Not all nominated participants were suitable and availability and commitment were the driving factors for the longitudinal Delphi technique. The KNRW nominations came from the use of a social network provided by the "Alumni Relations" departments of three Northeastern US universities, industry contacts, and researchers. The primary contacts were also kind enough to personally call their social network about the significance of the study and introduce both researcher and the research.

Ultimately, sixty-nine (69) nominations were received. A pre-notice was sent about a week before the administering the questionnaire. Every nominated person was contacted by email and telephone where they were briefed on the importance, format, and commitment concerning the field-study. Of the sixty-nine contacted, forty-three (43) agreed to participate. Eight (8) of the forty-three did not respond during the first brainstorming phase; three (3) dropped off in the validation phase; and one (1) dropped off during the ranking phase. *In toto,* thirty-one respondents provided their input for the entire longitudinal Delphi instrument.

I. Nomination and Brainstorming Phase: The first stage focused on identifying experts who have current experience in IT management (namely, senior IT executives). This was done by first creating a Knowledge Resource Nomination Worksheet (KRNW) for identifying the sources (such as journals, magazines,

books, or institutions) that could provide a template for where to look for the experts. The next step was to populate the KRNW with names as likely candidates for the Delphi panel. Our sampling strategy relied on "snowball sampling" where we utilized the social network of a few experts to populate the KNRW. The choice of experts was based on the following criteria (i) availability and (ii) commitment towards completing all phases of the DQ.

The DQ was pretested using semi-structured interviews with four senior IT managers who directed in reducing ambiguities (and therefore, measurement errors) by proper wording aimed at increasing objectivity of the questions to be administered to the Delphi panel. The DQ pretest indicated some ambiguity concerning the way constructs (the environmental subsystem, and IT infrastructure design subsystem) were defined in the questionnaire. The led to three types of revisions (see Table 3).

Table 3. Scales for the Delphi Instrument

	Construct	Type	Source(s)	Scale Changes
DELPHI QUESTIONNAIRE				
1	IT Capital Outlay Subsystem	Open-Ended	P.I. & Various	Pretested; wording changes to clarify the measure of investment.
2	IT Management Subsystem	Open-Ended	P.I.	Pretested; minor wording changes.
3	IT Infrastructure Design Subsystem	Closed-Ended with Open-Ended Options	P.I. & Various	Pretested; instruction wording changes; format changed to closed -ended questions with open-ended options; inclusion of a supporting diagram of the configurations.
4	Environmental Subsystem	Open-Ended	P.I.	Pretested; minor instruction wording changes.
5	Organization Productivity Subsystem	Open-Ended	P.I. & Various	Pretested; minor wording changes.
P.I.: Preliminary Investigations				

The first type of change involved revisions to the wording of the definitions.

The second was the change in format for the IT infrastructure design construct from an open-ended to a partly closed-ended question. This change was needed to mitigate problems stemming from respondents mixing logical and physical technologies for taxonomic classification of infrastructure categories. For example, in asking to identify technologies that converged content and computing domains, respondents could specify a logical view of the convergent technology (e.g. content processing) or a physical view (e.g. Statistica's Data Warehouse). While both responses are correct, they mix the logical and physical views, making it difficult to collate these technologies and pare them for the validation phase. The new format allowed the Delphi panel to allocate each predefined technology into one or more infrastructure domains (i.e., content, computing, communications). If a technology seemed to encompass more than one infrastructure domain, the panel could assign it accordingly. A similar format was followed by Nambisan, et al. (1999) in a Delphi study used to classify knowledge categories.

The third change concerned the incorporation of a diagram of the proposed IT infrastructure design configuration. Once completed, the pretest provided the DQ with the necessary face-validity.

The Delphi survey began with a set of open-ended questions administered via email to each of the experts. The experts unequivocally accepted Email as the preferred mode of administration. The questionnaire consisted of 8 open-ended questions- each of which prompted the participant to brainstorm and identify 3-4 important factors that could objectively define the construct. Because none of the questions are sensitive in nature (focusing on general IIP in general rather than

being firm-specific), the subjects were presented with fewer barriers to responding. Every Delphi panelist was asked to submit between 3-4 factors for each construct, and to provide short descriptions of the factors, to aid researchers in their collation efforts. The demographics of the Delphi panel respondents are elaborated on in the results section.

II. Validation Phase: The initial brainstorm elicited a generous number of pertinent factors (154) based on divergent opinions. Three coders were used for inter-coder assessment for narrowing down the list of factors identified in the first phase of the DQ. The coders were graduate students working as research assistants in the information systems discipline. An initial set of two Delphi responses was selected for independent analysis by the coders and the results of the analysis were compared. Coding decisions were discussed at the onset to discover and increase intercoder agreement and assure trustworthiness of the process (Lincoln & Guba, 1985). Once coders were cognizant of the decisions, the rest of the Delphi responses were independently coded. Intercoder agreement was relatively high on construct domains. Statistical assessment of intercoder reliabilities is discussed in the results section. Factors found to be interrelated, indistinct, or ambiguous by all three coders were discarded. Any conflicting issues were resolved thorough peer consultations. The rationale that followed the reduction of the inter-related factors is to diminish chances of the multicollinearity among factors measuring the same construct. It is more prudent and cost-effective to identify factors that may cause multicollinearity as an early stage. The new and extracted sets of distinct factors provided the much-needed identification of factors related to each construct, providing validity,

reinforcement, and new insight. All distinct factors were admitted. The synthesized set now consisted of 71 factors for the 5 constructs in the IIP framework.

Having extracted and developed the factor list consisting of *all* identified and distinct factors, the second phase of the Delphi technique focused on validating the intercoder-assessed factor list by the experts. This was done by resending all distinct factors to the experts, requesting them to identify whether all pertinent factors have been included, while allowing them to identify any factors misconstrued during intercoder assessment. All experts were advised to email a response affirming or non-affirming the set of factors sent to them. The response was forced in order make certain that the subjects were aware of and agreed with the reduced set of factors. The experts proposed the exclusion of 3 factors related to the environmental subsystem construct. All subjects were asked to respond to this exclusion and a consensus was achieved over 4 email iterations concerning the exclusion.

III. Ranking Phase: The reduced and pared set of factors for each construct now consisted of 47 factors spanning 4 construct domains (IT investment subsystem: 4 factors; IT management subsystem: 12 factors; environmental subsystem: 9 factors; productivity subsystem: 23 factors). The 5th construct domain of IT infrastructure design subsystem consisted of another 21 technologies (factors)- 3 technologies identified for each of the 7 categories. The new set of factors were now emailed back to the Delphi panel of experts- requesting them to rank the factors within each construct in decreasing order of perceived importance. Upon receipt of the ranked list, the frequency of the rankings was used in determining a parsimonious set of the

most important factors. The resulting ranked list validated some of the factors from precedent literature while identifying emergent factors unique to the context of each construct. The final parsimonious set consisted of 61 factors for the 5 constructs IT investment subsystem: 2 factors; IT infrastructure design subsystem: 21 factors; IT management subsystem: 10 factors; environmental subsystem: 8 factors; productivity subsystem: 20 factors). The pared and ranked Delphi list is shown in Table 4.

B. THE IIP SURVEY

Once the Delphi-based technique provided a set of distinct "factors" for each underlying construct, we progress to incorporate these factors as items in creating multi-dimensional constructs for conducting survey research. Survey research is the method of gathering primary "first-hand" data from respondents thought to be representative of a population, using an instrument with a response structure of closed structure or open-ended items (questions). This is perhaps the dominant form of data collection in the social sciences, providing for efficient collection of data over broad populations, amenable to administration in person, by telephone, and over the Internet.

Items in a survey provide measures that try to adequately sample the domains to capture the essence of each construct in the survey. As per Hinkin (1995:969), "a measure must adequately capture the specific domain of interest yet contain no extraneous content." Measures that encapsulate a construct or a domain have a strong content validity (i.e., the accurate operationalization of a construct). To do so, the items for the survey are drawn from pre-validated literature or identified by Delphi experts as important and relevant.

Table 4: Delphi Study Results

Delphi Study Results		
CONSTRUCTS	**FACTORS**	**SCALES**
IT Investment	IT Operating Expenditures	PV
IT Capital Outlays	IT Capital Expenditures	PV
IT Management	IT and Business executives are mutually informed about each other's objectives	PV
Social	Level of informal communication between IT and business executives	PV
Alignment	Flexible Organizational Structure	PI
	Level of informal participation between IT and Business executives	PI
	IT and Business executives in our organization are generally supportive of each other	PV
IT Management	IT appraisal and planning are well-coordinated between IT and business executives	PV
Strategic	Level of formal communication between IT and Business executives is generally high	PV
Alignment	Level of strategic control (monitoring, reporting, & accountability) is generally high	PV
	IT management has an objective understanding of IT and business policies/strategies	PV
	IT management expertise is well aligned with organizational objectives	PI
Organizational	Adoption of technology	PI
Environment	Diffusion of technology	PV
Environmental	Availability of venture capital for entrepreneurial activities	PI
Dynamism	Market demand for product/service innovations	PI
Organizational	Habits/preferences customers are volatile and fluctuating	PV
Environment	Information processing needs are heterogeneous and diverse	PV
Environmental	High degree of economic instability/fluctuation	PI
Complexity	Fluctuating supplier base	PI
Organizational	Increase capacity utilization (decrease spoilage)	PV
Productivity	Decrease inventory holding costs	PV
Operational	Result in shorter product/service cycles by reducing "Work-in-Process" (WIP) time	PV
Efficiency	Lowering total variable costs (Production/Development/Service/Personnel)	PV
	Reduce marginal costs of production	PV
Organizational	Lower "total costs of ownership" (TCO) of organizational resources	PV
Productivity	Increase inventory turnover	PV
Financial	Increase "Return on Investment" (ROI)	PV
Productivity	Result in higher "Return on Assets"	PV
	Increase ""Earnings" before Interests and Taxes" per employee (EBIT per employee)	PV
Organizational	Improve organizational work environment (collaboration, flexible workplace)	PV
Productivity	Add significant value to existing customer/supplier relationship	PV
Operational	Improved and secure information exchange (communication)	PI
Quality	Reduce training time	PI
	Improve product/service quality	PV
Organizational	Enhance management planning/decision making	PV
Productivity	Increase strategic/competitive advantage	PV
Strategic	Increase organizational capability for product/process innovations	PV
Productivity	Increase organizational flexibility and response	PI
	Identify/Tap new markets	PV
IT Infrastructure Design		
Computing	CPUs, PCs/PDAs, I/O devices, Operating Systems	PV
Content	Databases, File Systems, DBMSs	PI
Communications	Routers, Network OS, Network Management	PV
Cont & Comm	E-Commerce technologies, EDI, Distributed Databases, Storage Area Networks	PI
Cont & Comp	Mainframes, Mid-Range Systems & OS, Biometrics, Data Mining, Forecasting	PI
Comp & Comm	Distributed processing, Networked Security, Cryptography, Thin Clients	PV
Cont & Comp & Comm	Enterprise Systems, Servers, Groupware	PI
Legend: PV: Prevalidated Scales; PI: Preliminary Investigation		

Surveys are extremely helpful instruments in providing actual values that can be use to test predicted values and relationships that may be drawn from hypotheses or propositions (Lee, 1997). Surveys have the ability to refine problem conceptualization by researchers by matching it with actual experiences of practitioners, thereby providing a “reality check” (Straub, 1989). The choice of a survey instrument stems from ease of administration, coding, value determination, and confirmation and quantification of qualitative research. However, one must realize that surveys are generally cross-sectional and values are temporally constrained. Furthermore, surveys do not provide a thick and rich description of the situation compared to a case study, nor can provide strong causal evidence compared to experiments (For a more detailed review, refer to Newsted, et al., 1998). However, survey research as an instrument benefits from its viability of administration to its credibility as an essential tool for supplying values to constructs and relationships.

As Newsted, et al (1998: 4) points out, in IS research, surveys can epistemologically help obtain and validate knowledge- “going from observations to theory validation.” Surveys have gained prominence in studying unstructured organizational problems in IS by providing a platform for understanding and linking theoretical (unobserved abstractions) and operational (observable) domains through inductive and deductive research (Grover and Malhotra, 1998).

B.1. IIP SURVEY QUESTIONNAIRE

The IIP survey questionnaire is a web-based, self-administered questionnaire consisting of 45 questions (Refer to Appendix I) that was administered to senior IT executives and CIOs over the Internet. The Delphi study provided a current list of factors

that were used to populate the construct domain and became items in the IIP survey. The purpose of the IIP survey was to gather quantitative data for the factors elaborated from the Delphi study and subsequently use the data to confirm the propositions as a "reality check." The participants were asked to complete the survey over the Internet. A randomly-generated ID number was embedded in a unique hyperlink that was emailed to survey participant in order to maintain uniqueness of firm response and anonymity of the respondents. Once responses were filled in for the questionnaire, the results could be submitted by clicking on a "Submit" button at the end of the questionnaire. The only way to trace the responses to a specific firm is through the logged IP (Internet Protocol) for every submission. Respondents were assured anonymity unless they specifically chose to receive a copy of the results summary from the IIP survey.

This research used WebSurveyor 3.0 client to administer the IIP survey. WebSurveyor is a survey administration software that can automate the survey process from creating the questionnaire to collecting and analyzing results. The advantages of this dedicated survey software runs from automated trigger-based email pre-notifications, dedicated servers for collecting respondent data, to even tracking results in longitudinal surveys. The software has the ability to create complex skip patterns, data validation, embedding IDs to track responses, among many others.

The web design was kept simple and professional, with 12-font black Arial type text on a white background with the affiliated university logo (Information Systems and Decision Sciences- Louisiana State University) as the page header. The design aimed at reducing presentation inconsistencies stemming from the translation of html code by different browsers. The web-survey design stressed readability, restrained use of images

and color, and unimpeded navigational flow. Out of the 45 questions in the IIP survey, 44 were closed ended and 1 was open-ended. However, most of the closed-ended questions allowed some latitude where a respondent could choose “other” to deliberate any overlooked dimensions.

The first item gathered the informed consent of the participant. The next 7 items used nominal scales to collect data about the respondents and their firms. The rest of the items consisted of ordinal Likert-type scales. The survey items were distributed as follows: Informed Consent (1 item- binary); Respondent/Firm Characteristics (7 items- nominal); IT investment subsystem (2 items- ordinal Likert-type); IT management (10 items- ordinal Likert-type); IT Infrastructure Design Subsystem (21 items- ordinal Likert-type); Organizational Environment Subsystem (8 items- ordinal Likert-type); Organizational Productivity (20 items- ordinal Likert-type).

B.2. IIP SURVEY ADMINISTRATION

The IIP survey was used for cross-sectional data collection. While the data collection duration for the IIP survey lasted one month and entailed relatively less time and resource commitments, the potential sample was larger and independent of the Delphi participants. The same social network was used to gain access to telephone information for potential participants. The leads came from the social network provided access to their proprietary databases containing information (company name and telephone number) about 1100 Fortune firms. Only 26 of them included an email address.

Of the 1100 contacts provided, only 712 were found to be complete, i.e., containing complete and correct telephone numbers. Interestingly, none of the email addresses were found to be valid- returned due to user ID or domain errors. Every

potential candidate was contacted using a combination of telephone and email. A preliminary telephone call was made to every contact, which, in all cases, led to their secretaries or administrative assistants. During the call, the researcher identified the sponsoring university and department, the occupation of the researcher, the importance of the survey, the survey administration mode, confidentiality issues, and the expected completion time for the IIP survey. In response, the secretary informed us whether the senior IT executive's schedule would permit responding to the survey, and, if deemed possible, provided us an email address for future correspondence. Out of the initial 712 firms, only 310 provided us an email for correspondence.

A single "Thank you" email was sent to all 310 addresses for establishing initial correspondence and checking the accuracy of the email address. The email relayed the initial conversation in words. An average of 1.8 follow-up calls was made and 1.1 emails sent over the next month confirming the commitment of potential respondents, with the last call made just prior to emailing the survey pre-notice. Among the 310 firms, 231 firms reciprocated all email correspondence to confirm their interest. In general, participants advised the announcement of the survey following the end of the tax-period in April- allowing for the necessary slack. The pre-notice introduced the survey a week before its formal announcement. The formal announcement was made on a Thursday via a personalized email, with a hyperlink that embedded a randomly generated ID. Ultimately, 217 responses were received.

Given that our participants are senior IT professionals in Fortune firms, the use of web-based surveys follows as a corollary. The potential of Internet surveys has been deliberated in terms of being cost and time-effective (Dillman, 2000; Brewer, 2000),

easier and faster communications (Coomber, 1997), niche targeting of upwardly mobile demographics (Kehoe and Pitkow, 1996), and dynamic interactions (Dillman, 2000). However, Dillman (2000: 356) points out the primary limitation of Internet surveys in terms of coverage, something unrelated to this research's choice of a representative sample.

- Prior to the start of the formal administration, a pretest of the survey was conducted to test the usability of the survey instrument. A total of four researchers and practitioners took the pretest by reviewing the questionnaire. They looked for vague or confusing instructions, inconsistent questions and answer categories, incomplete or redundant sections, poor pace and tone, and question format. The pretest advised the omission of an item regarding IT-related capital outlays because it was felt to be redundant and ambiguous. The other changes concerned the inclusion of the sponsor's logo, minor rewording of instructions, and changes in an answer category to make it consistent. In addition, a pilot study was conducted using 11 candidates holding mid-level IT positions in the industry. Using it in a simulated data-collection situation, the pilot tests checked for the length of the questionnaire, content, and format. Analysis of the results revealed sufficient reliability between construct items. The changes that resulted from the pilot study are shown in Table 5 below and are as follows:
    - The reduction of the "type of business" categories from a set of fourteen to a set of three: manufacturing, services, and both. Several companies were involved in multiple industries over-demarcations were found confusing.

Table 5: IIP Survey Scales

	Construct	Type	Source(s)	Scale Changes
IIP Survey Questionnaire				
1	IT Capital Outlay Subsystem	Likert-type Scale 2 Specific Items	Delphi; Various	Pretested; 1 redundant item dropped; minor wording changes; 1 scale added.
2	IT Management Subsystem	Likert-type Scale Social (5), Strategic (5)	Delphi; Reich & Benbasat (2000)	Pretested; minor instruction wording changes; scales changed from 1-5 to 1-6 to accommodate categorical fit
3	IT Infrastructure Design Subsystem	Likert-type Scale Infrastructure Convergence: Less (9); Partial (9) High (9)	Delphi; Bharadwaj (2000)	Pretested; instruction wording changes; added two more examples of infrastructure design configurations; added an outsourcing component to each infrastructure configuration.
4	Environmental Subsystem	Likert-type Scale Dynamism (4) Complexity (4)	Delphi; Duncan (1972)	Pretested; minor instruction wording changes; scales changed from 1-5 to 1-6 to accommodate categorical fit
5	Organization Productivity Subsystem	Likert-type Scale Strategic (5) Accounting (5) Oper. Quality (5) Oper, Efficiency (5)	Delphi; Various	Pretested; minor wording changes.
6	Feedback	Enumeration Checkbox	Delphi	Pretested; inclusion of other as an open-ended field for poinitng out any missing process constituents.

- The inclusion of two additional examples for items related to the IT infrastructure design construct.

The IIP survey was formally administered during April-May, 2003. The IIP survey administration followed Dillman's (2000) "tailored design" approach. The IIP survey consisted of a pre-notice a week before announcing the survey. Shaeffer and Dillman (1998) suggest that an e-mail pre-notice before sending a web-survey can increase response rates. The pre-notice specified a date and prepared respondents for the oncoming survey. The formal survey was announced a week later. All participants were given detailed instructions on completing the questionnaire and assured in a disclosure maintaining privacy and anonymity of the respondents. All IIP respondents requested a summary report of the findings as an incentive to participate.

10.4. GENERAL DESIGN ISSUES

10.4.1. UNIT OF ANALYSIS

Our unit of analysis is organizations that invest in, employ, and support an information systems infrastructure. The sample-frame in this study comprises of Fortune 1100 firms with our choice of CIOs (or senior IT executives) as the requisite organizational informants. We safely assume that the population of the informants within our sample frame exhibits a requisite understanding related to the use of and access to the Internet, thus alleviating limitations related to coverage (Dillman, 2000).

10.4.2. CHOICE OF SAMPLE FRAME AND RESPONDENTS

Individuals or groups with the greatest degree of knowledge about the constructs of interest can be considered potential informants for surveys. This research focuses on the CIO as the informant for the organizational unit of analysis, on the assumption that the CIO has the greatest degree of knowledge about IIP in organizations. While there has been some debate about the scope of knowledge pertinent to CIOs, there remains some support for the CIO as a legitimate and knowledgeable entity. In an MISQ executive overview, Stephens, et al. (1992) studied CIOs and provided a rich and insightful portrait of their performance. CIOs were found to act as a "bridge" with other units in the organization, efficiently managing to meet functional and organizational objectives- going beyond their positional powers to influence organizational outcomes. Another study by Feeny, et al. (1992) compared the relationship between CEOs and CIOs in organizations. They reported that CIO perceptions strongly resembled the views of the CEO. The researchers also found that CIOs could successfully integrate their business and IT understanding that went beyond their conventional "functional" or "positional"

power to serve operational, tactical, and strategic levels in an organization (Watson, et al., 1998).

The role of the CIO has evolved to "understand" and "bridge" different organizational units, communicating frequently and at length with "organizational peers" (Stephens, et al., 1992). Using Wenger's (1998) "communities of practice" (CoP) theory, Pawlowski, et al. (2000) illuminate the amazingly broad view acquired by the IT professional, spanning both informal boundaries of communities along with formal organizational boundaries- brokering across multiple organizational units. As Stephens, et al. (1992: 463) confirm, "The CIO is an executive rather than a functional manager. As the senior executive charged with bridging the gap between information technology and other functional units, and between the organization's strategy and its use of information technology resources, the CIO's role is primarily a strategic one."

It is this vision, brokerage function, and encompassing role of the CIOs that makes them the choice as "organizational informants" in the context of IIP. Using the (CIO) as our organizational unit of analysis, we take care so that the survey instrument consistently reflects the same unit of analysis with careful attention to item development that does not shift across organizational hierarchies (Grover and Malhotra, 1998). It is also rationally assumed that all the CIOs have access to email and the Internet, eliminating chances of any potential coverage or sample error.

10.4.3 SAMPLING ERROR AND NON-RESPONSE BIAS

Sampling error is one of the most critical issues surrounding field studies. Sampling error arises out of two other errors. The first error is called *sample frame error* that stems from the fact that the sample frame is inaccurate, excluding necessary elements

and including unnecessary elements. Grover and Malhotra (1998) stress that survey research in the field of Information Systems should describe and justify the choice of the sample frame and the respondents (something that is done in detail in the next paragraph). The second type of error is an “error of selection” that occurs if the derived sample is not representative of the sample frame. Random sampling from the sample frame mitigates selection error; and this research achieves random selection by considering the entire sample frame as the population of interest and relying on the random responses from the sample frame. Another way of mitigating is addressing response rates and non-response biases (Grover and Malhotra, 1998), issues that we discuss below.

The lack of anonymity of the Delphi experts makes it relatively easy to check for non-response bias. Non-response bias tests to see if there are significantly discerning factors that separate respondents from non-respondents. Due to the unavailability of the demographic characteristics of the respondents, organizational characteristics of organizational type (Corporations/Franchises) and industry types (Manufacturing/Services) were used to test for non-response bias. A Student’s t-Test of differences of sample means is used to test for non-response bias. The t-Test determines whether a sample is representative of a known population or whether two samples are likely to be from the same population. Results did not indicate the presence of any biases at a 5% level of significance (p-value > 0.10).

The same discerning factors were used to tests for non-response bias in the case of the IIP survey. This research tested for non-response bias in this case was by comparing the non-respondents from the initial 712 with the 217 firms that committed to partake in

the IIP survey. In this case, the results from the student's t-Test of the difference between two means did not reveal any non-response bias at a 1% level of significance ($p > 0.10$).

Finally, as all IIP survey items were restricted to a fixed scale, the risk of variable outliers is negligible.

10.4.4. DATA PREPARATION

Prior to commencing analysis, some variables were created through the transformation of the survey. The data preparation for the IIP survey involved coding raw data for the moderating categories. For example, IT management and organizational environment values obtained from the survey item variables were transformed to fit the dichotomous categorical dimensions for each construct as follows:

- Each of the two dimensions of IT management- social alignment and strategic alignment is classified to define them in terms of high or low on being above or below the cutoff point in the Likert-type scale. The distinction was made by assigning values of low ($x \leq 3$) or high ($x > 3$) for each dimension. The dichotomous classification assisted in using the values from the survey to match the categories derived from the 2x2 matrix. The classification is values as: Functional (1); Decentralized (2); Coordinated (3); Centralized (4). These categorical values are used to test moderation.
- Similar to IT management, the organizational environment is also classified in terms of its dynamism and complexity. For purposes of this dissertation, each of these dimensions is defined in terms of low ($x \leq 3$) or high ($x > 3$). The dichotomous classification of each dimension allows them to fit the 4 four environment categories defined by the 2x2 matrix. The classification is valued as:

Stagnant (1); Discontinuous (2); Hypercompetitive (3); Innovative (4). These categorical values are used for testing moderation.

- The construct of IT infrastructure design subsystem is derived transforming its values through summations and interactions of the variables. As discussed in detain in Chapter 4.3., IT infrastructure design (IID) consists of a technical infrastructure (IIDT), a human resource infrastructure (IIDH), and IT infrastructure services (IIDS) as an interaction of technical and human resources. The value is derived as follows:

$$\Rightarrow \; IIDT = \sum_{i=1}^{n} IIDT_i \; ; \; IIDH = \sum_{i=1}^{n} IIDH_i \; ; \; IIDS = \sum_{i=1}^{n} IIDT_i \sum_{i=1}^{n} IIDH_i$$

$$\Rightarrow \; IID = IIDT + IIDH + IIDS$$

Other analysis techniques are addressed as needed during the presentation and discussion of results.

10.5. INSTRUMENT VALIDITY AND RELIABILITY

10.5.1. DELPHI VALIDITY AND RELIABILITY

A combination of the exploratory qualitative Delphi technique along with the confirmatory IIP survey is used to empirically test the IIP framework. This approach provided a multi-method, multi-respondent technique in increasing reliability and validity.

⇒ Validity: Iterative improvements in questions, format, and the scales, establish face validity for the Delphi instrument. In addition, because the respondents are sampled from a current state of practice, factors identified and ranked by the subjects arrive from a consensus among researchers and are both current and relevant. Convergent validity is a default outcome of Delphi studies, as

consensus building is the main objective. The reiteration of the Delphi brings about an inherent convergence of opinions as the stages progress.

Discriminant validity is another outcome of a Delphi-based technique. The validation phase of the Delphi technique is used to ascertain the distinctiveness of each construct factor. First, inter-coder assessment is used to flesh out distinct factors underlying each construct; second, this is followed by the ratification of the assessed factors by industry experts constituting the Delphi panel.

⇒ Reliability: In addition to achieving reliability through pretesting of the questionnaire, multiple administration of the study (test-retest), and consensus among multiple experts, this research also uses a statistical assessment. Reliability for the Delphi traced in terms of intercoder reliability assessment in the validation phase. Cronbach's alpha is used as the standard measure of reliability. The alpha coefficient ranges in value from 0 to 1 and the higher the score, the more reliable the generated scale is. Intercoder reliability was statistically assessed by reliability analyses and pairwise consistency was quite high, with overall intercoder reliability (Cronbach's alpha) exceeding 0.78 for all factors- reflecting good reliability (Nunnally, 1978).

The Delphi technique identifies factors germane as research constructs- used to develop an authoritative list of factors pertinent to each identified subsystem construct. According to Schmidt, et al. (2001), factor research is an effective mode of eliciting, validating, and identifying pertinent factors that can address organizational issues in the realms of information systems. And as a factor research, the Delphi technique inquires

the importance of each factor and builds a consensus through feedback-based convergence. The use of consensus building in the Delphi technique is used to reiteratively generate convergent consensus from divergent factors. The result is a portfolio of factors characterized as unambiguous, objective, and current. Because of these characteristics, these factors prove to be strong candidates for inclusion as items in the IIP survey.

10.5.2. IIP SURVEY VALIDITY AND RELIABILITY

Reliability and validity of the IIP survey instrument is tested in terms of measurement error (to see that errors are random rather than systematic), face validity (if the questions seem to measure what they purport to), content validity (if questions do measure what they purport to), reliability (quality of measurement), and construct validity (ability to capture all dimensions of a concept). Each of these measures is discussed below.

⇒ Measurement Error: Multi-Item Constructs, Reliability, and Validity: In the field of survey research, Instrument validation should precede other core empirical validities. Straub (1989:150) duly notes, “Researchers…first need to demonstrate that developed instruments are measuring what they are supposed to be measuring,” a lack of which is likely to result in measurement error. Measurement error is one of the major problems researchers face in instrument validation for survey research (Grover and Malhotra, 1998). The use of multi-item scales for constructs provides a primary relief in reducing measurement errors. In order to minimize measurement errors and to better specify the construct domain, the survey design incorporates multiple

measures of a variable. Recommended by several researchers (e.g. Churchman, 1979), multi-item scales can "better specify the construct domain, average out uniqueness of individual items, make fine distinctions between people, and have higher reliability" (Grover and Malhotra, 1998: 8). The 9 constructs and sub-constructs that use multi-item scales in the IIP survey are: (i) IT-related capital outlays (2 items), IT Management ((ii) Strategic Alignment (5 items); (iii) Social Alignment (5 items)), Environment ((iv) Dynamism (4 items); (v) Complexity (4 items)), Organizational Productivity ((vi) Financial Productivity (5 items); (vii) Strategic Productivity (5 items); (viii) Operational Efficiency (5 items); (ix) Operational Quality (5 items)).

⇒ Face Validity: Face validity provides a basic support for the appearance of measurement and items. The survey research achieves face validity because of its use of the factors identified by the Delphi technique as items in the questionnaire.

⇒ Content Validity: The use of expert panels for item generation and validation is not completely without pretext. In assessing content validity, or the appropriateness of items to the construct domain, Grover and Malhotra (1998: 3) indicate that validity can be achieved from referent literature or via "a panel of experts who are well versed with the domain." The authors mention the use of a Q-sort technique- a reiterative technique where experts identify items relevant to the construct domain, a process similar to the Delphi technique. Another similar method is Trochim (1989)'s use of Concept Mapping, a technique that uses brainstorming and "structured conceptualization" for

generating a range of factors as survey items. This survey cultivates a cumulative research tradition by combining emergent and revalidated factors from referent literature.

⇒ Reliability: Reliability relates to the consistency and stability of a test, something that Grover and Malhotra (1998) refer to as internal consistency, testing whether items "hang together". According to Trochim (1989), yielding consistent measurements is reliant on the agreement of independent observers on the measures used to assess a construct domain, a key feature of inter-coder reliability. In addition to assessing inter-coder reliability for the Delphi study, reliability is also assessed for the IIP survey. Reliabilities (Cronbach's alpha coefficients) were calculated on multi-item scales (see Table 6). All of the 9 multi-scale constructs and sub-constructs used have coefficients of 0.73 and higher- indicating good reliability (Nunnally, 1978).

⇒ Construct Validity: Construct validity addresses the issue of how well the instrument can potentially measure theoretical constructs. In assessing construct validity, both convergent and discriminant validity are used to examine whether the measures defining a construct are inherently similar (convergent validity) while measures between constructs are inherently different (discriminant validity). One method of establishing convergent validity is through principal component analysis. In summary, in order to achieve construct validity, correlations between items defining a construct should be higher than correlations across items in different constructs (Grover

and Malhotra, 1998). Construct validity of the IIP survey is further discussed in the results section that follows.

Table 6: Intercoder and Scale Reliabilities (alpha coefficients)

Question/Scale	Reliability (α)	Items
Delphi Instrument	**Intercoder Reliability**	
IT Capital Outlays	0.893	-
IT Management	0.783	-
Organizational Environment	0.801	-
Organizational Productivity:		
Strategic	0.837	-
Financial	0.912	-
Operational Efficiency	0.889	-
Operational Quality	0.846	-
IIP Survey Instrument	**Scale Reliability**	
IT Capital Outlays	0.909	2
IT Management:		
Strategic Alignment	0.769	5
Social Alignment	0.752	5
Organizational Environment:		
Dynamism	0.748	4
Compelxity	0.738	4
Organizational Productivity:		
Strategic	0.882	5
Financial	0.838	5
Operational Efficiency	0.891	5
Operational Quality	0.871	5

Upon culmination of the IIP survey, the data was analyzed for missing values. In designing the Internet survey, this research attempted to minimize errors in data entry and eliminate chances of missing data. This was done by the use of compulsory response criteria and conditional logic statements- services provided by the WebSurveyor client software.

Missing values surfaced only in terms of respondents' choice of "do not know" and "rather not say" for some items in the IIP questionnaire. Results show that these values constituted only 2.15% of all item responses. A missing value analysis was performed to check for their non-randomness. A non-randomness of missing values would indicate a biased question or item leading to a patterned avoidance. However, missing value analysis using t-tests comparing means of groups (missing vs. non-missing) for each quantitative indicator variable found no evidence on a patterned avoidance. The missing values were imputed by their series means.

10.6. MULTIVARIATE STATISTICAL TECHNIQUE

The research uses a multivariate technique called LVPLS (Latent Variable Partial Least Squares) approach to regression and Structural Equation Modeling. LVPLS is a recently developed technique that shares a common conceptual bond between principal component analysis, canonical analysis, and multiple regression to develop a path analytic method for analysis of the relationship between multiple indicator and response variables. Although LVPLS is related to canonical correlation and factor analysis, it remains unique by maintaining the asymmetry (uni-directional relational property) between the predictor and the dependant variables, where other techniques treat them symmetrically (bi-directional relational property) (Abdi, 2003). This econometric technique, first developed by Wold in 1985, was mainly used for chemometric research, until it gained popularity within Information Systems research (Chin, 1998).

Abdi (2003) provides a mathematical explanation for LVPLS. If A number of observations are defined by M number of variables, the values can be stored in a A x M matrix called Y. Similarly, values of N predictors for A observations can be stored in a A

x M matrix called X. Once the matrices are established, the goal is to predict Y from X and develop a common structure. This is addressed by the use PLS regression that uses orthogonality attributes of principal component analysis (PCA) to reduce multicollinearity. The aim is to search for a set of components as latent constructs (or vectors) that decompose X and Y under the constraint that these components explain as much as possible the covariance between X and Y. Then the decomposition of X is used to predict Y. Because PCA is used to define the latent constructs, the orthogonality of principal components mitigates the risk posed by multicollinearity.

Altogether, LVPLS provides the advantage of being able to handle and model multiple independents and dependents. The use of principal components also reduces chances of multicollinearity. Furthermore, PLS analytic methods are robust in the face of deviations from normality, noise, and missing data- with a better ability for predictions. However, the disadvantages of the technique lies in the difficulty of interpreting the loadings of variables, which are based on cross-products rather than correlations as in factor analysis. Still, LVPLS is seen to be extremely efficient and robust in explaining complex relationships. As Wold (1985: 270) notes, “PLS is primarily intended for causal-predictive analysis in situations of high complexity but low theoretical information….In large, complex models with latent variables PLS is virtually without competition” (Ibid: 590). Therefore, where SEM is limited in its robustness in the face of noise, complexity, or assumptions, LVPLS provides the necessary latitude.

Because LVPLS is an extension of multiple regression, it also shares similar assumptions. They are: (a) Proper Model Specification: No relevant variables should be omitted as it can lead to misspecification, wrong attribution of common variance, and

inflation of the error term- leading to spuriousness; (b) Continuous or Categorical Variables: Interval or ratio data should be used in general, although LVPLS is robust for nominal and categorical data; (c) Lack of perfect Multicollinearity: Independent variables should not be perfectly correlated among themselves. The PCA technique in LVPLS largely reduces that risk.

Falk and Miller (1992: 4) explain that, for open systems, "the concept of causation must be replaced by the concept of predictability" and LVPLS offers the necessary latitude for estimating the likelihood of an event as a predictive tool.

The language of LVPLS follows forth (Wold, 1985; Falk and Miller, 1992):

⇒ Exogenous and Endogenous Variables: Exogenous variables are variables that have no predictors modeled with arrows leading from it but not to it (e,g, IT Investment, IT Management, IT Environment). Endogenous variables have predictors and also have arrows leading to them (e.g IT Infrastructure Design, Organizational Productivity). Because exogenous variables have no predictors, their spans are implied. All exogenous variables are therefore assigned a variance of one (1) as a scaling constraint.

⇒ Latent Variables are theoretical constructs that are not measurable by themselves (e,g, IT Investment subsystem, IT Management subsystems,…) and graphically represented as circles;

⇒ Manifest Variables are measurable and are known as indicators or manifest variables used to objectively define a latent variable (e.g. items used to define IT Investment) graphically denoted as a square;

⇒ Blocks: Blocks involve a latent variable along with a set of manifest or indicator variables. An inner-directed block is shown by arrows from manifest variables pointing towards a latent variable and is common when a latent variable consists of ordinal classifications (e,g, ordinal classifications of IT Management and Organizational Environment). Here, the latent variable is estimated as regressed weights and factors weights are identified. An outer-directed block is shown by arrows from a latent variable pointing towards its corresponding manifest variables. In this case, latent variables are estimated by factor loading s representing the predictable and common variance among manifest variables.

⇒ Asymmetric or unidirectional relationships between variables shown as single-headed arrows- representing the prediction of the variance for the variable pointed towards;

⇒ Symmetric or bidirectional relationships between variables called spans and shown as double-headed arrows. Symmetric spans reveal the relationship among the latent variable (LV) constructs.

⇒ Spans among latent variables are not interpreted as causality or prediction by correlation or covariance between one or two variable. Spans drawn on endogenous latent variables represent the unaccounted or residual variances, where R^2 (from regression analysis)= 1-value of the span. Spans can also be drawn on exogenous variables but the variance is always set to be 1.0 because of the absence of predictors for exogenous variables.

⇒ Inner and Outer Models: An inner model is a latent variable path model consisting of arrows and spans between the latent variables- resembling a structural model. An outer model, on the other hand, involves the arrows and spans between each latent variable and its corresponding manifest variables and is also called the measurement model.

⇒ Nomogram: A nomogram is a graphical representation of the variables and their relationships- providing a visual organization of the hypothesized relationships.

The LVPLS technique is implemented using a LVPLS tool called PLS-GUI (Li, 2003), an augmentation of the original LVPLS software developed by Lohmöller (1989). PLS uses correlation rather than covariance matrices to produce principal component loadings for the outer model and latent variable (LV) regression weights for the inner model. It also prints residuals for the inner and outer models using Theta and Psi matrices. The software is limited in its ability to provide a graphical path diagram as an output Altogether, results from these matrices can be used to draw a nomogram and assign necessary values. “Loadings” of indicators of each LV construct can be interpreted as loadings in a principal components factor analysis while “Paths” can be interpreted as standardized beta weights in a multiple regression analysis.

The estimation process in LVPLS follows is conducted in partial increments where blocks in the nomogram are solved one at a time. The entire nomogram is partitioned into blocks to establish an initial estimate of the latent variable. Latent variable scores are calculated by constraining their variance to one. This makes proper specification an important factor. Once initial estimates are developed for the latent

variables, a least square criterion is imposed to map the path between the latent variables and aims at minimizing of residuals, especially on manifest variables. The estimated parameters become stable when no parameter changes (minimization of residuals) occur at the fifth decimal place.

As discussed previously, the IIP framework involves two moderating variables, namely IT Management and Organizational Environment. Factoring the moderating effects into the LVPLS technique is achieved by developing interaction terms between the antecedent and the moderating variable (IT Investment and IT Management; IT Infrastructure Design and Organizational Environment). As proposed by Chin (1998), the interaction terms can be better developed if the categories for the moderating variables are contained and parsimonious. Every distinct interaction becomes a variable and a parsimonious set is an advisable condition, especially to reduce multicollinearity. In the context of the IIP framework, IT Management and Organizational Environment are finally defined as four categories each, therefore maintaining the precondition of parsimony while reducing chances of misspecification.

As "a theoretical enterprise dealing with the relationships between abstract concepts, not operational definitions" (Falk and Miller, 1992: 30), specification remains one of the most important criteria for PLS. And as a specification tool, a nomogram becomes more than a "didactic device" to diagram model specifications that translate hypotheses to a more visual form. "This specification is of utmost importance, because it distinguishes theory-based techniques from exploratory/inductive techniques" (Ibid). Comparisons between PLS Regression, Structural Equation Modeling, and Multiple

Regression are tabulated in Table 6b[3]. The nomogram of the IIP framework is shown in Figure 11a and 11b.

10.7. EXECUTING THE DESIGN

The research design adopted for this study provides the development of an inductive and deductive understanding of IT infrastructure productivity. Altogether, the data collection commenced in November, 2002 and was completed at the end of May, 2003. The research design acts as a precursor to an empirical validation of the hypotheses. SPSS base is used to analyze issues such as cross-tabulations, descriptives, and reliability. PLS is used to test the relationships implied by the research model. The next chapter reports the results for this dissertation.

Table 6b: Comparison between Statistical Techniques

Issues	SEM (Structural Equation Modeling)	Latent Variable Partial Least Squares (LVPLS)	Linear Regression
Analytical Objective	Overall Model Fit using χ^2 and other Fit Measures	Overall Model Fit and Variance Explanation R^2	Variance Explanation
Theoretical Support	Sound and Validated Theoretical Base; Primarily Confirmatory	Supports Emergent Theory; Both Confirmatory and Exploratory	Supports Emergent Theory; Confirmatory and Exploratory
Assumed Distribution	Multivariate Normality	Robust to Deviations from Normality	Partly Robust to Deviations
Model Support	Handles Multiple Independent and Dependent Variables	Handles Multiple Independent and Dependent Variables	Handles Multiple Independent Variables

[3] Based on: Esteves, J, Pastor, J.A., & Cassanovas, J. (2002). *Using the Partial Least Squares (PLS) Method to Establish Critical Success Factors Interdependence in ERP Implementation Projects.* Working Paper, Department of Information Systems, Polytechnic University of Catalonia.

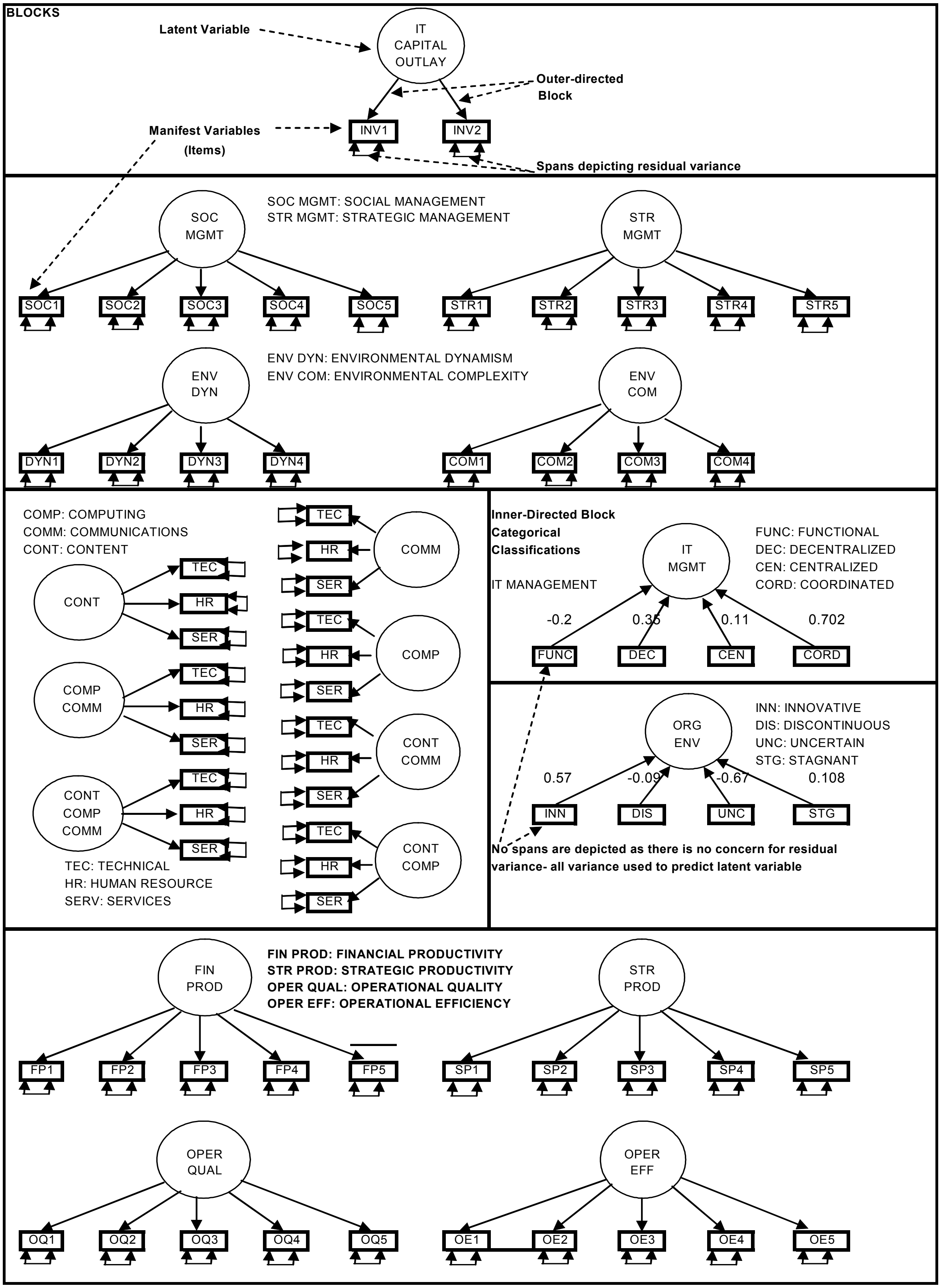


Figure 11a: LVPLS Blocks

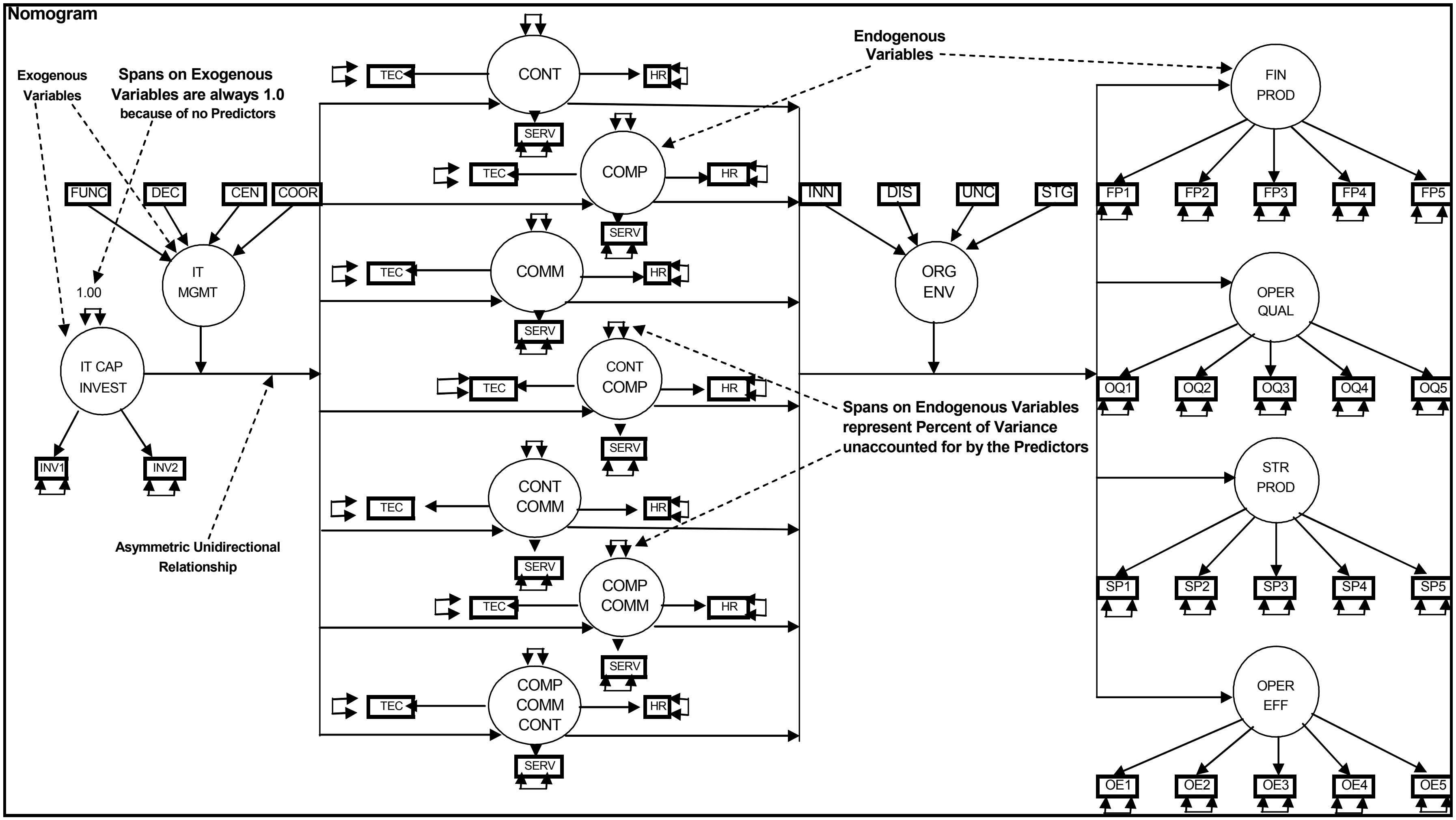


Figure 11b: A Preliminary LVPLS Nomogram of the IIP Framework

CHAPTER 11. RESULTS

"All theory, dear friend, is gray, and green the golden tree of life…
…What is important in life is life, and not the result of life"

Faust- Wolfgang von Goethe

This chapter begins with the presentation of the response rates and basic demographic profile statistics. The results from the Delphi instrument are then analyzed and presented. This is followed by the elaboration of the PLS (Partial Least Squares) multivariate statistical software used to analyze the hypotheses. Underlying statistical considerations are also discussed in detail. The hypotheses are then analyzed in light of the results through the explication of the measurement and the structural models.

11.1. RESPONSE RATES AND DEMOGRAPHIC PROFILES

11.1.1. RESPONSE RATES

Altogether, conservative response rates were achieved for both the Delphi (DQ) and IIP survey instruments (Table 7). The overall response rate for the Delphi instrument is 44.93% and 30.48% response rate for the IIP survey. For the Delphi instrument, the initial list of participants comprised 62.32% of the 69 nominations. The number of respondents fell by 18.6% during phase 1; 8.6% during phase 2; and by 3.125% during phase 3. The usable response rate for the Delphi instrument is a respectable 44.93%. All results from the Delphi instrument is therefore reported on 31 respondents ($n_1 = 31$).

The response rate for the IIP survey is lower at 30.48%. For the IIP survey, the initial sample frame of 1100 Fortune firms resulted in a list of 712 usable contacts. Contacts were deemed unusable when potential respondents (or their administrative assistants) were unreachable in the preliminary attempts. Once the list of 712 usable

contacts was obtained, correspondence was established. The list of 310 interested correspondents comprised 43.54% of the corresponded list. 231 or 74.5% of these correspondents reconfirmed their interest. Of these, 217 or 93.94% responded. The usable response rate for the IIP survey is a conservative 30.48%. Results from the IIP survey is reported using the 217 responses ($n_2 = 217$).

The response frequency (see Figure 12) was generally high with 66.5% of the responses flowing in within the first two weeks. A reminder was sent on a Friday, followed by a “thank you” note five days later. The reminder prompted 30.8% of the responses and the “Thank you” note generated the final 2.7% responses (perhaps, by triggering a sense of guilt!!!).

Table 7: Instrument Administration and Response Rates

	Instrument		
	Delphi		**IIP Survey**
Nominations	69	Total List of Contacts	712
Participants (Initial)	43	Intitial Correspondence	712
Respondents (Phase 1)	35	Correspondents (Phase 2)	310
Respondents (Phase 2)	32	Correspondents (Phase 3)	231
Final Respondents (Phase 3)	31	Final Respondents (Phase 3)	217
Usable Responses	31	Usable Responses	217
Start Date	November, 2002		April, 2003
End Date	March, 2003		May, 2003
Total Response Rate	44.93%		30.48%

11.1.2. PROFILE STATISTICS

The basic demographics surrounding the organizations and the individuals serving as respondents provide an initial view of their demographic distribution. The data from both Delphi and the IIP survey is organized and presented in this section as descriptives, frequencies, and bar charts for a preliminary perusal.

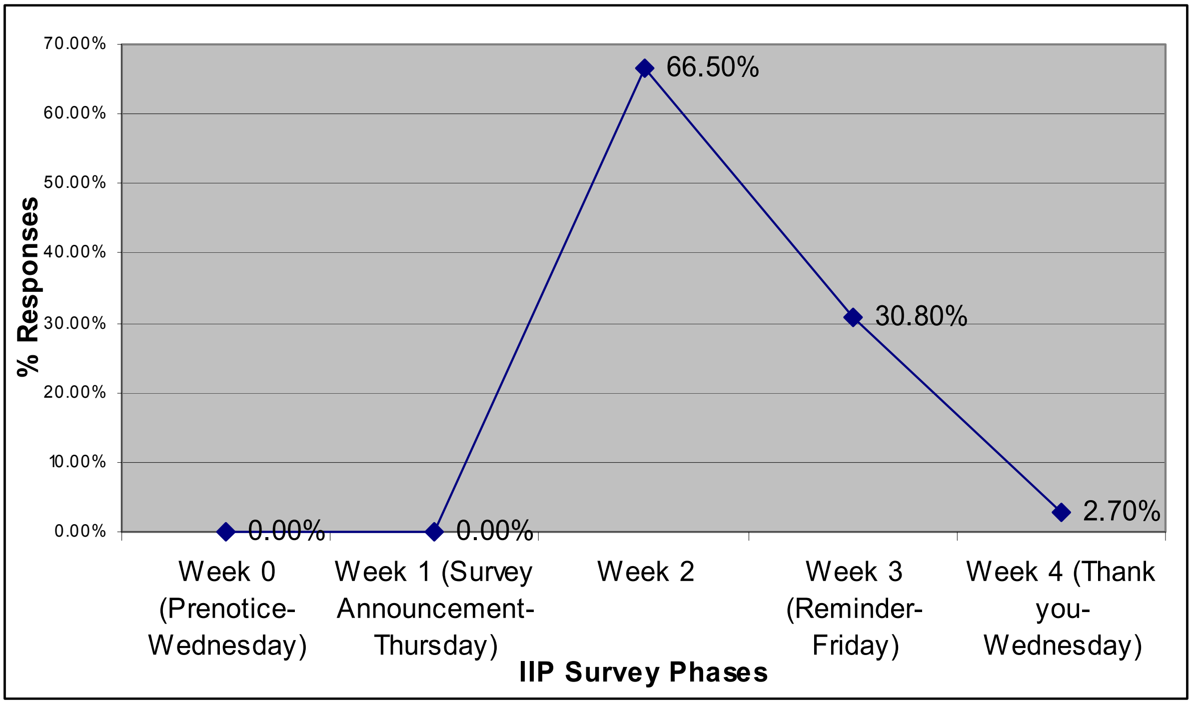


Figure 12. IIP Survey Response Frequencies

Organizations participating in both the Delphi and the IIP survey are quite diverse in terms of type (Corporation or Franchise), business activity (Manufacturing, Service, and a combination of Manufacturing and Service), and geography (regional, national, global). Table 8a shows the distribution for both instruments. For both the Delphi and the IIP survey, corporations constitute the major organizational type (71% and 84%, respectively); a majority of the organizations are national firms (45% and 49%, respectively); and firms in the service sector constitute the majority of their business activity (52% and 43%, respectively). Figure 13a shows a bar graph depicting the organizational profiles for both instruments.

Respondents drawn from the specified sample frame are assessed in terms of their organizational position and tenure. The respondent demographics are shown in Table 8b and Figure 13b. For the Delphi, 84% of the respondents are Senior IT Management

followed by CIOs who constitute 10% of the respondents. Demographics of organizational position are different for the IIP survey where 57% of the respondents are CIOs followed by Senior IT Managers constituting 42%. In both the Delphi and the IIP survey, there is a very limited response from Non-IT Management (6% and 1%, respectively). In both the Delphi and IIP survey, most of the respondents have an organizational tenure of 1-5 years (74% and 66%) followed by respondents with tenure of more than 5 years (19% and 26%).

The operational profile for organizations is also shown in across data collected from both Delphi and IIP survey instruments. The operational profiles are presented in Table 8c and Figure 13c and uses sales revenues of and IT expenditures of participating firms as preliminary operational profile descriptors. As results indicate, organizations with \$10m-\$100m sales revenues make up the majority (52%) of Delphi instrument, followed by firms with \$500m to \$1billion in revenues (32%). As for the IIP survey, a majority of the respondent firms seem to be equally distributed with \$100m-\$500m (36%) and \$500m-\$1billion (35%) in revenues; the rest of the firms show revenue extremes with 15% having \$10m-\$100m revenues and another 13% with over \$1billion revenues.

IT expenditures, on the other hand showed a steady distribution among both Delphi and IIP survey respondents. 61% of the Delphi respondents and 51% of the IIP survey respondents seem to commit \$1m-\$10m in IT expenditures; followed closely by a commitment of \$500,000-\$1m by 26% and 40% of the Delphi and IIP survey respondents, respectively. About 13% of the Delphi and 6% of the IIP survey respondents

committed less that $500,000 towards IT expenditures. Only 3% of the IIP survey respondents indicated their IT expenditures to be between $10-$100m annually.

Table 8a: Organizational Profiles

	Delphi		IIP Survey	
Organizational Profile	Count	Percentage	Count	Percentage
Corporation	22	70.97%	183	84.33%
Franchise	9	29.03%	34	15.67%
Regional	12	38.71%	41	18.89%
National	14	45.16%	107	49.31%
Global	5	16.13%	69	31.80%
Manufacturing	8	25.81%	66	30.41%
Service	16	51.61%	93	42.86%
Manufacturing & Service	7	22.58%	58	26.73%

Table 8b: Respondent Profiles and Cross-Tabulation

	Delphi		IIP Survey	
Respondent Profile	Count	Percentage	Count	Percentage
<1 Year	2	6.45%	18	8.29%
1-5 Years	23	74.19%	143	65.90%
>5 Years	6	19.35%	56	25.81%
CIO	3	9.68%	123	56.68%
Senior IT Management	26	83.87%	91	41.94%
Senior Non-IT Management	2	6.45%	3	1.38%

Table 8c: Operational Profiles

	Delphi		IIP Survey	
Sales Revenues	Count	Percentage	Count	Percentage
$10m-$100m	16	51.61%	33	15.21%
$100m-$500m	5	16.13%	78	35.94%
$500m-$1bil	10	32.26%	77	35.48%
>$1billion	0	0.00%	29	13.36%
IT Expenditures				
$0.1m-$0.5m	4	12.90%	12	5.53%
$0.5m-$1m	8	25.81%	87	40.09%
$1m-$10m	19	61.29%	112	51.61%
$10m-$100m	0	0.00%	6	2.76%

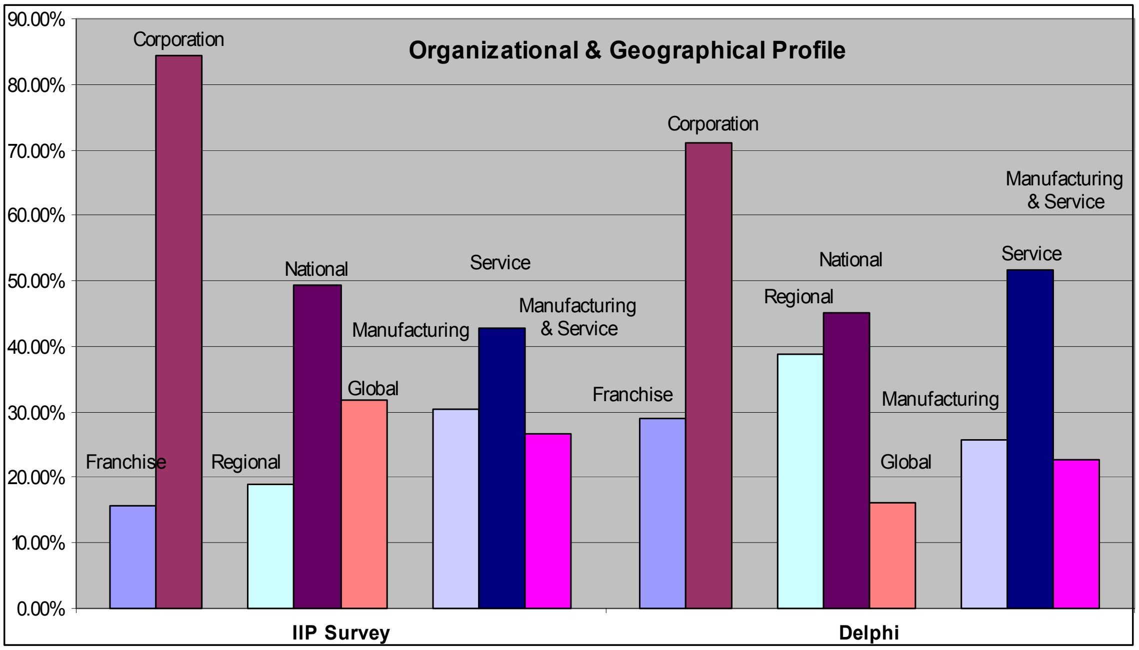


Figure 13a: Clustered Bar-Graph of Organizational Profiles

Figure 13b: Clustered Bar-Graph of Respondent Profiles

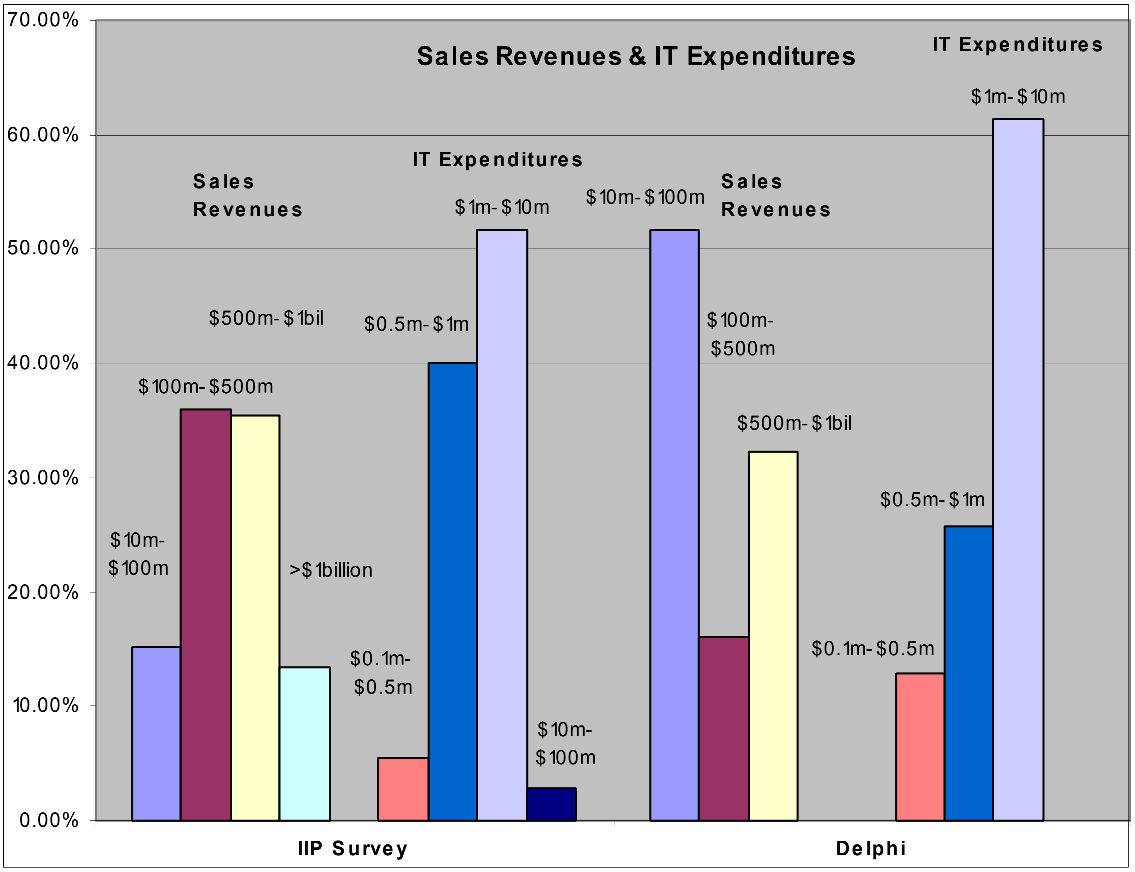


Figure 13c: Clustered Bar-Graph of Operational Profiles

11.2. DELPHI RESULTS

The goal of the Delphi study was to use "expert" opinion to identify and validate factors and classify technologies. The objectives achieved were twofold: First, the list generated by the Delphi panel generated an authoritative list with a wide coverage of pertinent factors. Second, in addition to validating some of the factors identified by referent literature, the Delphi also identified a set of factors much more current than the pre-validated factors identified previously- some dating over a decade. Although the pre-validated factors were current at the time they were first identified, the radical changes that have occurred in the computing environment have outdated some of the earlier

factors. The same issue is deliberated by Schmidt, et al. (2001) expecting (1) some factors to remain relatively stable, (2) the importance of some factors to decline over time, and (3) the list from the disciplined Delphi to contain some unique items not identified in previous studies.

The subset of pre-validated factors that has remained stable over time matches 31 of the 47 factors (66%) identified by the Delphi panel. 16 of the 47 factors, about 34%, are identified as new factors, validated by the Delphi panel and unique to the context of IIP. A description of the results follows hereunder:

⇒ IT-related capital outlays Subsystem: Among the two distinct factors related to IT capital outlays, operating expenditures for IT is ranked to be the most important. The other identifying factor relates to capital IT expenditures. Both of these factors match pre-validated items.

⇒ IT Management: IT management is identified in terms of social and strategic alignment of IT with business. Among the five factors that comprise social alignment, three are supported as pre-validated items, and two identified by the Delphi panel as unique and current factors. They are flexible organizational structure and level of informal participation between IT and Business Executives. Items for the strategic alignment dimension, on the other hand, include four factors that match pre-validates measures and one elicited as a unique factor- the alignment of IT management expertise with organizational objective.

⇒ Organizational Environment: Two dimensions are used to define the organizational environment- environmental dynamism and environmental

complexity. Among the four items defining dynamism, only one of them, diffusion of technology, matches a pre-validated factor. The other three, namely technology adoption, availability of venture capital, and market demand for innovations are uniquely identified factors. In regards to the complexity dimension, two of the four items match pre-validated factors while the other two factors- economic instability and fluctuating supplier base, are unique identifications by the Delphi panel.

⇒ Organizational Productivity: Organizational productivity has been explicated in terms of financial productivity, operational efficiency, operational quality, and strategic productivity. Five items are used to define financial productivity, all of which match pre-validated factors in referent literature. This same also stands for operational efficiency. Alternatively, operational quality is defined using five items, three of which match pre-validated measures. The other two items, namely improved and secure information exchange and reduced training time, are uniquely identified by the Delphi panel. As for strategic productivity, four of the five factors used to define the dimension match pre-validated factors. The other factor- organizational flexibility and response, is a unique item identified by the Delphi.

⇒ IT infrastructure design: The IT infrastructure design construct uses seven dimensions defined by their varying levels of convergence between three primary types of technologies: content, computing, and communication. Because such a taxonomic classification is unique to this study, most of

the dimensions have also been uniquely defined by the Delphi panel. The only two technology categories as items that match pre-validated measures are Computing and Communications. The rest are new and distinct in the context of this research.

In addition to generating a list of factors, the Delphi panel, in the third phase, also ranked the factors in terms of pertinence and importance. The panel ranked the factors in order of priority so that less important factors can be pared out and the more important factors can be used as items used as measures in the IIP survey. The panelists were asked to rate the identified factors for each construct dimension in descending order of importance so as to note the perceived significance of factors. Upon completion, the ranked list is analyzed to examine whether differences exist by business activity and type. The reasoning behind a paired analysis is to understand if respondents by business type and business activity are biased in their view of what factors constitute the important versus unimportant measures.

In order to empirically ascertain whether significant differences exist in the rankings by business activity and type, two non-parametric tests are used. The first is the Friedman's test, which is based on the rationale that if two groups do not differ in terms of the criterion variable (in this case, the total rankings), the rankings are unbiased and random. The Friedman's test statistic is approximated as a chi-square distribution where a significant chi-square indicates no difference in rankings. The other test is called Kendall's W test, where W is the coefficient of concordance which is interpreted as a coefficient of agreement among the panelists. Kendall's W is a normalization of the

Friedman's test to a value between 0 and 1, where 0 indicates no agreement and 1 indicates complete agreement.

The results from both the Friedman's test and Kendall's W are shown in Table 9. The results show that the total rankings between Manufacturing and Service industries are in moderate agreement (Friedman's test p-value<0.05; Kendall's W > 0.6). In contrast, there seems to be a high degree of disagreement in total rankings between Corporations and Franchises (Friedman's test p-value>0.1; Kendall's W < 0.2).

Table 9: Delphi Rankings Result

Manufacturing/Service	
Friedman's Chi-Square	4.71
df	1
Asymptotic Significance	0.03
Kendall's W (Coefficient of Concordance)	0.604
Corporation/Franchise	
Friedman's Chi-Square	0.037
df	1
Asymptotic Significance	0.865
Kendall's W (Coefficient of Concordance)	0.122

11.3. IIP SURVEY STATISTICS

11.3.1. DESCRIPTIVE STATISTICS FOR THE IIP SURVEY

The context of IT infrastructure productivity is a composition of multiple interrelated constructs exists as input/antecedents, mediators, moderators, or outcomes. The descriptive statistics for each are provided in Table 10 and Figures 14a-14e. The results indicate the following:

⇒ IT-related capital outlays (Input/Antecedent): The mean of IT-related capital outlays is 3.49 – moderately high considering the expected mean to be 2.5. IT capital outlays seem to be still on the rise despite surrounding pessimism.

⇒ IT Infrastructure Design (Mediator): Firms seem to manifest a steady mix of IT infrastructure technologies and related personnel across varying degrees of convergence. Among the proposed less-convergent infrastructure designs, computing-related infrastructure (technical and HR) stands out. This is followed by a communications related infrastructure design. The lowest reported proposed IT infrastructure design is a content-related infrastructure. Among the proposed partially-convergent IT infrastructure design, infrastructure related to the convergence of computing and content (e.g. Data Mining, Content Administration) comprise the most proposed infrastructure, especially in terms of the HR for development and support. Highly convergent infrastructure designs (e.g. Enterprise Systems) are not commonly proposed. However, there is a considerably greater emphasis on developing a stronger HR base for maintenance and support of the infrastructure design. At all levels of convergence, proposed infrastructure designs seem to show a greater propensity for HR than for the technical component, with the exception of one. For proposed Infrastructure designs supporting the convergence of computing and communication (e.g. Biometrics, Thin Clients), respondents lay a greater emphasis on the technical, rather than the HR infrastructure-perhaps because of the novelty/need for such technologies or their inherently low maintenance and support needs.

⇒ IT Management (Internal Moderator): IT management is classified in terms of strategic and social alignment. The results show that respondents find the level of social alignment in their firms to be significantly lower compared to

strategic alignment, indicating a stronger inclination for a centralized style of management.

⇒ Organizational Environment (External Environment): Organizational Environment faced by firms is captured in terms of environmental dynamism and environmental complexity. As the results indicate, respondents rate their environments more in terms of dynamism rather than complexity- implicating more innovative operational environments.

⇒ Organizational Productivity (Output): Productivity from commitment to a proposed infrastructure is a perceived measure. The disaggregated view of productivity allows a spectral perspective of where productivity may be traceable. Results indicate that executive's perceived levels of productivity from their proposed infrastructure design are indeed diffused. The area of productivity perceived to be impacted most by proposed IT infrastructure designs is that of strategic productivity. The second area of productivity is that of operational quality, followed by operational efficiency, and lastly by financial productivity.

⇒ Productivity Feedback: Feedbacks from Productivity offer a recursive and dynamic perspective of the IIP system. Productivity as an outcome serves as an informational trigger for future changes in other process precursors. The results of productivity feedback are partitioned by business activity and business type and presented in Table 11 and Figure 14e. As shown, most manufacturing (41%) and a majority of manufacturing and service firms (62%) tend to use information from productivity to restructure their IT

management. However, most service firms (48%) used the fed back the information to reconfigure their IT infrastructure design. Among the business activity categories, a third of the manufacturing firms (32%) used productivity outcomes to restructure their IT-related capital outlays. Among all business activities, most of the information from productivity is used to restructure IT management (40%), followed by IT infrastructure design (34%) and IT-related capital outlays (26%). In terms of business type, information from productivity was used by a majority of corporation to reconfigure their IT infrastructure design (42%) while a majority of franchises used it to restructure their IT-related capital outlays (56%). IT management followed second for both business types. Considering all business types, a majority of the information flows back to reconfigure IT infrastructure design (38%) followed by IT management (35%) and IT-related capital outlays (27%). For all firms in the IIP survey, information from productivity provided the most feedback to restructuring IT management closely followed by IT infrastructure design.

⇒ Time Lags: Time lags indicate the temporal difference between IT-related capital outlays, IT infrastructure design, and perceived productivity from the proposed infrastructure. The results of perceived time lags are shown in Figure 14f. Independent of a particular IT infrastructure, majority of the firms (37%) reported a time lag between initial capital outlays and productivity to be 2-4 years. The next most reported (23%) time-lag is over 5 years. Only

21% of the firms reportedly expect to reap productivity from their IT infrastructure design within 2 years.

Table 10: Descriptive Statistics of the IIP Constructs and Dimensions

Descriptive Statistics					
Constituent	IIP Constructs	IIP Dimensions	N	Mean	Std. Deviation
Input	IT Capital Outlay	Operating Inv	217	3.49	1.74
Mediator	IT Infrastructure	Computing	217	3.06	1.46
		Computing HR	217	3.14	1.38
		Content	217	0.70	0.11
		Content HR	217	1.12	0.47
		Communications	217	1.62	0.33
		Communications HR	217	2.68	1.01
		Content/Comm	217	2.62	0.87
		Cont/Comm HR	217	2.65	1.03
		Computing/Cont	217	2.98	1.14
		Comp/Cont HR	217	4.36	2.06
		Computing/Comm	217	2.92	0.97
		Comp/Comm HR	217	2.41	1.21
		Com/Con/Comm	217	1.57	0.69
		Com/Con/Comm HR	217	2.59	1.40
Moderator (Internal)	IT Management	Soc Alignment	217	0.71	0.26
		Str Alignment	217	4.52	1.71
Moderator (External)	Environment	Env Dynamism	217	4.88	1.15
		Env Complexity	217	0.91	0.23
Outcome	Productivity	Oper Efficency	217	1.27	0.47
		Financial Prod	217	0.74	0.19
		Oper Quality	217	3.13	1.18
		Strategic Prod	217	4.34	2.11

Table 11: Feedbacks from Productivity

Feedback to…	Manufacturing	Service	Manufacturing & Service	Total by Business Activity	Corporation	Franchise	Total by Business Type
IT Capital Outlay	31.82%	26.88%	18.97%	26.27%	21.31%	55.88%	26.73%
IT Management	40.91%	24.73%	62.07%	39.63%	36.61%	26.47%	35.02%
IT Infrastructure Design	27.27%	48.39%	18.97%	34.10%	42.08%	17.65%	38.25%

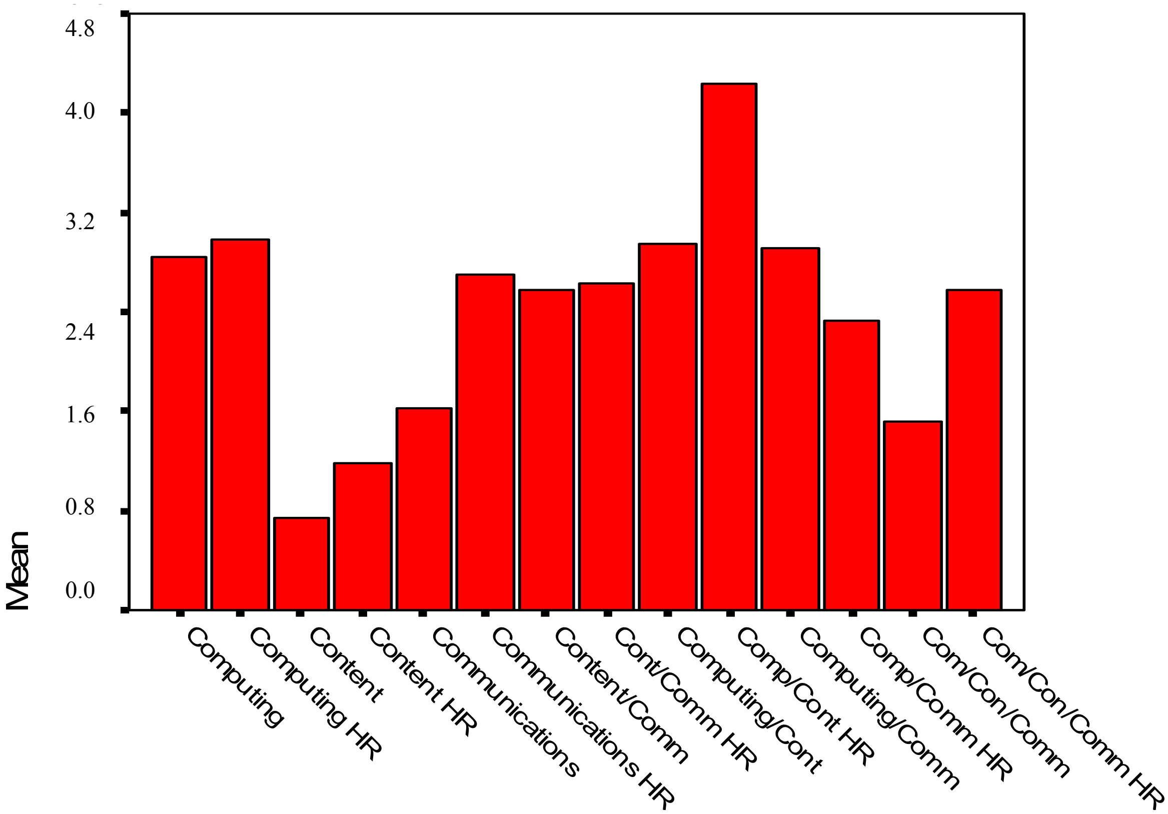


Figure 14a: Bar-Graph of IT Infrastructure Design Responses

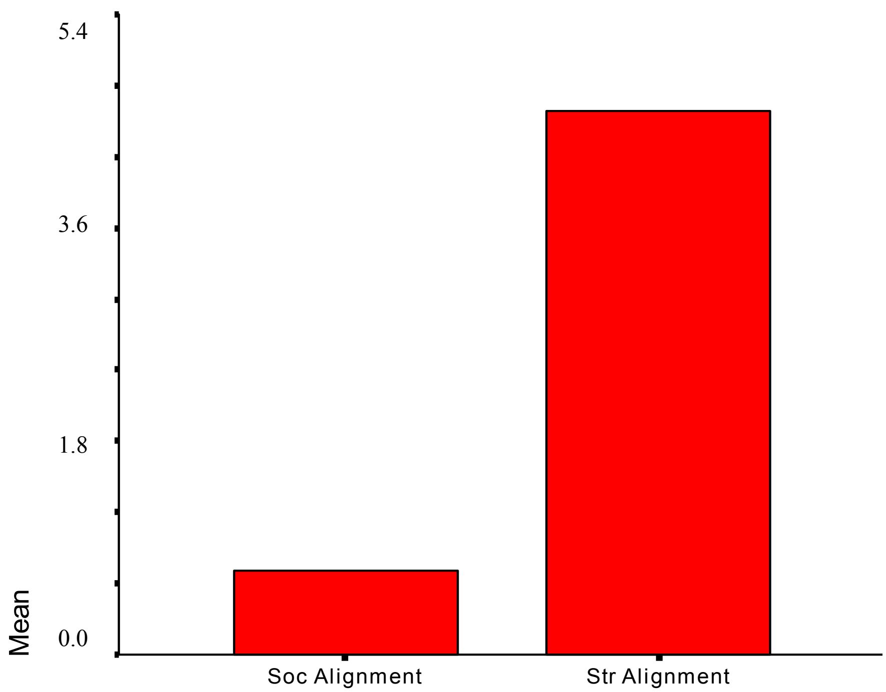


Figure 14b: Bar-Graph of IT Management

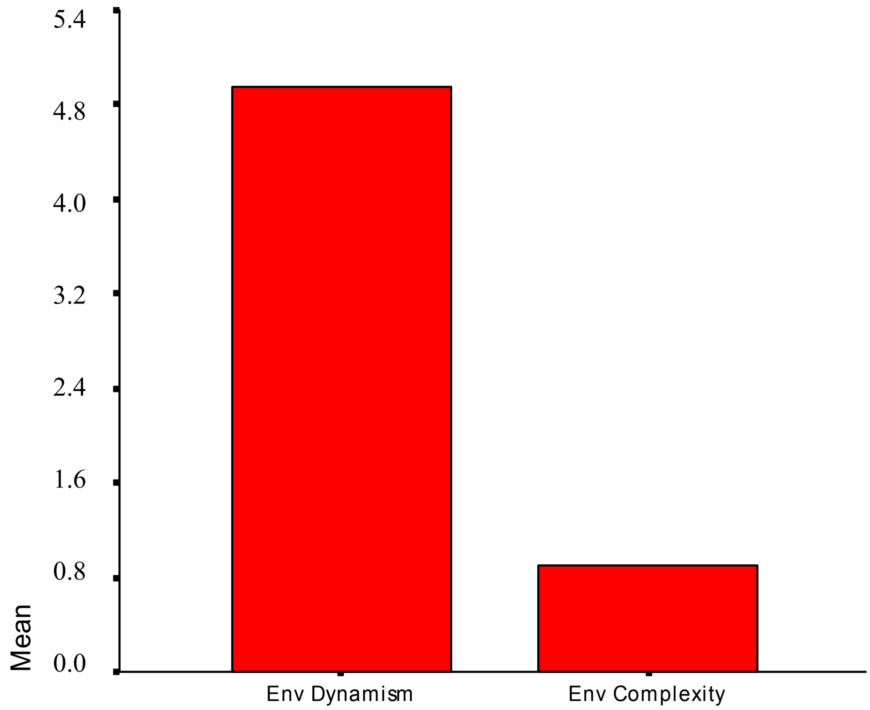


Figure 14c: Bar-Graph of Organizational Environment

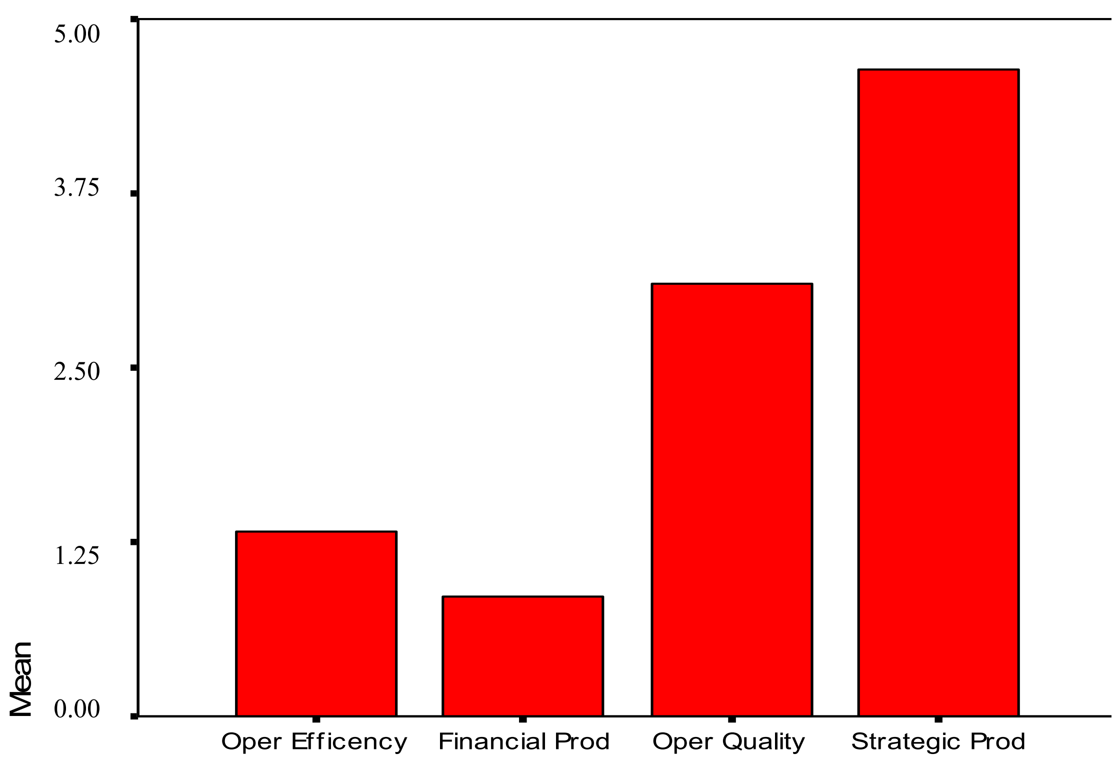


Figure 14d: Bar-Graph of Organization Productivity

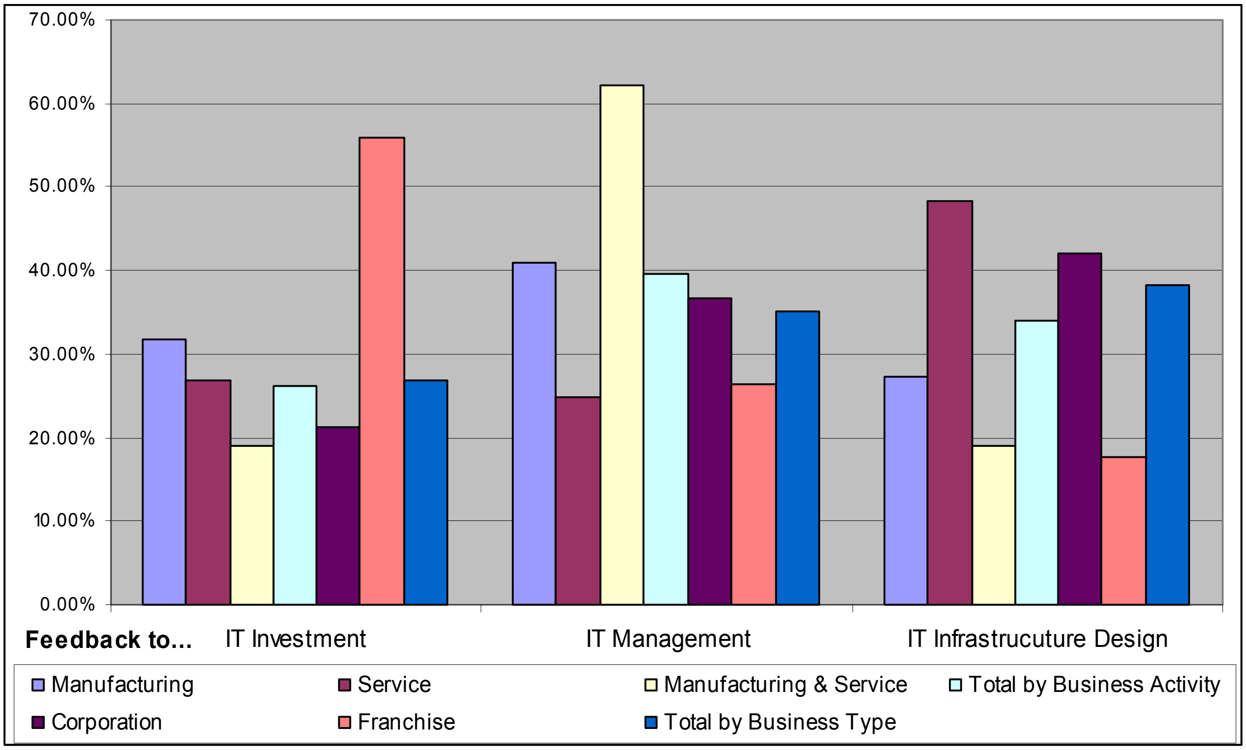


Figure 14e: Bar-Graph of Productivity Feedbacks by Business Activity and Type

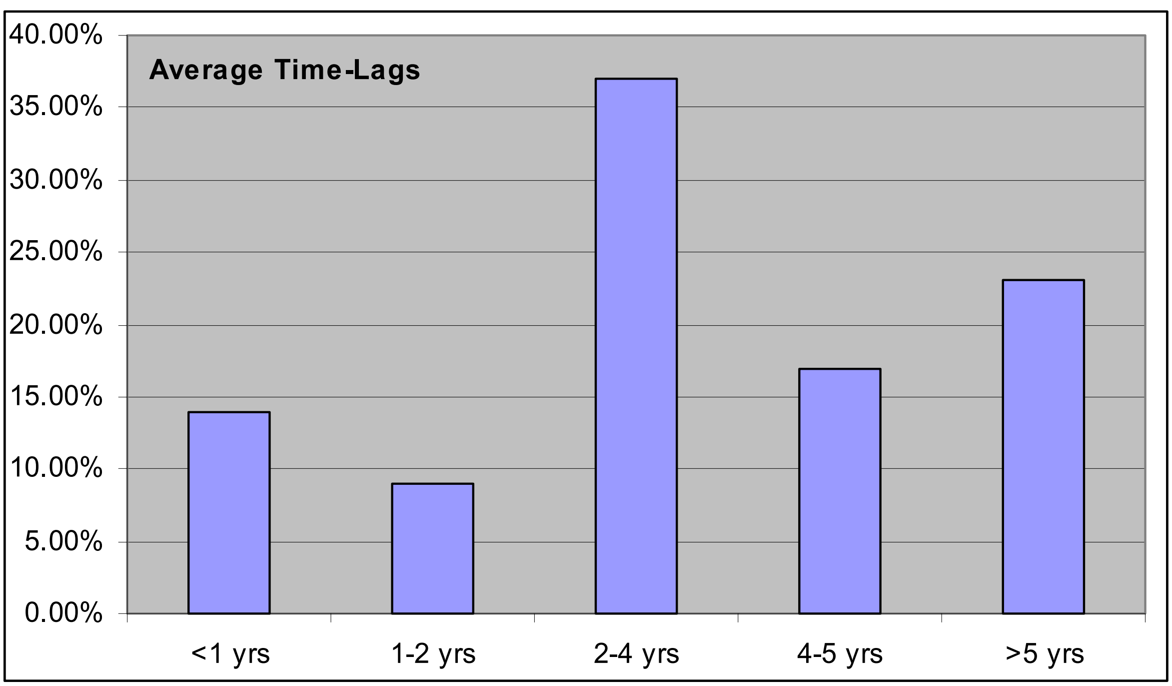


Figure 14f: Bar-Graph of Average Time-Lags

11.4. ANALYSIS OF HYPOTHESES

The five propositions are addressed using a series of sub-hypotheses that explore all mediating and moderating relationships within the IIP framework. The hypotheses are all tested using a multivariate partial least squares LVPLS technique. This section begins with an explication of the measurement models for each construct block in the PLS model. The sections following the measurement model deal with the hypotheses. Every major hypothesis is assigned a section. At the beginning of each section, the proposition appears on the left and a summary of the findings appear on the right. Corresponding results are also presented along with each proposed hypothesis.

11.4.1. MEASUREMENT MODEL

The measurement model is also known as the outer model in the language of LVPLS. The measurement model denotes the principal component loadings for outer-directed blocks and the factor weights of a regressed variate for estimating inner-directed blocks. The outer model diagnostics show the adequacy of the block construction (the loading and weights of manifest variables on the latent constructs).

To gain an estimate of the measurement model, different matrices are relied on. The LV (Latent Variable) weight matrix is used to determine the weights for the manifest variables (MV_k) in the inner-directed blocks. The category weights (W_{kh}) are a surrogate for the regression weights regressed on the latent (criterion) variate for the best possible prediction without regard to the residual variance of the predictor variable. The latent variable score (LV_h) is estimated as follows:

$$LV_h = \sum_k (W_{kh} * MV_k)$$

The measurement model for inner-directed blocks shows the regressed weight coefficients of manifest variables. The two instances of inner-directed blocks are IT Management and Organizational Environment. Classifications of IT management into four distinct categories of Functional, Centralized, Decentralized, and Coordinated Management were derived from values of social and strategic alignment. Similarly, Organizational Environment is also classified into categories of Uncertain, Discontinuous, Innovative, and Stagnant Environment, derived from values of environmental dynamism and complexity. The inner-directed blocks of IT Management and Organizational Environment consist of categories that do not have a clear rank order or share common variances in a principal component context. Each of these categories is distinct and a multiple regression solution reveals the category weights that maximally predicts IT Management and Organizational Environment.

Results for the regressed weights for IT Management (Table 12) indicate varying magnitude and direction of weights. Functional Management negatively impacts IT Management (regression weight: -0.205, p-value<0.01) while Coordinated (regression weight: 0.702, p-value<0.05), Centralized (regression weight: 0.113, p-value<0.05), and Decentralized (regression weight: 0.352, p-value<0.05) Management positively influence IT management. However, Coordinated Management significantly outweighs other management styles, specifically, functional management, which seems to have a significantly negative weight.

Results for the regressed weights for Organizational Environment (Table 12 and Figure 15) also reveal varying direction and magnitude. Results indicate that both Stagnant (regression weight: 0.108, p-value<0.05) and Innovative (regression weight:

0.566, p-value<0.05) Environments positively influence Organizational Environments, while Discontinuous (regression weight: -0.093, p-value<0.05) and Uncertain (regression weight: -0.671, p-value<0.05). Altogether, an innovative environment shows the strongest positive impact, in opposition to an uncertain environment showing the strongest negative influence. The other two values are clustered to the midpoint, with lower weights.

Table 12: Regressed Weights for Inner-Directed Blocks

Latent Variable Weight Matrix			
		1	2
IT Management	Coordinated	0.702 **	0
	Centralized	0.113 *	0
	Decentralized	0.352 *	0
	Functional	-0.205 **	0
Organizational Environment	Stagnant	0	0.108 **
	Discontinuous	0	-0.093 **
	Uncertain	0	-0.671 *
	Innovative	0	0.566 **
* - p-val<0.05; ** - p-val<0.01			

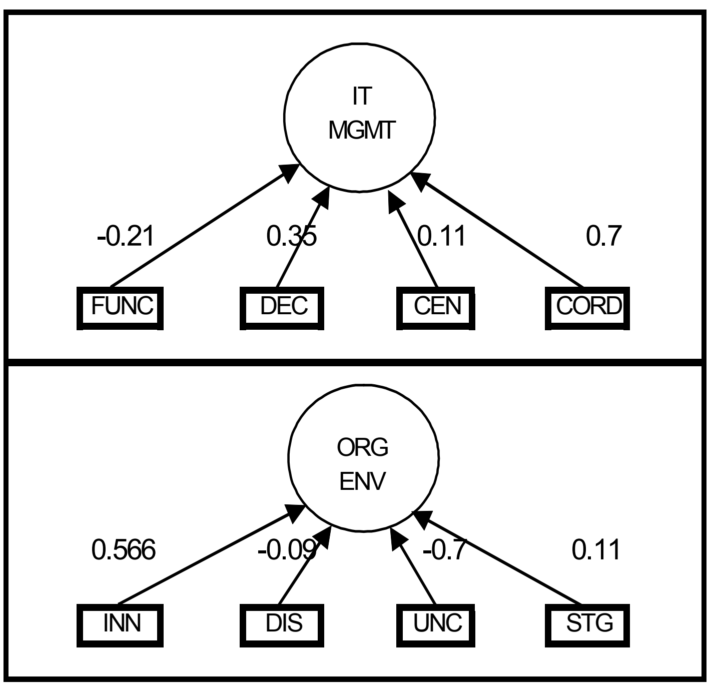


Figure 15: Regressed Weights Inner-Directed Blocks

The LV (latent variable) loading pattern matrix, which is a principal component matrix, is used to determine the principal component loading coefficient (P_{kh}) from a latent construct (LV) to corresponding manifest variables (MV). The matrix also acts as a precursor to determining the residual variances (E_k) unaccounted for. The estimation of loadings for outer-directed blocks (ODB) is done as follows:

$$MV_k = \sum_h (P_{kh} * LV_h) + E_k$$

The measurement model for the outer-directed blocks is tabulated in Table 13a and 13b for testing construct validity through convergent and discriminant validity. Convergent validity is assessed by the significant PCA factor loadings while discriminant validity is assessed by the higher loading of the LV on itself compared to other LVs. Discriminant validity in PLS is assessed by first standardizing the indicators (*Z-scores)*. Construct scores are then developed as summation of the cross-products of the standardized variables and their respective weights for every construct. The correlation cross-loadings between the construct scores ascertain discriminant validity (Chin, 1998).

The measurement model has a mean "communality of variance" of 0.634- the shared variation between variables measured as the square of all factor loadings. The mean communality is greater than the general rule-of-thumb of 0.5 (Falk and Miller, 1992). Loadings on each of the constructs and sub constructs are quite high and consistent with the Delphi study indicating the factor structure of the constructs. Principal Component Analysis is used to load the manifest variables for every construct or sub-construct. Principal components serve as a more appropriate technique for prediction and validation of factors. Factor analysis, in comparison, suffers from factor indeterminancy where multiple factor models (e.g. Varimin, Varimax, Oblique rotations) will generate

different factor scores. Principal components, on the other hand, use less restrictive assumptions to extract maximum portion of variance represented in the original set of variables. Falk and Miller (1992) use a general heuristic to validate the measurement model on the premise that the loadings on the paths between latent constructs and manifest variables should be ≥ 0.55. When manifest variables have lower loadings, little variance is shared in common and their inclusion becomes questionable. A loading of 0.55 indicates a communality of 0.3025- indicating that only 30.25% of the variance of the manifest variable is related to the corresponding construct. As noted before, the average communality for this model is 0.634, which is greater than 55%, and shares 63.4% of the variance. The measurement model is diagrammed in Figure 16.

Table 13a: Principal Component Loadings for the Outer-Directed Block Matrix

Component Matrix: Latent Variable Pattern Loading Matrix								
Principal Component Loadings for Organizational Prod.		Items	Principal Component 1	2	3	4	Communality of Variance	Residual Variance
Operational Efficiency	OE1	1	0.951	0.000	0.000	0.000	0.904	0.096
	OE2	2	0.932	0.000	0.000	0.000	0.869	0.131
	OE3	3	0.900	0.000	0.000	0.000	0.810	0.190
	OE4	4	0.890	0.000	0.000	0.000	0.792	0.208
	OE5	5	0.926	0.000	0.000	0.000	0.857	0.143
Financial Productivity	FP1	6	0.000	0.892	0.000	0.000	0.796	0.204
	FP2	7	0.000	0.763	0.000	0.000	0.582	0.418
	FP3	8	0.000	0.880	0.000	0.000	0.774	0.226
	FP4	9	0.000	0.904	0.000	0.000	0.817	0.183
	FP5	10	0.000	0.876	0.000	0.000	0.767	0.233
Operational Quality	OQ1	11	0.000	0.000	0.876	0.000	0.767	0.233
	OQ2	12	0.000	0.000	0.864	0.000	0.746	0.254
	OQ3	13	0.000	0.000	0.787	0.000	0.619	0.381
	OQ4	14	0.000	0.000	0.811	0.000	0.658	0.342
	OQ5	15	0.000	0.000	0.806	0.000	0.650	0.350
Strategic Productivity	SP1	16	0.000	0.000	0.000	0.782	0.612	0.388
	SP2	17	0.000	0.000	0.000	0.711	0.506	0.494
	SP3	18	0.000	0.000	0.000	0.735	0.540	0.460
	SP4	19	0.000	0.000	0.000	0.677	0.458	0.542
	SP5	20	0.000	0.000	0.000	0.761	0.579	0.421

(Continued Next Page…)

Principal Component Loadings for IT Investments		Items	Principal Component 1	Communality of Variance	Residual Variance
IT Capital Outlay	INV1	1	0.871	0.759	0.241
	INV2	2	0.828	0.686	0.314

Principal Component Loadings for IT Management		Items	Principal Component 1	Principal Component 2	Communality of Variance	Residual Variance
Social Alignment	ITMSOC1	1	0.832	0.000	0.692	0.308
	ITMSOC2	2	0.845	0.000	0.714	0.286
	ITMSOC3	3	0.881	0.000	0.776	0.224
	ITMSOC4	4	0.821	0.000	0.674	0.326
	ITMSOC5	5	0.839	0.000	0.704	0.296
Strategic Alignment	ITMSTR1	6	0.000	0.809	0.654	0.346
	ITMSTR2	7	0.000	0.862	0.743	0.257
	ITMSTR3	8	0.000	0.698	0.487	0.513
	ITMSTR4	9	0.000	0.776	0.602	0.398
	ITMSTR5	10	0.000	0.682	0.465	0.535

Principal Component Loadings for Organization Environment		Items	Principal Component 1	Principal Component 2	Communality of Variance	Residual Variance
Environmental Dynamism	ITEDYN1	1	0.811	0.000	0.658	0.342
	ITEDYN2	2	0.789	0.000	0.623	0.377
	ITEDYN3	3	0.781	0.000	0.610	0.390
	ITEDYN4	4	0.765	0.000	0.585	0.415
Environmental Complexity	ITECOM1	5	0.780	0.779	0.607	0.393
	ITECOM2	6	0.640	0.643	0.413	0.587
	ITECOM3	7	0.720	0.718	0.516	0.484
	ITECOM4	8	0.720	0.697	0.486	0.514

Principal Component Loadings for IT Infrastructure Design		Items	Principal Component 1	2	3	4	5	6	7	Communality of Variance	Residual Variance
Communications	NTEC	1	0.839	0.000	0.000	0.000	0.000	0.000	0	0.703921	0.296079
	NHR	2	0.821	0.000	0.000	0.000	0.000	0.000	0	0.674041	0.325959
	NSER	3	0.829	0.000	0.000	0.000	0.000	0.000	0	0.687241	0.312759
Content	DTEC	4	0.000	0.817	0.000	0.000	0.000	0.000	0	0.667489	0.332511
	DHR	5	0.000	0.824	0.000	0.000	0.000	0.000	0	0.678976	0.321024
	DSER	6	0.000	0.818	0.000	0.000	0.000	0.000	0	0.669124	0.330876
Computing	CTEC	7	0.000	0.000	0.798	0.000	0.000	0.000	0	0.636804	0.363196
	CHR	8	0.000	0.000	0.784	0.000	0.000	0.000	0	0.614656	0.385344
	CSER	9	0.000	0.000	0.791	0.000	0.000	0.000	0	0.625681	0.374319
Content/ Communications	NDTEC	10	0.000	0.000	0.000	0.756	0.000	0.000	0	0.571536	0.428464
	NDHR	11	0.000	0.000	0.000	0.721	0.000	0.000	0	0.519841	0.480159
	NDSER	12	0.000	0.000	0.000	0.740	0.000	0.000	0	0.5476	0.4524
Computing/ Communications	NCTEC	13	0.000	0.000	0.000	0.000	0.729	0.000	0	0.531441	0.468559
	NCHR	14	0.000	0.000	0.000	0.000	0.711	0.000	0	0.505521	0.494479
	NCSER	15	0.000	0.000	0.000	0.000	0.722	0.000	0	0.521284	0.478716
Content/ Computing	DCTEC	16	0.000	0.000	0.000	0.000	0.000	0.687	0	0.471969	0.528031
	DCHR	17	0.000	0.000	0.000	0.000	0.000	0.721	0	0.519841	0.480159
	DCSER	18	0.000	0.000	0.000	0.000	0.000	0.696	0	0.484416	0.515584
Content/ Communications/ Computing	NDCTEC	19	0.000	0.000	0.000	0.000	0.000	0.000	0.603	0.363609	0.636391
	NDCHR	20	0.000	0.000	0.000	0.000	0.000	0.000	0.786	0.617796	0.382204
	NDCSER	21	0.000	0.000	0.000	0.000	0.000	0.000	0.729	0.531441	0.468559

Table 13b: Latent Variable Correlation Matrix

Correlations Between Constructs (LVs)	IT INV		IT MGMT				IT INF DESIGN				ORG ENV			ORG PROD		
Discriminant validity	IT Capital Outlays	Soc Mgmt	Str Mgmt	Cont	Comp	Comm	Cont/ Comm	Cont/ Comp	Comp/ Comm	Cont/ Comm/ Comp	Env Dyn	Env Com	Str Prod	Fin Prod	Oper Qlty	Oper Eff
IT Capital Outlays	0.736															
Soc Mgmt	0.067	0.976														
Str Mgmt	0.162	0.386	0.925													
Cont	0.091	0.245	-0.217	0.838												
Comp	0.277	0.303	-0.336	0.446	0.836											
Comm	0.249	0.397	-0.244	0.601	0.484	0.853										
Cont/ Comm	0.233	0.307	-0.037	0.06	0.022	0.35	0.844									
Cont/ Comp	0.352	0.331	0.43	0.255	0.257	0.422	0.369	0.867								
Comp/ Comm	0.398	0.298	0.33	0.262	0.224	0.36	0.371	0.3	0.883							
Cont/ Comm/ Comp	0.413	0.208	0.11	0.406	0.371	0.415	0.176	0.225	275	0.921						
Env Dyn	0.182	-0.193	0.253	0.283	0.411	0.334	0.386	0.195	0.398	0.366	0.904					
Env Com	0.217	0.15	0.123	0.263	-0.28	0.426	0.162	0.301	0.134	0.34	0.299	0.819				
Str Prod	0.113	0.262	0.144	0.417	0.14	0.101	0.17	0.388	0.315	0.371	-0.4	0.141	0.886			
Fin Prod	-0.184	0.313	0.417	0.304	0.265	0.367	0.134	0.389	0.268	0.124	0.379	-0.14	0.212	0.928		
Oper Qlty	-0.238	0.305	0.16	0.314	0.33	0.305	0.334	0.399	0.425	0.191	0.138	-0.27	0.158	0.414	0.932	
Oper Eff	0.218	0.279	0.365	0.123	0.124	0.41	0.413	0.206	0.236	0.221	0.107	0.236	0.228	0.116	0.335	0.896

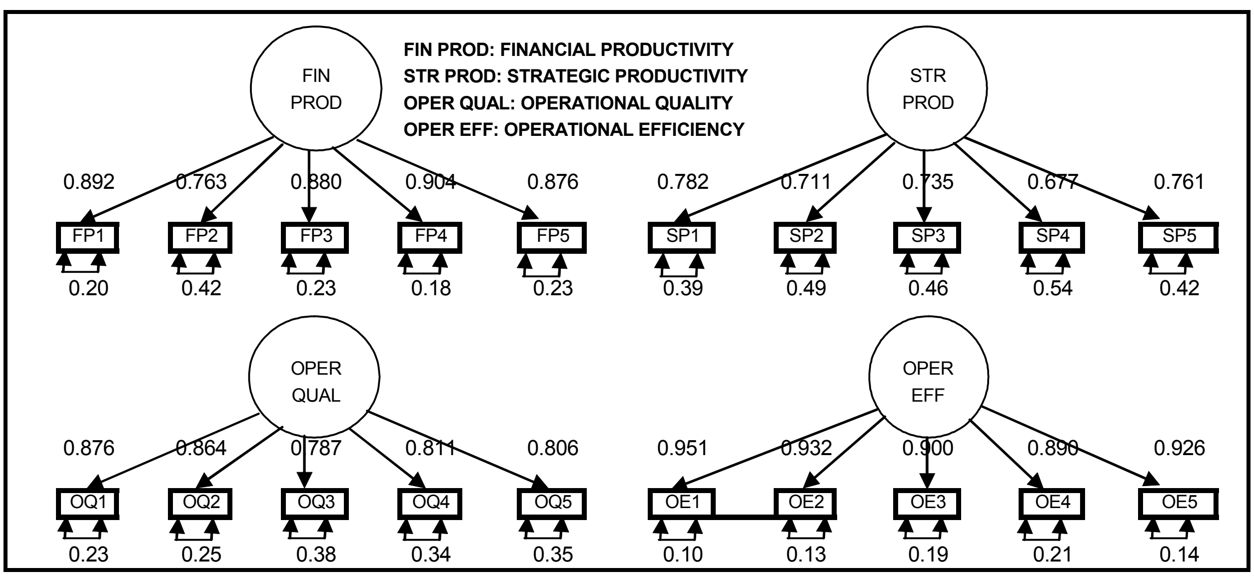


Figure 16: Component Loadings and Residuals on Measurement Model

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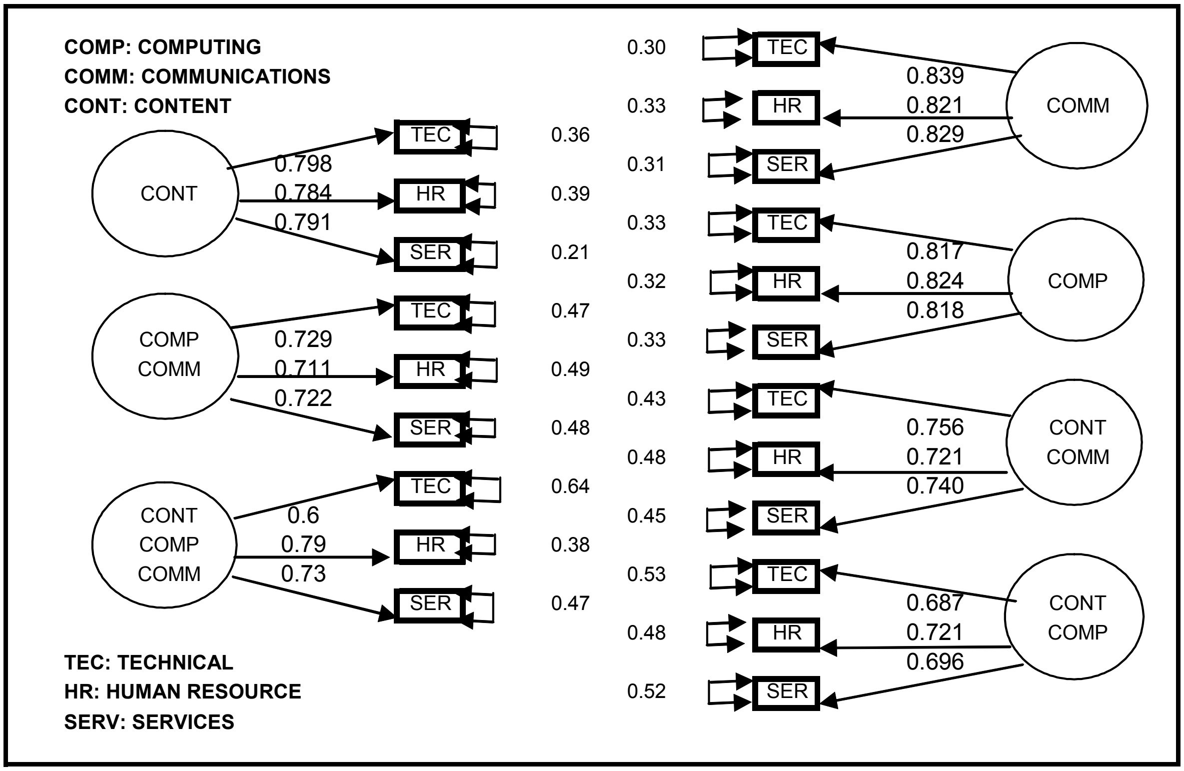
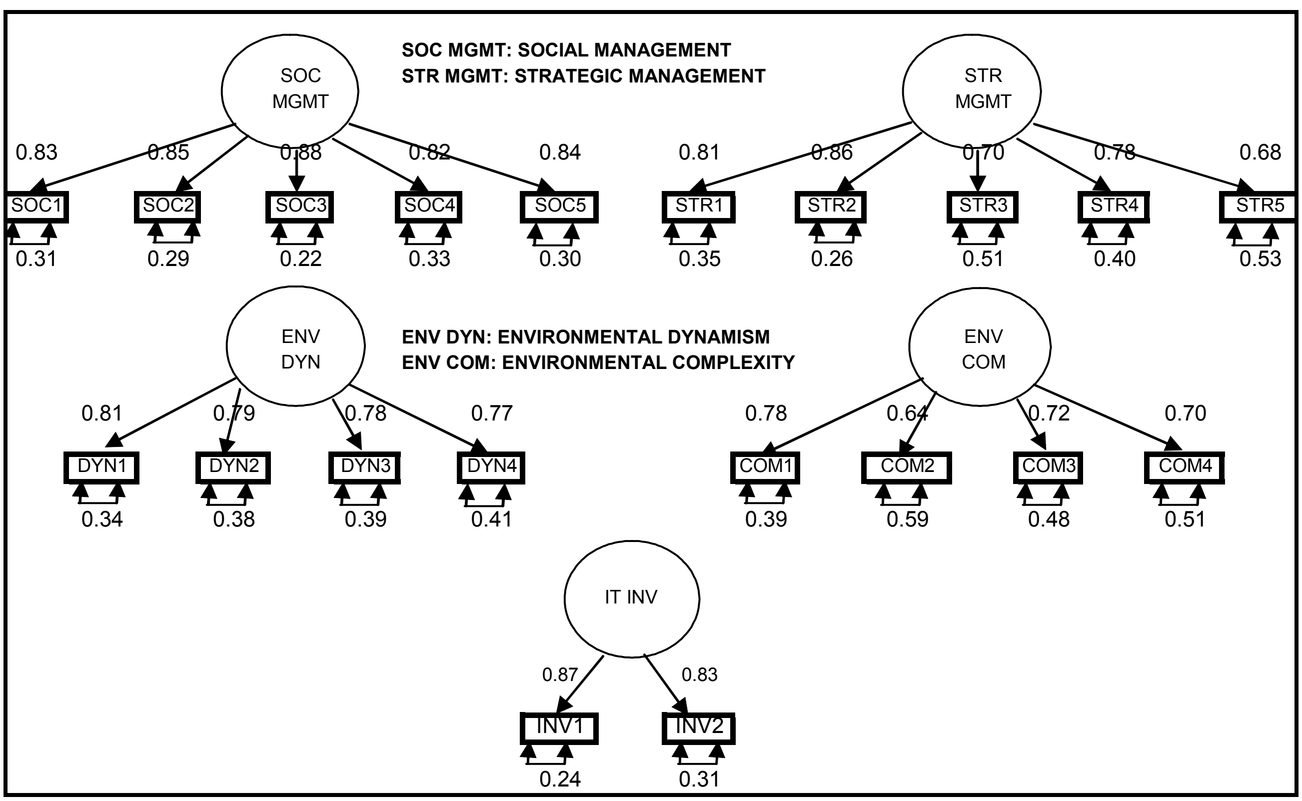

COMP: COMPUTING
COMM: COMMUNICATIONS
CONT: CONTENT
CONT
0.798
0.784
0.791
TEC
HR
SER
0.36
0.39
0.21
COMP
COMM
0.729
0.711
0.722
0.47
0.49
0.48
CONT
COMP
COMM
0.6
0.79
0.73
0.64
0.38
0.47
TEC: TECHNICAL
HR: HUMAN RESOURCE
SERV: SERVICES
0.30
0.33
0.31
COMM
0.839
0.821
0.829
0.33
0.32
0.33
COMP
0.817
0.824
0.818
0.43
0.48
0.45
CONT
COMM
0.756
0.721
0.740
0.53
0.48
0.52
CONT
COMP
0.687
0.721
0.696


SOC MGMT: SOCIAL MANAGEMENT
STR MGMT: STRATEGIC MANAGEMENT
SOC
MGMT
0.83
0.85
0.88
0.82
0.84
SOC1
SOC2
SOC3
SOC4
SOC5
0.31
0.29
0.22
0.33
0.30
STR
MGMT
0.81
0.86
0.70
0.78
0.68
STR1
STR2
STR3
STR4
STR5
0.35
0.26
0.51
0.40
0.53
ENV
DYN
ENV DYN: ENVIRONMENTAL DYNAMISM
ENV COM: ENVIRONMENTAL COMPLEXITY
0.81
0.79
0.78
0.77
DYN1
DYN2
DYN3
DYN4
0.34
0.38
0.39
0.41
ENV
COM
0.78
0.64
0.72
0.70
COM1
COM2
COM3
COM4
0.39
0.59
0.48
0.51
IT INV
0.87
0.83
INV1
INV2
0.24
0.31

11.4.2. STRUCTURAL MODEL

The structural model is used to test the hypotheses in the IIP framework. The structural model is also referred to as the Inner Model. The model consists of asymmetrical unidirectional arrows between latent constructs called path coefficients, symmetrical bidirectional arrows between latent constructs called spans that use latent variable correlations, and spans on the endogenous constructs that denotes unexplained variance. In LVPLS, path coefficients are determined by the Path Coefficient Matrix; values for symmetric spans are determined by the LV Correlation Matrix; and the parameter estimate for the span on each latent construct is determined by the Inner Residual Matrix. These matrices are used to complement one another. Their purpose is bi-fold: providing values for the structural model nomograms and testing the proposed hypotheses based on the specified values.

For the purposes of testing the proposed hypotheses, the main IIP framework is partitioned into five smaller models (PLS Nomograms). One is used to trace the relationship between IT-related capital outlays and Organizational Productivity (H1); the other to trace the relationship between IT-related capital outlays and IT Infrastructure Design (H2); and the third to understand the relationship between IT Infrastructure Design and Organizational Productivity (H3). The remaining two partitioned models are used to trace the interaction effects of IT Management (H4) and Organizational Environment (H5). For the moderated hypotheses (H4 and H5), nomograms depicting the moderated relationships are shown to maintain brevity and focus on the propositions. Marginal changes from introducing the moderators can be found in the overall model statistics (χ^2, R^2, and other measures of fit).

11.4.2.1. HYPOTHESIS 1: IT-RELATED CAPITAL OUTLAYS AND ORGANIZATIONAL PRODUCTIVITY

H1: The level of IT-related capital outlays in an organization is positively and significantly related to higher levels of productivity.	Not Supported; Negative or low Path Coefficients between IT investments and organizational productivity measures; low R-square; lack-of-fit.

This hypothesis is not supported. As shown in Figure 17a, higher IT-related capital outlays do not result in increased productivity. The relationship between IT-related capital outlays and productivity varies from being negative to a low positive. Only operational efficiency and strategic productivity seem to be positively related to IT-related capital outlays. In contrast, increases in IT-related capital outlays seem to decrease both financial productivity and operational quality.

The path coefficients are estimates of the standardized regression weights between the predictor and predicted LVs. The path coefficients provide an estimate of the magnitude of direct effect of IT-related capital outlays on organizational productivity measures. Findings for the relationship between IT-related capital outlays and operational quality show the highest negative effect with a path coefficient (P) of -0.36 along with a high variance contribution of 11.16%. The second highest variance contribution (VC) (3.75%) is from the negative P (-0.25) between IT-related capital outlays and financial productivity. IT-related capital outlays only show a positive direct effect on operational efficiency with a path coefficient (P) of 0.19 and strategic productivity with a path coefficient (P) of 0.28. However, the positive direct effects account for insignificant variance contributions (VCs) of 1.33% and 1.4%, respectively.

Altogether, the model does not show a very good fit. The mean R^2 is low (0.38). The χ^2 value (278.76, df= 231) is large and the high significance indicates a poor fit between the proposed and the actual model matrices. The RMS COV value is also quite

high, revealing an insufficient fit. In addition, the TLI shows a weak incremental fit index of 0.813.

The results indicate that the direct effects of IT-related capital outlays are not well related to organizational productivity. The only significant direct are that of the negative influences on operational quality and financial productivity. The positive effects on operational efficiency and strategic productivity are both non-significant.

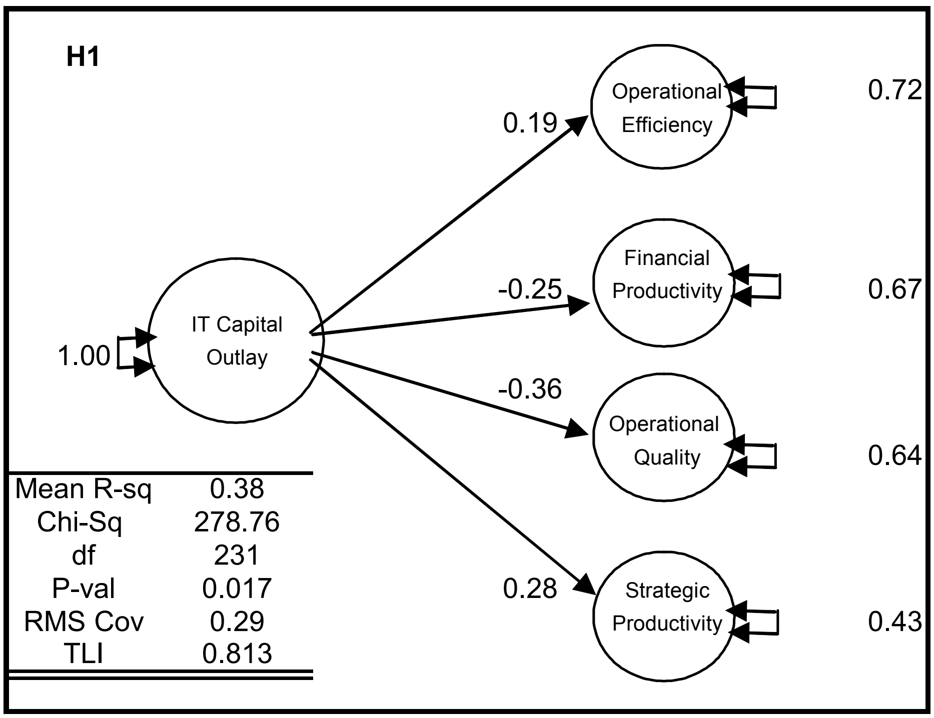


Figure 17a: LVPLS Inner-Model for Hypothesis 1

11.4.2.2. HYPOTHESIS 2: IT-RELATED CAPITAL OUTLAYS AND IT INFRASTRUCTURE DESIGN

H2: The level of IT-related capital outlays in an organization will be significantly and positively related to the level of convergence of its IT infrastructure design	Marginally Supported; Significant differences in path coefficients across levels of convergence; low or marginal fit indicators; moderate R-square

The hypothesis is marginally supported. Figure 17b shows the direct effects between IT-related capital outlays and IT infrastructure design. Greater capital outlays seem to have a positive effect on convergent IT infrastructure design configurations.

Increases in capital outlays seem to imply more convergent IT infrastructure designs. However, the model by itself shows marginal fit.

The standardized regression weights from the path coefficients indicate positive direct effects on IT-related capital outlays on IT infrastructure design. Marginal increases in IT-related capital outlays have the lowest positive impact on the design of a communications infrastructure (P= 0.08; VC= 2.56%), mainly due to the fact that firms try to leverage their existing communications infrastructure without recourse towards new communications-infrastructure initiatives. The path coefficients for computing (P= 0.14; VC= 3.64%) and content infrastructures (P= 0.17; VC= 5.78%) are larger and about twice the effect on a communications infrastructure- supported by the increased growing number of innovative devices in the field of computing and the steady interest in database related technologies. Partially Convergent IT infrastructure designs show higher direct effects from marginal increases in IT-related capital outlays. IT-related capital outlays seem to have the most direct effect on infrastructure designs supporting computing and content (P= 0.31; VC= 3.41%) followed by infrastructure designs related to the convergence of computing and communications (P= 0.27; VC= 5.13%) and lastly by infrastructure designs converging communications and content technologies (P=0.18; VC= 6.12%)- marginally higher than the content infrastructure design. However, the direct effects of IT-related capital outlays on a highly-convergent IT infrastructure design seems quite high (P= 0.41; VC= 9.43%). The variance contributions for all direct effects are significant.

Altogether, the model shows a marginal fit. The R^2 of 0.57 is moderate. The absolute fit is marginal with p-value of 0.055 (χ^2 = 289.91; df = 253)- barely non-

significant. The RMS COV does not indicate a good fit but the TLI value shows a marginal incremental fit between the predicted and the actual model matrices.

The results support the hypothesis, albeit marginally. Increases in IT-related capital outlays seem to have positive direct effects on more convergent IT infrastructure design considerations. For marginal increases in IT-related capital outlays, firms tend to opt for more convergent IT infrastructure designs.

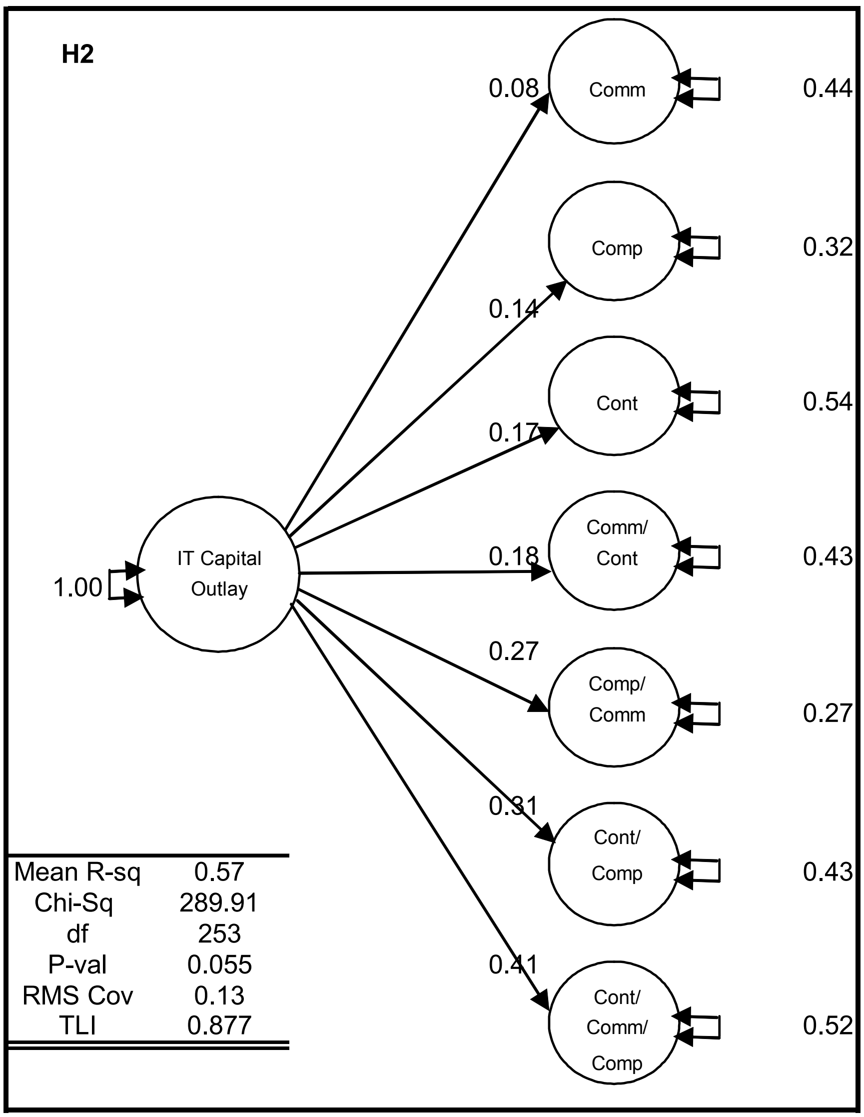


Figure 17b: LVPLS Inner-Model for Hypothesis 2

11.4.2.3. HYPOTHESES 3a-3e: IT INFRASTRUCTURE DESIGN AND ORGANIZATIONAL PRODUCTIVITY

Hypothesis 3 is supported by the use of five sub-hypotheses that relate different IT infrastructure design configurations to the potential achievement of different types of productivity. The results for each of these sub-hypotheses are shown in Figure[4] 18 and discussed below. For some sub-hypotheses, mean R^2 values are used when applicable in order to match the propositions.

Altogether, the model shows a moderate fit. The R^2 value is moderately low (0.53). Absolute fit is also moderate with a p-value of 0.0752 (χ^2=878.12; df= 820). The RMS COV index is 0.186 indicating an extremely marginal fit. The incremental fit is also moderate (TLI= 0.867).

11.4.2.3a. HYPOTHESIS 3a: HIGHLY-CONVERGENT IT INFRASTRUCTURE DESIGN AND STRATEGIC PRODUCTIVITY

H3a: A highly-convergent IT infrastructure design will be significantly and positively associated with higher levels of strategic productivity compared to other productivity measures	Supported; Significant differences exist across productivity categories; moderately high R-square; significant path coefficients

The sub-hypothesis is supported. A highly-convergent IT infrastructure design is positively and significantly associated with higher levels of strategic productivity. While strong path coefficients do seem to exist between a highly-convergent IT infrastructure design and other productivity measures, strategic productivity seems to be the most anticipated value assessment.

The paths coefficients are quite high for all predicted latent variables denoting organizational productivity. The highest perception of value is traceable in strategic productivity (P= 0.78; VC= 0.14). This is followed by an anticipation of operational

[4] In order to reduce clutter, the path diagrams are drawn separately for each infrastructure configuration.

quality (P= 0.69; VC= 0.23). Next follows anticipated increases in operational efficiency (P=0.62; VC= 0.11). The lowest anticipated productivity category is that of financial productivity (P= 0.53; VC= 0.5). The R^2 is moderately high at 0.61.

The results show strategic productivity benefits to be the most anticipated benefits from a highly-convergent IT infrastructure design. Operational quality is next followed by anticipations of operational efficiency. However, there still remains a dismal view towards anticipating financial productivity from a highly convergent infrastructure design such as ERP systems.

11.4.2.3b. HYPOTHESIS 3b: LESS-CONVERGENT IT INFRASTRUCTURE DESIGN AND FINANCIAL PRODUCTIVITY

H3b: A less convergent IT infrastructure design will be significantly and positively associated with higher levels of financial productivity compared to other productivity measures.	Not Supported; Low path coefficient compared to other productivity measures; Low to Moderate R-squares

This hypothesis is not supported. Less-convergent IT infrastructure designs are not well-associated with anticipations of financial productivity. This infrastructure design has a greater direct effect on operational efficiency compared to financial productivity. The path coefficients are generally low with one instance of a negative direct effect on operational quality. The means

The path coefficients are modest to low in terms of productivity anticipations from a less-convergent IT infrastructure design. This infrastructure design is negatively related to operational quality (P= -0,04; VC = 2.51%). Positive productivity anticipations are found in terms of operational efficiency, financial, and strategic productivity. A less-convergent infrastructure seems to provide the most anticipation for operational efficiency gains (P= 0.15; VC= 2.87%) followed by financial productivity (P= 0.11; VC= 2.9%). There is some positive association of a less-convergent infrastructure design with

anticipations of strategic productivity, but the association is minimal (P= 0.07; VC= 3.3%); The R^2 is moderate to low at 0.496.

The results indicate that gains from operational efficiency followed by financial productivity are most anticipated from a less-convergent IT infrastructure design. Strategic productivity also has a positive association but minimal in magnitude. A less-convergent IT infrastructure design is perceived to negatively impact operational quality. Altogether, the magnitude of the path coefficients in this sub-hypothesis is quite low.

11.4.2.3c. HYPOTHESIS 3c: PARTIALLY-CONVERGENT IT INFRASTRUCTURE DESIGN (CONTENT AND COMMUNICATIONS) AND PRODUCTIVITY

H3c: An IT infrastructure design based on the convergence of content and communications will be significantly and positively associated with higher levels of operational productivity in terms of operational quality compared to other productivity measures.	Supported; Significantly higher path coefficient compared to other productivity metrics; Moderately high R-square

This hypothesis is supported. A convergence of content and communications infrastructures does seem to have a significantly positive effect on perceived gains in operational quality. The most impact is perceived in terms of operational quality followed by strategic productivity, operational efficiency, and financial productivity. The magnitude of each of these impacts is moderately high.

The regression weights indicated by the path coefficients are moderately strong and significant. The strongest impact of the convergence of content and communications seems to be on operational quality (P= 0.62; VC= 3.72%). Strategic productivity (P= 0.4; VC= 5.2%) is the second major anticipated gain followed by operational efficiency (P= 0.36; VC= 11.52%). The least gain anticipated in that of financial productivity (P= 0.31; VC= 11.16%).

Results suggest that technologies converging data and networks seem to positively impact operational quality because of its reliance on good, accurate, and real-

time information. Strategic productivity gains are also positively perceived along with operational efficiency and financial gains. The R^2 is also moderately high (0.58).

11.4.2.3d. HYPOTHESIS 3d: PARTIALLY-CONVERGENT IT INFRASTRUCTURE DESIGN (COMPUTING AND COMMUNICATIONS) AND PRODUCTIVITY

H3d: An IT infrastructure design based on the convergence of computing and communications will be significantly and positively associated with higher levels of operational productivity in terms of operational efficiency compared to other productivity measures.	Supported; Significantly high path coefficient in relation to other productivity measures; Moderate R-square

This hypothesis is supported. Convergent computing and communications infrastructures have a positive and significant effect on operational efficiency compared to other productivity measures. The magnitude of this impact is significantly high and the comparative difference in the path coefficients is conspicuous. Perceived gains in operational efficiency are followed by operational quality, strategic productivity, and financial productivity.

The path coefficients are quite strong across the productivity measures. There is a discernible difference in the magnitude of the path coefficients between operational efficiency (P= 0.68; VC= 14.28%) compared to other productivity metrics. Gains in operational quality follow (P= 0.42; VC= 4.62%). Strategic productivity (P= 0.37; VC= 11.1%) comes next followed by perceived gains in financial productivity (P= 0.33; VC= 12.21%).

Results point out that convergent computing and communications infrastructures have a strong bearing on perceived gains in operational efficiency, mainly through better control and capacity utilization of [computing] resources. Operational quality, strategic, and financial gains are also anticipated. The R^2 is moderately high (0.59) indicating a moderate fit.

11.4.2.3e. HYPOTHESIS 3e: PARTIALLY-CONVERGENT IT INFRASTRUCTURE DESIGN (COMPUTING AND CONTENT) AND PRODUCTIVITY

H3e: An IT infrastructure design based on the convergence of computing and content will be significantly and positively associated with higher levels of operational productivity in terms of operational efficiency and operational quality compared to other productivity measures.	Supported; Both operational quality and effiiciency show considerably higher path coefficients in relation to other productivity measures; Moderate R-square.

This hypothesis is supported. A convergent computing and content infrastructure seems to be positively and significantly associated with both operational efficiency and operational quality, compared to other productivity perceptions. Among both the operational measures, this infrastructure configuration has a greater impact on operational quality rather than operational efficiency. Strategic and financial productivity are also anticipated but are less-strongly associated with such an infrastructure design.

The path coefficients as standardized regression weights are the strongest for the operational measures followed by strategic and financial productivity. Gains in operational quality are the most anticipated (P= 0.73; VC= 26.28%) with high path coefficient and a large variance contribution. Perceived gains in operational efficiency are also significant (P= 0.61; VC= 18.91%). Perceived strategic (P= 0.39; VC= 4.68%) and financial productivity (P= 0.23; VC= 6.21%) gains follow.

The results show that a convergent content and computing infrastructure has the most bearing on operational level productivity. This can be attributable to better, faster, and more accurate information generation. Although strategic and financial gains are also perceptible, the direct effects are relatively weaker. In general, there is very little perception of financial productivity as a major outcome of a given IT infrastructure design. However, there is an increasing shift towards strategic productivity and operational quality. The R^2 is moderately strong (0.61).

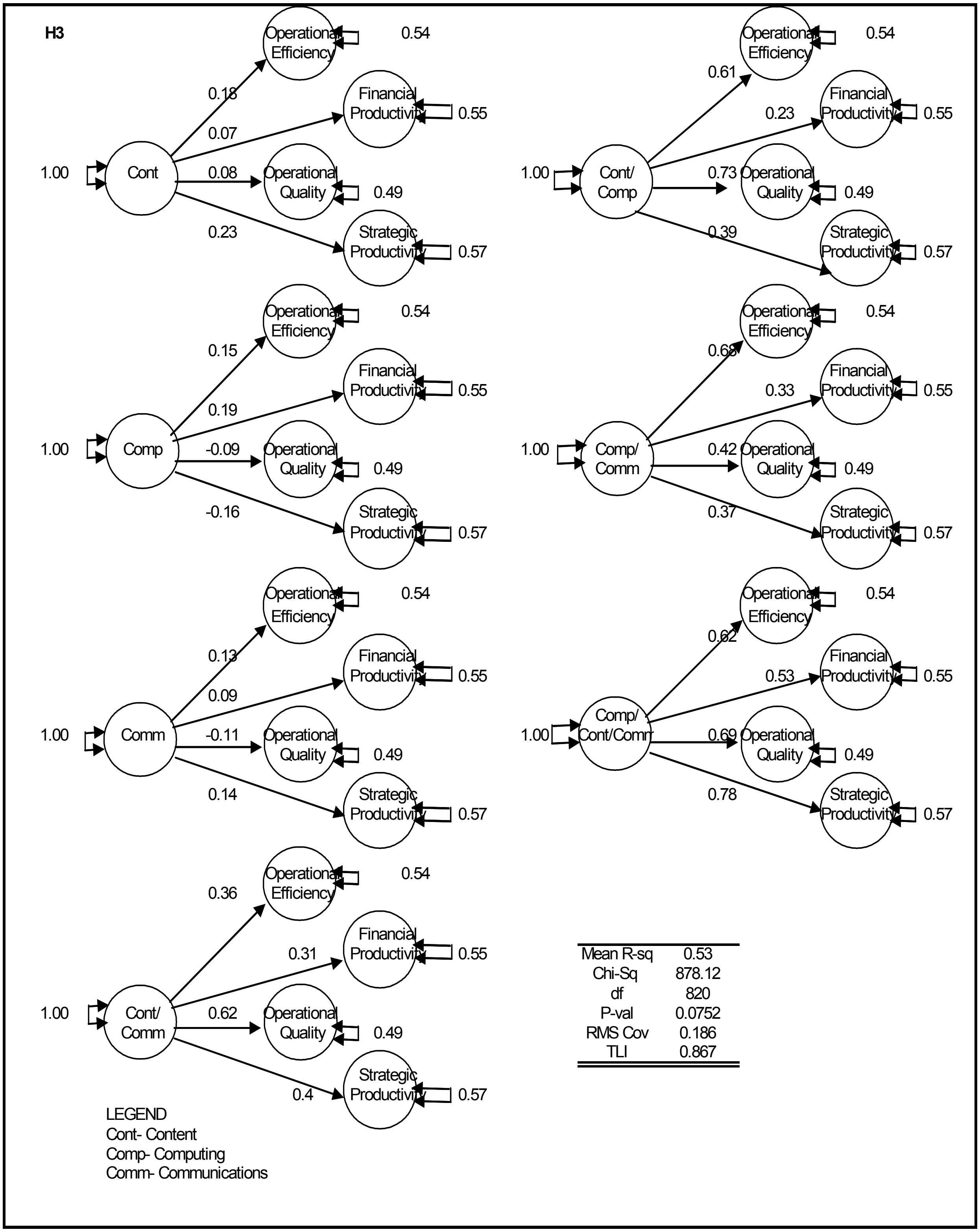


Figure 18: LVPLS Inner-Model for Hypothesis 3 (3a-3e)

The results offer an interesting cue that supports the IIP framework. Consider IT-related capital outlays as A, IT Infrastructure Design as B, and Organizational Productivity as C. While the relationship between IT-related capital outlays (A) and productivity (C) is weak (R^2= 0.38), the relationships between IT-related capital outlays (A) and IT infrastructure design (B) is moderate (R^2= 0.57); so is the relationship between IT infrastructure design (B) and productivity (C) (R^2= 0.53). As Baron and Kenny (1996) relate, when relationships between A and B and B and C are higher than that of A and C, one can postulate that B is a mediator. This implicates that rather than IT-related capital outlays directly impacting organizational productivity, impacts IT infrastructure design that subsequently impact productivity. In the language of PLS, the indirect effect of IT-related capital outlays and productivity is greater than its direct effect.

11.4.2.4. HYPOTHESIS 4: MODERATING EFFECTS OF IT MANAGEMENT ON IT INFRASTRUCTURE DESIGN

Moderating effects are understood using statistical interactions. A moderating interaction is said to exist when the effect of an independent variable (X) on a dependent variable (Y) differs across levels of a third (or control) variable (IT Management and Organizational Environment). For example, the IT management (Z) subsystem has four levels. The association between X and Y for Z=1 is first calculated, followed by separate calculations of the associations between X and Y for Z=2, Z=3, and Z=4. If the four "parts" of the association between X and Y, controlling Z, differ, statistical interaction exists (Hanneman, 1998). There is no single standard way of representing interaction in causal diagrams; however, this method is found to be simple and is consistently used in this dissertation. Although the direct affects are also examined, the path diagrams are

explicated only for the interaction terms. If the inclusion of moderators enhances the fit of the model compared to the original unmoderated model, one may assume that moderating effects are significant.

Hypothesis 4 examines the moderating role of IT management in translating IT-related capital outlays into IT infrastructure design. Moderation is the PLS context is shown as an interaction effect between the antecedent and the moderator. As Chin (1998) points out, interaction effects in PLS are modeled as distinct latent variables. For example, IT investment has one category while IT management has four distinct categories. The moderating effect of IT management on IT-related capital outlays results in the creation of a 1x4 exogenous matrix of the interaction effect. The nomograms here depict the path coefficients for the moderated effects only in order to maintain consistency with the hypotheses.

Altogether, the model shows a considerable fit. A moderately high R^2 of 0.698 seems to account for about 70% of the total variance and is significantly higher in terms of its incremental effects and fit than unmoderated direct linear effects. The measure of absolute fit, χ^2 (df= 595), shows a good fit with a non-significant p-value of 0.113. The RMS COV is also low at 0.0854, indicating a modest fit. Lastly, the incremental fit measure index, TLI, is robust at 0.903, suggesting a considerably good fit.

In support of the major hypothesis concerning the moderating effect of IT management, four sub-hypotheses are proposed. The condensed results are compiled in Table 14 and shown in Figure[5] 19. The sub-hypotheses are discussed below in terms of path loadings and fit measures.

[5] In order to reduce clutter, the path diagrams are drawn to depict interaction (moderation) only.

11.4.2.4a. HYPOTHESIS 4a: MODERATING EFFECTS OF FUNCTIONAL IT MANAGEMENT

H4a: Given a specific level of IT capital outlay in an organization, a functional management style will significantly and positively result in a less-convergent IT infrastructure design compared to any other infrastructure design.	Supported; Strong evidence of a less-convergent IT infrastructure design with significant path coefficients; Moderately high R-square

This hypothesis is supported. Given that firms have committed IT-related capital outlays, a functional IT management style is positively associated with a less-convergent IT infrastructure design. A functional management style is most associated with the design of a less-convergent infrastructure. There is a less association in designing a partially-convergent infrastructure. Finally, a functionally managed IT investment is the least associated with creating a highly-convergent infrastructure.

The path coefficients provide the standardized regression weights for the associations. The path coefficient between functional IT management and a less convergent IT infrastructure design has the largest magnitude (P= 0.57; VC= 17.4%). The association with a partially-convergent infrastructure design is considerably lower (P= 0.24; VC= 3.62%). The lowest association is traceable for a highly-convergent IT infrastructure design (P= 0.14; VC= 4.2%). The R^2 is moderately high (0.69).

The results suggest that a functional style of IT management is most likely to design a less-convergent IT infrastructure, mainly because the aim of IT management is to serve a process or a particular department rather than the organization. The focus is quite functional where convergence of disparate systems is not a major issue to be considered. Rather a functional management style relies more on ad-hoc IT infrastructure design considerations that try to match existing work, rather than organizational practices.

11.4.2.4b. HYPOTHESIS 4b: MODERATING EFFECTS OF COORDINATED IT MANAGEMENT

H4b: Given a specific level of IT capital outlay in an organization, a coordinated management style will significantly and positively result in a highly convergent IT infrastructure design compared to any any other infrastructure design.	Not Supported; moderate path coefficient compared to partially convergent IT infrastructure designs; Moderately high R-square

This hypothesis is not supported. A coordinated IT management style does not lead to a highly-convergent IT infrastructure design but to more partially-convergent IT infrastructure design. The association with a highly-convergent IT infrastructure design is weaker in magnitude. The association has the least direct effect on a less-convergent infrastructure.

The path coefficients between a coordinated IT management style and IT infrastructure designs are moderately strong but varied in magnitude. The strongest association is seen in terms of partially-convergent IT infrastructure design (P= 0.75; VC= 18.5%). This is followed by the second-highest association in terms of a highly-convergent IT infrastructure design (P= 0.54; VC= 9.18%). The direct effect is the lowest for less-convergent IT infrastructure designs (P= 0.29; VC= 7.05%). As seen, the differences in the magnitude of direct effects of the three categories are considerable and significant. The R^2 is significantly high (0.746).

Altogether, the results indicate that coordinated IT-related capital outlays are more focused on developing a partially-convergent IT infrastructure design, perhaps led by its flexibility and relative simplicity compared to the complexity of a highly-convergent design and the rigidity of a less-convergent IT infrastructure design. In matching strategy and participative structure, coordination begets the need for a flexible infrastructure design where both open control and communication channels are an imperative.

11.4.2.4c. HYPOTHESIS 4c: MODERATING EFFECTS OF CENTRALIZED IT MANAGEMENT

H4c: Given a specific level of IT capital outlay in an organization, a centralized management style will result a partially-convergent IT infrastructure design compared to any other infrastructure design.	Not Supported; Significantly higher path coefficient supporting a highly-convergent IT infrastructure design. Moderately high R-square

This hypothesis is not supported. The direct effect of centralized IT-related capital outlays is more associated with a highly-convergent IT infrastructure design compared to any other infrastructure design categories. Centralized IT management shows a lower degree of association with partially-convergent infrastructure and the least association with a less-convergent IT infrastructure design.

The path coefficients denoting the standardized regression weights denote significant differences in the magnitude of associations between centralized IT management and IT infrastructure designs. The path coefficient associated with a highly-convergent IT infrastructure design is the highest (P= 0.74; VC= 17.02%). Considerably less-associated was the relationship with a partially-convergent IT infrastructure design (P= 0.47; VC= 12.81%). The lowest association is found with the design of a less-convergent IT infrastructure (P= 0.31; VC= 3.43%). The R^2 seems to be moderately high (0.70).

Results indicate that centralized management styles tend to have a greater focus towards creating a highly-convergent infrastructure design. This is perhaps due the evolved aspects of control that remained strong for integrating the enterprise. The control mechanisms are more structured and strategic for enterprise-related convergent IT infrastructures. A centralization of authority allows for stronger monitoring and control when supported by a highly convergent infrastructure design that integrates organizational access-leading to swifter response and control

11.4.2.4d. HYPOTHESIS 4d: MODERATING EFFECTS OF DECENTRALIZED IT MANAGEMENT

H4d: Given a specific level of IT capital outlay in an organization, a decentralized management style will result in a partially convergent IT infrastructure design compared to any other infrastructure design.	Not Supported; Path coefficients significantly higher for less-convergent IT infrastructure designs; Moderately high R-square

This hypothesis is also not supported. The magnitude of association between decentralized IT management and a partially-convergent IT infrastructure is lower than its association with a less-convergent IT infrastructure design. The differences in association between a highly convergent IT infrastructure design and a partially convergent IT infrastructure design is marginal to none.

The path coefficients are considerably different in their associations. The direct effects of association with a less-convergent IT infrastructure is considerably high (P= 0.68; VC= 17.22%). The associations between a decentralized management with a partially-convergent (P= 0.26; VC= 6.58%) and a highly convergent (P= 0.26; VC= 1.30%) IT infrastructures are significantly lower. While both of he latter share the same path coefficient, the association with a highly-convergent IT infrastructure design is found to be insignificant. R^2 is moderately high (0.6557).

Results show that a decentralized management style tends to develop a less-convergent IT infrastructure design- much akin to functional management. This is perhaps due to the reason that decentralized management mirrors a functional management style, with every unit operating as a profit center. Respective business-unit profit enhancements tend to take precedence over other organizational considerations. Because executives need to accountable for their individual units, ad-hoc policies abound and prioritized on. In this instance, convergent IT infrastructure designs intended to serve enterprise-wide efforts are relegated to the backstage.

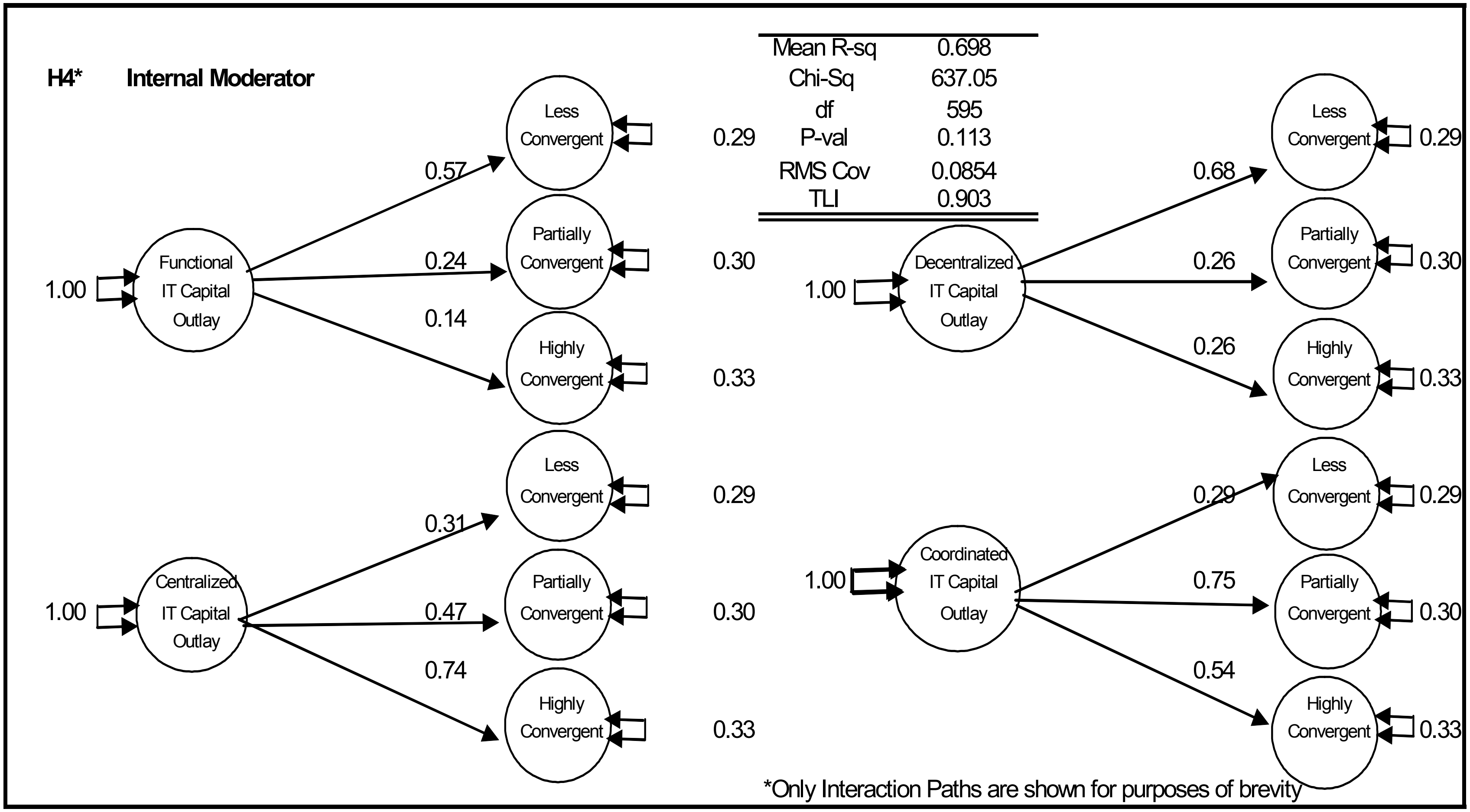


Figure 19: LVPLS Inner-Model for Hypothesis 4 (4a-4d)

11.4.2.5. HYPOTHESIS 5a-5d: MODERATING EFFECTS OF ORGANIZATIONAL ENVIRONMENT ON ORGANIZATIONAL PRODUCTIVITY.

Hypothesis 5 examines the moderating role of organizational environments on organizational productivity. Organizational environments are extrinsic factors that influence organizational productivity from a given IT infrastructure design. As in the case with IT management, the interactions between IT infrastructure configurations (7 categories) and environmental types (4 categories) result in creating an exogenous interaction set of 28 latent variables (7x4) associated with the 4 endogenous categories of organizational productivity. Again, only interaction effects are admitted in the examination, although direct effects are also calculated. The inclusion of the environment as a moderator shows a statistically significant effect as seen by the incremental fit measures when compared with the direct linear effects. The marginal difference is both positive and significant under moderated conditions.

Altogether, the model seems to show a modest level of fit. The R^2 value shows a moderate accounting for the variance (0.59). As a measure of absolute fit, the χ^2 is non-significant (χ^2 = 6002.72; df= 5886) at p-value of 0.1412- indicating good fit. The RMS COV value is a modest 0.09, denoting a marginally modest fit. Lastly, the incremental fit measure of TLI shows a value of 0.882- supporting a conservative fit.

In support of the major hypotheses proposed by the moderating influence of the organizational environment, four sub-hypotheses are proposed for empirical investigation. The results are tabulated in a condensed form in Table 15 and the path model is shown in Figure[6] 20.

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[6] [6] In order to reduce clutter, the path diagrams are drawn to show interaction (moderation) effects only.

11.4.2.5a. HYPOTHESIS 5a: MODERATING EFFECT OF A STAGNANT ENVIRONEMENT

H5a: Given a specific IT infrastructure design, organizations facing a stagnant environment will rely more on financial productivity compared to other productivity metrics.	Mixed Support; Path coefficient for operational efficiency marginally higher than financial productivity; Moderate R-Square and Marginally supportive

There is mixed support for this hypothesis. While infrastructure designs in stagnant environments do seem to have a significantly positive association with financial productivity, they are equally related to operational efficiency, with marginal differences. However, there are considerable differences in the magnitude of associations among operational quality and strategic productivity.

The path coefficients reveal the individual weights of association. The strongest association is with financial productivity, as predicted (P= 0.55; VC= 8.6%). However, the association with operational efficiency is equally strong with miniscule differences (P= 0.54; VC= 8.7%). Not only are the path coefficients extremely close, the variance contributions too, are marginally different. The associations with operational quality (P= 0.24; VC= 6.0%) and strategic productivity (P= 0.21; VC= 2.5%) are comparatively lower in magnitude and significance. The R^2 is moderately high (0.69).

Results indicate that, given an IT infrastructure design, firms operating in a stagnant environment try to focus more towards financial productivity followed closely (to be precise, in parallel) by operational efficiency. Strategic and financial productivity show significantly lower associations. Such environments are evident across particular industry sectors and macro-level national economies. These are generally very mature industries marked by monopolies or oligopolies. The threat of new entrants is low and products and services are rarely unique and rather commoditized. In such an environment, batch and mass-production strategies are used to reduce costs and IT related

capital outlay overheads and variable costs are grounded in terms of differentiable productive efficiencies that generally manifest themselves in conventional accounting and financial reporting measures.

11.4.2.5b. HYPOTHESIS 5b: MODERATING EFFECT OF AN UNCERTAIN ENVIRONMENT

H5b: Given a specific IT infrastructure design, organizations facing an uncertain environment will positively and significantly rely more on operational quality compared to other productivity metrics.	Supported; Path coefficient also shows a high path coefficient for strategic productivity; Moderately high R-square.

This hypothesis is supported. Firms operating within uncertain environments tend to rely more on achieving operational quality compared to any other types of productivity. The magnitude of association closely resembles that of strategic productivity, with marginal differences between the two. This is closely followed by operational efficiency and financial productivity.

The path coefficients reveal the magnitude of direct effects of the moderating effects of organizational environment on productivity. The path coefficient is the greatest for operational quality (P= 0.71; VC= 12.5%) followed very closely by strategic productivity (P= 0.69; VC= 14.9%). This is followed by the direct effects on operational efficiency (P= 0.28; VC= 5.7%) and lastly, the low association with financial productivity (P= 0.17; VC= 1.18%). Associations with financial productivity are insignificant. In general, the R^2 reveals a moderate accounting of variance (0.6).

The results indicate that, given a specific infrastructure design, firms operating in an uncertain environment are most likely to focus on operational quality and strategic productivity. There is also some degree of association with operational efficiency. The uniqueness and flux of this environment fuel the need for dynamic assessment and anticipation of the competitive landscape. Operational quality allows for a meaningful

differentiation in products and services; strategic productivity allows for a proactive assessment of uncertainty and flux; while operational efficiency relies on cost-reduction for ongoing operations.

11.4.2.5c. HYPOTHESIS 5c: MODERATING EFFECT OF AN INNOVATIVE ENVIRONMENT

H5c: Given a specific IT infrastructure design, organizations facing an innovative environment will positively and significantly rely more on strategic productivity compared to other productivity metrics.	Not Supported; Path coefficient higher for operational quality, although path coefficient for strategic productivity is also high; Moderate R-square

This hypothesis is not supported. The moderating effect of an innovative environment does not reveal the most association with strategic productivity but with operational quality. Strategic productivity shows a slightly lower degree of association, followed by associations with financial productivity and operational efficiency.

The standardized regression weights are explicated by the path coefficients. The path coefficients are the strongest for operational quality (P= 0.67; VC= 14.8%). The association with strategic productivity is also strong but has a modest difference in magnitude of path coefficients (P= 0.59; VC= 12.24%). This is followed by an association with financial productivity (P= 0.41; VC= 8.0%). The lowest association perceived is in terms of operational efficiency (P= 0.32; VC= 4.6%). The general R^2 is moderately high (0.62).

Altogether, results show that the moderating role of an innovative environment significantly impacts operational quality followed by strategic productivity, financial productivity and operational efficiency. The associations across each productivity category are strong and significant. Innovation hinges on better anticipation of future consumer demands. A strategic focus is the cornerstone for proactive anticipatory

understanding about how demands are likely to shift and how customized innovations can cater to such anticipated changes.

11.4.2.5d. HYPOTHESIS 5d: MODERATING EFFECT OF A DISCONTINUOUS ENVIRONMENT

H5d: Given a specific IT infrastructure design, organizations facing a discontinuous environment will rely more on operational efficiency compared to other productivity metrics.	Supported; Significantly high path coefficient compared to other productivity measures. Moderate R-square.

This hypothesis is supported. The moderating influence of a discontinuous environment seems to have a significant direct effect on operational efficiency compared to other productivity measures. The magnitude of association with financial productivity is slightly lower followed by associations with operational quality and strategic productivity.

The magnitude of the impacts is shown in terms of the path coefficients. The strongest impact is explicit for operational efficiency (P= 0.59; VC= 10.7%). Slightly lower associations are visible in terms of financial productivity (P= 0.49; VC= 7.6%). This is followed by the lesser magnitude of associations between operational quality (P= 0.18; VC= 2.64%) and strategic productivity (P= 0.12; VC= 2.2%). The R^2 is conservative (0.57).

The influence of discontinuous environments and particular IT infrastructure designs on productivity seems to be strongly aimed at achieving operational efficiency and financial productivity. Significantly lower impacts are perceived in terms of operational quality and strategic productivity. Discontinuous environments suffer from uncertainty and flux in the market rather than in customer demand. Such a scenario denotes few innovative efforts but tremendous efforts expended on achieving differentiations by price. This leads to focused efforts on transaction automation and

other operational efficiency related cost cutting strategies that can assist organizations in price wars and lead to lower reporting of expenses in financial reports.

In addition to pointing out the mediating role of the IT infrastructure design, the analysis of the hypothesis has also elicited the significant role of the moderators in influencing both mediators and outcomes. The moderating effects of IT management and organizational environment seem to be better predictors (better model fit measures and variance accounted for) than non-moderated direct effects. The unaccounted residual variances are also comparatively lower for the moderated PLS models.

Hypotheses H1 to H5 are tabulated by their propositions and findings in Table 16.

Table 14: A Condensed Table for the Moderating Influences of IT Management

Antecedent	Moderator	Outcome	Average Path Coefficients	Average R-Sq	Average Residual
IT-related Capital Outlays	Functional	Less Convergent	0.57	0.69	0.29
		Partially Convergent	0.24		0.30
		Highly Convergent	0.14		0.33
	Centralized	Less Convergent	0.31	0.68	0.29
		Partially Convergent	0.47		0.30
		Highly Convergent	0.74		0.33
	Decentralized	Less Convergent	0.68	0.63	0.29
		Partially Convergent	0.26		0.30
		Highly Convergent	0.26		0.33
	Coordinated	Less Convergent	0.29	0.76	0.29
		Partially Convergent	0.75		0.30
		Highly Convergent	0.54		0.33

Table 15: A Condensed Table for the Moderating Influences of the Environment

Antecedent	Moderator	Outcome	Average Path Coefficients	Average R-Sq	Average Residual
IT Infrastructure Design	Stagnant	Operational Efficiency	0.54	0.59	0.41
		Financial Productivity	0.55		0.39
		Operational Quality	0.24		0.42
		Strategic Productivity	0.21		0.38
	Discontinuous	Operational Efficiency	0.59	0.57	0.41
		Financial Productivity	0.49		0.39
		Operational Quality	0.18		0.42
		Strategic Productivity	0.12		0.38
	Uncertain	Operational Efficiency	0.28	0.60	0.41
		Financial Productivity	0.17		0.39
		Operational Quality	0.71		0.42
		Strategic Productivity	0.69		0.38
	Innovative	Operational Efficiency	0.32	0.62	0.41
		Financial Productivity	0.40		0.39
		Operational Quality	0.66		0.42
		Strategic Productivity	0.59		0.38

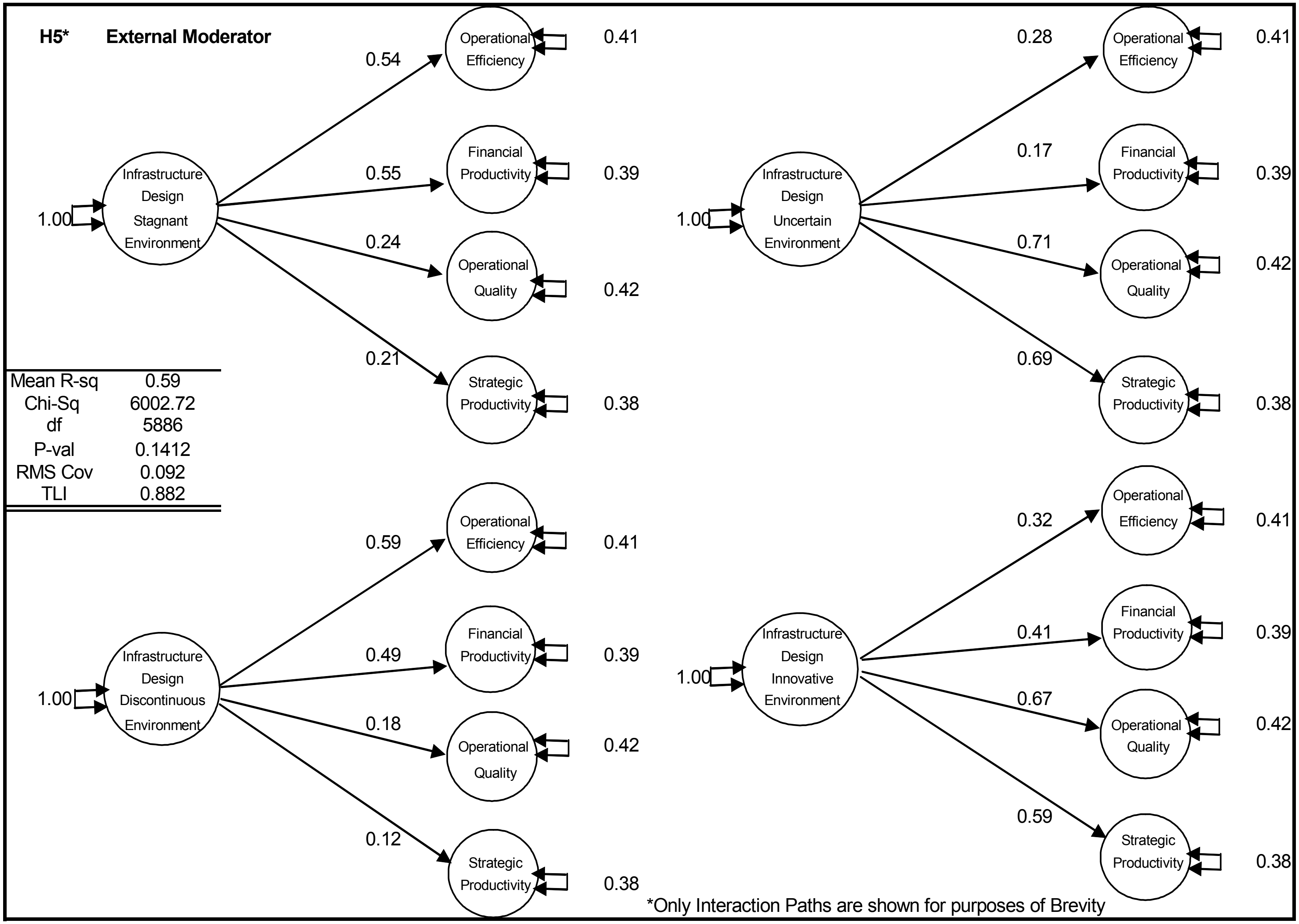

Figure 20: LVPLS Inner-Model for Hypothesis 5

Table 16: Summary of Hypotheses H1-H5

IIP Framework Hypotheses	Summary Findings
IT CAPITAL OUTLAYS & PRODUCTIVITY	
H1: The level of IT-related capital outlays in an organization is positively and significantly related to higher levels of productivity.	Not Supported; Negative or low Path Coefficients between IT investments and organizational productivity measures; low R-square; lack-of-fit.
IT CAPITAL OUTLAYS AND INFRASTRUCTURE DESIGN	
H2: The level of IT-related capital outlays in an organization will be significantly and positively related to the level of convergence of its IT infrastructure design	Marginally Supported; Significant differences in path coefficients across levels of convergence; low or marginal fit indicators; moderate R-square
IT INFRASTRUCTURE DESIGN AND ORGANIZATIONAL PRODUCTIVITY	
H3a: A highly-convergent IT infrastructure design will be significantly and positively associated with higher levels of strategic productivity compared to other productivity measures	Supported; Significant differences exist across productivity categories; moderately high R-square; significant path coefficients
H3b: A less convergent IT infrastructure design will be significantly and positively associated with higher levels of financial productivity compared to other productivity measures.	Not Supported; Low path coefficient compared to other productivity measures; Low to Moderate R-squares
H3c: An IT infrastructure design based on the convergence of content and communications will be significantly and positively associated with higher levels of operational productivity in terms of operational quality compared to other productivity measures.	Supported; Significantly higher path coefficient compared to other productivity metrics; Moderately high R-square
H3d: An IT infrastructure design based on the convergence of computing and communications will be significantly and positively associated with higher levels of operational productivity in terms of operational efficiency compared to other productivity measures.	Supported; Significantly high path coefficient in relation to other productivity measures; Moderate R-square
H3e: An IT infrastructure design based on the convergence of computing and content will be significantly and positively associated with higher levels of operational productivity in terms of operational efficiency and operational quality compared to other productivity measures.	Supported; Both operational quality and effiiciency show considerably higher path coefficients in relation to other productivity measures; Moderate R-square.
MODERATING EFFECT OF IT MANAGEMENT ON IT INFRASTRUCTURE DESIGN	
H4a: Given a specific level of IT capital outlay in an organization, a functional management style will significantly and positively result in a less-convergent IT infrastructure design compared to any other infrastructure design.	Supported; Strong evidence of a less-convergent IT infrastructure design with significant path coefficients; Moderately high R-square
H4b: Given a specific level of IT capital outlay in an organization, a coordinated management style will significantly and positively result in a highly convergent IT infrastructure design compared to any any other infrastructure design.	Not Supported; moderate path coefficient compared to partially convergent IT infrastructure designs; Moderately high R-square
H4c: Given a specific level of IT capital outlay in an organization, a centralized management style will result a partially-convergent IT infrastructure design compared to any other infrastructure design.	Not Supported; Significantly higher path coefficient supporting a highly-convergent IT infrastructure design. Moderately high R-square
H4d: Given a specific level of IT capital outlay in an organization, a decentralized management style will result in a partially convergent IT infrastructure design compared to any other infrastructure design.	Not Supported; Path coefficients significantly higher for less-convergent IT infrastructure designs; Moderately high R-square
MODERATING EFFECT OF THE ENVIRONMENT ON ORGANIZATIONAL PRODUCTIVITY	
H5a: Given a specific IT infrastructure design, organizations facing a stagnant environment will rely more on financial productivity compared to other productivity metrics.	Mixed Support; Path coefficient for operational efficiency marginally higher than financial productivity; Moderate R-Square and Marginally supportive
H5b: Given a specific IT infrastructure design, organizations facing an uncertain environment will positively and significantly rely more on operational quality compared to other productivity metrics.	Supported; Path coefficient also shows a high path coefficient for strategic productivity; Moderately high R-square.
H5c: Given a specific IT infrastructure design, organizations facing an innovative environment will positively and significantly rely more on strategic productivity compared to other productivity metrics.	Not Supported; Path coefficient higher for operational quality, although path coefficient for strategic productivity is also high; Moderate R-square
H5d: Given a specific IT infrastructure design, organizations facing a discontinuous environment will rely more on operational efficiency compared to other productivity metrics.	Supported; Significantly high path coefficient compared to other productivity measures. Moderate R-square.

11.4.3. VALIDITY CHECKS FOR THE LVPLS MODEL

In addition to denoting the path coefficients for each sub-hypothesis, every major hypothesis is supported by measures of fit that checks the validity of the LVPLS structural model (inner model). The measures are used as complements and have been included in every major hypothesis. They are:

⇒ Mean R^2: The mean R^2 values are obtained from the tables of multiple squared correlations in the LVPLS output. The R^2 represents the percent of variance in the endogenous (predicted) latent variable that is accounted for by the predictor latent variables in the particular model. This relationship is one of the most valuable descriptors of the relationships among the constructs (Falk and Miller, 1992) and should be ≥ 0.10, i.e., the predictors should explain at least 10% of the variance and minimize residuals. Furthermore, a predictor variable should account for more than 1.5% of the variance in a predicted variable, calculated by the multiplication of a path by its corresponding correlation.

⇒ Chi-Square (χ^2) Statistic: χ^2 statistics provide a fundamental measure for the overall "absolute" goodness-of-fit statistic for the model. The χ^2 test uses the degreed of freedom (df)[7] to assess statistical significance. Because the test compares actual versus predicted relational matrices to see if the differences between the two are non-significant, non-significant p-values indicate a good

[7] Degrees of Freedom (df) for the χ^2 is calculated as:
$df = 0.5\ \{(p + q)(p+q+1)\} - t$
where,
p= number of endogenous indicators (MVs),
q= number of exogenous indicators (MVs),
t = number of estimated coefficients in the proposed model.

fit. One should, however, note that χ^2 statistics become extremely sensitive for models with more than 200 observations (Hair, et al. 1995).

⇒ Tucker-Lewis Index (TLI): The Tucker-Lewis Index provides incremental fit measures by comparing the constrained and unconstrained model to generate a comparative index ranging between 0 and 1.0, where a TLI of approximately 0.90 or higher is generally recommended (Hair, et al. 1995).

⇒ RMS COV (E, U) (Root Mean Square of the Covariance between MV Residuals and LV Residuals): RMS COV coefficient serves as an index of how well the proposed model fits the variance of the data. Using the average correlation between MV spans (residuals) and LV spans, a low coefficient indicates a better fit with a recommended value < 0.20 (Falk and Miller, 1992).

The detailed statistics of all matrices for all hypotheses and sub-hypotheses are included in Appendix II.

In addition to the measures of fit statistics that validate the general LVPLS structural model (inner model), several other heuristics are used to validate the measurement model (outer model). Falk and Miller (1992) provide a set of rules that determine the strength of the measurement models. The heuristics are listed below:

⇒ Latent and Manifest Variables: For proper identification of a latent variable (LV), there should be at least three indicators or manifest variables (MVs). With three or more MVs, only the shared variance will be used to define the LV. In contrast, a lower set of MVs will assume more variance, leading to underestimation and potential measurement errors. In the IIP research model,

only the IT investment construct (LV) violates this rule to a certain degree. However, the MVs for IT-related capital outlays are constrained by the number of factors identified by the Delphi panel, and therefore limited to two MVs.

⇒ Loadings: The loadings of the MVs on LVs are based on the fundamentals of principal components. The loadings between the LVs and MVs should be greater than 0.50. A lower loading indicates that the MV shares very little in common with other measures and does not well define an LV. A 0.50 loading indicates a communality of 0.25, i.e., only 25% of the variance of the MV is related to the LV.

⇒ Construct Reliability: Construct reliability estimates to assess whether the specified MVs are sufficient in their representation of the LVs. The calculation of construct reliability complements Cronbach's reliability coefficient with a recommended value ≥ 0.70. The calculation considers the standardized loadings and indicator measurement errors and is shown below in Table 17. The construct reliability uses the ratio of indicator loadings from the measurement models and the residuals to assess the degree of explanation that indicators or manifest variables provide for their corresponding latent variables or constructs. A higher reliability indicates how well the manifest variables serve to denote and differentiate the theoretical constructs.

$$\text{Construct Reliability:} \quad \frac{(\text{Sum of Standardized Loadings})^2}{\text{Sum of Indicator Measurement Error} + (\text{Sum of Standardized Loadings})^2}$$

Table 17: Construct Reliability of Variables

RELIABILITY OF SUB-CONSTRUCTS					
		Sum of Loadings	Sum of Loadings sq	Sum of Residual Var. (Measurement Error)	Sub-Construct Reliability
Organizational Productivity	Operational Efficiency	4.599	21.151	0.767	0.96
	Financial Productivity	4.315	18.619	1.263	0.94
	Operational Quality	4.144	17.173	1.559	0.92
	Strategic Productivity	3.666	13.440	2.305	0.85
IT Capital Outlays	IT Investments/Expenditures	1.699	2.887	0.556	0.84
IT Management	Social Alignment	4.218	17.792	1.440	0.93
	Strategic Alignment	3.827	14.646	2.048	0.88
Organizational Environment	Environmental Dynamism	3.146	9.897	1.525	0.87
	Environmental Complexity	2.860	8.180	1.978	0.81
IT Infrastructure Design	Communications	2.489	6.195	0.935	0.87
	Content	2.459	6.047	0.984	0.86
	Computing	2.373	5.631	1.123	0.83
	Content/Communications	2.217	4.915	1.361	0.78
	Content/Computing	2.162	4.674	1.442	0.76
	Computing/Communications	2.104	4.427	1.524	0.74
	Content/Computing/ Communications	2.118	4.486	1.487	0.75

11.5. SUMMARY OF FINDINGS

To facilitate discussion in the next chapter, the key findings are reviewed below. The findings revolve around the propositions, time lags, and feedbacks associated with the proposed IIP framework.

Senior executives in organizations routinely acquire, deploy, and use their IT infrastructure in an attempt to gain future productivity benefits. These executives are mostly Senior IT Managers or CIOs with tenure of between 1 and 5 years. The companies these informants represent are national or global corporations with sales revenues for the majority between $100 million and $1 billion. Capital outlays for IT in most of these corporations are between $1 million and $10 million, about 1% of the gross revenues.

Capital outlays for IT are moderately high- constituting between 5% and 15% of a firm’s capital expenditures and operating revenues. However, proposed IT infrastructure designs uncovered in the research show a strong inclination towards particular types of technologies. Among less-convergent technologies, the focus is more towards a

computing infrastructure; among partially-convergent technologies, the focus is the greatest for “computing and content” and “computing and communication” technologies. In general, the focus on highly-convergent technologies is relatively low. Altogether, judging against the technical infrastructure, firms seem to be more focused towards developing an HR infrastructure to harness the technology. Highly convergent technologies such as ERP systems, among others, serve as exemplars where the proposed need for developing an HR-related ERP support infrastructure is more acute than the technical infrastructure itself. To the same extent, Brynjolfsson and Hitt (1998) highlight that HR assets complement the technical infrastructure. HR commitments such as consulting tend to considerably outweigh the technical ERP software itself (Ibid). This paper concurs- noting that, in most cases, HR related infrastructure development surpasses its corresponding technical infrastructure by a distinct margin.

In the process of generating productive returns from IT-related capital outlays, the role of IT management becomes distinct as they try to align their IT infrastructure design to serve business objectives. Most firms seem to be more strategically rather than socially aligned. Although the firms seem to be well-cognizant of organizational strategic objectives, there is little emphasis on participative communication between the IT and the non-IT departments. Altogether, a centralized IT management style seems to be in vogue.

Respondent firms are also influenced by their environments that comprise customers, suppliers, markets, and economies. Most of the influence occurs from high levels of environmental dynamism- stemming from the changing demands within the environment. However, albeit relatively high dynamism, firms report low levels of environmental complexity. This implies that most firms have been able to identify a

market niche to cater to. In general, most of these firms seem to be operating within an innovative environment.

There is an emphatic shift in the assessment of perceived productivity from proposed infrastructure designs. Proposed IT infrastructure designs are aimed at increasing strategic presence for respondent firms. There is also a strong inclination towards operational quality. In a significant shift from convention, financial productivity is neither touted not perceived as a consequence of an infrastructure design.

As implicated, the recursive nature of productivity feedbacks is confirmed. In the majority of cases, feedbacks from productivity seem to trigger the restructuring of IT management, followed closely by a reconfiguration of the proposed IT infrastructure design, and lastly, changes in IT investment decisions. By linking previously committed IT-related capital outlays to perceived future productivity, the time lagged nature of IT value is also captured. Majority of firms perceive an average between 2 and 4 years before any productivity can be directly assessed from IT-related capital outlays.

In general, IT-related capital outlays do not seem to impact productivity directly and significantly. Actually, with increased capital outlays, financial productivity and operational quality are perceived to drop. However, when mediated by the creation of an IT infrastructure design as an organizational asset, the indirect impacts of IT-related capital outlays on organizational productivity seem more sincere. Companies also seem to subscribe to a portfolio of configurations at varying degrees of convergence rather than a single type of infrastructure configuration. As proposed, each infrastructure configuration carries a price tag and implicates a propensity for particular types of productivity. Generally, more convergent technologies appear to be more expensive and

are endowed with particular perceptions of productive varieties. Firms perceive a less-convergent IT infrastructure design to positively impact operational efficiency; a partially-convergent infrastructure positively impacts both operational efficiency and quality; and a highly-convergent IT infrastructure is perceived to have direct positive impacts on strategic productivity. None of the firms perceive financial productivity as an essential outcome of any particular infrastructure design, irrespective of the level of convergence.

IT management asserts a definite influence on IT infrastructure design. Firms with centralized management lead to a highly-convergent design; a functional management style leads towards a less-convergent design; while both decentralized and coordinated management styles seem to influence the development of a partially-convergent IT infrastructure. Once an infrastructure is in place, the contingencies shift beyond the boundaries of a firm. The impact of the environment on perceived productivity is perceptibly strong. Firms operating within stagnant and discontinuous environments tend to be driven by operational efficiency; uncertain environments seemed to rely more on strategic productivity; and firms in innovative environments focused more strategic productivity. Redundantly enough, companies do not seem to completely rely on financial productivity given any particular infrastructure configuration or contingent to any particular environment.

In general, the role of IT infrastructure design as a mediator and IT management and the environment as moderators is significant and strong in understanding the relationship between IT-related capital outlays and organizational productivity. Once capital outlays are made, IT management translates the capital outlays into a portfolio of

IT infrastructure configurations. A portfolio of IT infrastructure configurations are prudent in the face of future flexibility and adaptability- a type of IT infrastructure hedging. Rather than committing to a single type of IT infrastructure configuration, the prudent firm employs an assortment of infrastructure configurations- from less-convergent to highly-convergent technologies, albeit assigning individual weights to each configuration to match the organizational context. "The skillful employer," suggests Sun Tzu in *The Art of War,* "... will employ the wise…the brave…the covetous…and the stupid... For the wise…delights in establishing his merit, the brave…likes to show his courage in action, the covetous…is quick at seizing advantages, and the stupid…has no fear of death." The reference is analogous to the choice of IT infrastructure design in an organization. Every infrastructure technology brings with it unique set of attributes that can deliver a specific type of productivity. They complement rather than supplant, albeit their weights may vary at the discretion of IT management.

Once an IT infrastructure design is established, the influence of the environment leads a firm to seek definite types and levels of productivity diffused as a spectrum of shapes and forms. Every environment reveals its own competitive landscape. And every landscape requires a distinct and suitable approach to productivity. The inclination towards one or more types of productivity emerges as a function of the firm's market environment- serving as an influence and a client.

CHAPTER 12. DISCUSSION AND CONTRIBUTION

"We shall not cease from exploration
And the end of all our exploring
Will be to arrive at where we started
And know the place for the first time"

T. S. Eliot, Four Quartets, "Little Gidding," V, 26-29

The dissertation aimed at developing and testing a framework linking IT-related capital outlays, IT infrastructure design, and organizational productivity. Using a systems theoretical perspective, a conceptual IIP framework was introduced to capture the essential interactions that mirror reality. A set of propositions was forwarded to serve the case-in-point. Finally, the conceptual framework was empirically examined to validate the propositions for a "reality check." The results assisted in confirming or disconfirming the proposed theoretical conjectures.

By explicating the link between IT-related capital outlays and organizational productivity, the dissertation serves to inform business managers that a firm must do more that merely throw money at IT. Companies must simultaneously focus on addressing the multitude of subsystems deliberated in the IIP framework. Through the use of theoretical arguments, practical examples, and empirical support, this dissertation points out the need for researchers and practitioners to look and think beyond the box.

This chapter discusses the implications of the research in light of both the quantitative and qualitative results obtained from the pretests, the Delphi, and the survey. The following section identifies its contributions of the research and reviews its limitations in terms of theory, methodology, and philosophy. Furthermore, the chapter provides directions for future research in this area.

12.1. DISCUSSION AND IMPLICATIONS

The implications of investigation findings for the research questions are discussed in light of quantitative results from field surveys and qualitative results gathered from initial interviews. The qualitative data is interspersed within the quantitative results for developing a more granular discussion piece. The implications of the IIP framework relate to the definition and attributes of the framework elements and to the nature of the proposed relationships. This dissertation had broadly inquired:

- What is the process by which IT capital outlays are transformed into organizational productivity?

Time was, both practitioners and researchers viewed a company's information technology capital outlays as a quintessential and sufficient antecedent to organizational productivity (Brynjolfsson, 1993). It was simple but fallacious- leading to a plethora of investigators finding no discernible positive association between IT-related capital outlays and productivity. And the paradox was born.

But that was before organizations realized that looking at productivity as merely a function of IT-related capital outlays was analogous to missing a major part of the puzzle. "You must realize that IT costs a lot of money, a lot of capital investments" mentions a senior IT executive, "…still…capital outlay for IT is an input, not *the* input…other factors remain in between - that we control…that separate us from our competitors." Equating IT-related capital outlays directly with productivity leapfrogs other invariably influential and important factors- leading researchers to lose sight of land. Yet, it has recurrently been the relational currency of choice by a majority of the research community. Even in the aforesaid empirical investigation, the association between IT-

related capital outlays and organizational productivity shows an extremely weak fit, with negative or very low positive associations. This finding resonates past associations of insignificant and/or negative relationships between IT and productivity. However, this relationship reveals partial truths.

12.1.1. CAPITALIZING ON IT CAPITAL

Once capital is committed, IT management enters the equation, influencing how the capital should be allocated for the creation of an IT infrastructure portfolio- as a mix of technologies, HR, and services. It is IT management that potentially demarcates the "how much" from the "how" of IT capital expenditures. While the "how much" represents the scale of spending, the "how" represents the direction. And there lies the aim of IT management.

IT management is a shared outcome of IT and business managers engaged a process of aligning IT and organizational needs. Keeping partisan control over how IT-related capital outlays should be translated into organizational assets has been one of the essential issues faced by organizations, yet only strategic alignment seems to be in effect. Social alignment or participative communication still remains low and ineffectual. As a senior IT manager notes, "Informal participation? ...that is a myth," he bemoans, "we rarely agree with our business counterparts…so we formally communicate instead…and that means memos and more memos." Most IT management still remains centralized, strategically aligned but socially detached. "In the end, it is all about control," mentions a non-IT senior manager, "sharing [IT investment] objectives would mean sharing the money- and who wants to lose the reins to a common denominator?"

The role of IT management lies in providing sense, direction, and purpose for IT capital outlays over divergent degrees of alignment between IT and business objectives. Altogether, sense, direction, and purpose provide for a conduit for developing the intermediary IT asset- the IT infrastructure design. In what Soh and Markus (1995) explain as "conversion contingencies" IT expenditures are converted into IT assets, strongly influenced by the IT management who help channel expenditures to match organizational objectives. A similar method called "management by maxim" is suggested by Broadbent and Weill (1997) where IT and corporate executives together decide on how to translate IT dollars into an organizational IT assets (i.e., IT infrastructure design). IT-related capital outlays, therefore, when coupled with distinct management maxims (styles), help develop a causally ambiguous IT infrastructure design that is meaningfully different and difficult to mimic.

The results suggest how IT management influences unique IT infrastructure designs. A centralized management style where decision are made top-down and strategic alignment is on the fore, organizations try to standardize their infrastructure towards central monitoring and control. To achieve this degree of control, a highly-convergent infrastructure seems the most likely candidate. Reuters Trading Services, for example, uses an ERP system to keep organization-wide tabs on data for centralized management and strategic integration. On the other hand, a functional management style is captive to a specific department and infrastructure considerations are limited in their purpose- serving departmental functions only. Here, infrastructure designs are aimed towards automated processing, database creation, or network-installations- all marked by very little convergence and high task specialization. Again, a decentralized management style

focuses on developing an infrastructure that serves ad-hoc purposes as defined by local organizational units. The independence in organizing and maintaining IT systems within a distributed organizational setting relies more on an ad-hoc infrastructure that balances conformance with flexibility- resulting in partially-convergent IT infrastructure designs. Werbach (2002) notes that monolithic technological infrastructure designs are under siege because they limited in terms of scalability thus leading way towards decentralized collaboration. Decentralized management leans more towards developing a collaborative computing, communications, or content platform that can empower but not conform. Likewise, a coordinated management style also focuses on a partially-convergent IT infrastructure design. To coordinate activities across the enterprise, the infrastructure design in generally content or information-based delivery. The Treasury Board of Canada uses a coordinated management style and that has led them to adopt a partially-convergent IT infrastructure design focused on converging content and communications for better and faster information delivery across all tiers within the government. Every management style therefore serves to plan, design, and execute a requisite type of IT infrastructure.

12.1.2 BUILDING AN IT INFRASTRUCTURE DESIGN

With an understanding that IT management influences the conversion of IT-related capital outlays into distinct IT infrastructure designs, one is concerned with the underlying "how" of this conversion process. How does IT management plan, design, and execute an IT infrastructure design? The answer can be found as a sub-process model that was elicited by the CIOs and senior IT executives during the interview process. As shown in Figure 21, once capital outlays towards IT have been committed, IT management sets

the translation process in motion. As Severance and Passino (2002: 12) succinctly note, “sizeable investments in IT infrastructure alone will not guarantee favorable business results.” To enable the new infrastructure, IT management “will first need to direct a planning process that critically assesses the firms business model and challenges the fundamental assumptions under which it currently operates” (Ibid).

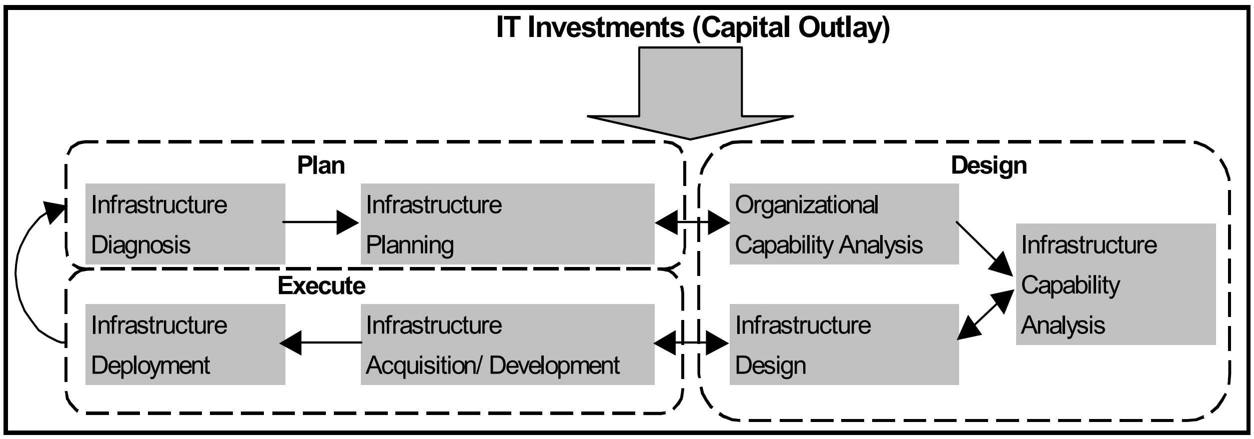

Figure 21: Role of IT Management in Translating IT-related capital outlays into IT Infrastructure

The process of “how” begins with capital commitments for IT that management uses to plan, design, and execute its proposed IT infrastructure design. The planning phase is a formulation process that diagnoses existing infrastructure to find where and how the present infrastructure design needs to be advanced to meet emerging business objectives. Once the need for change is ascertained through a definition of shared vision of the proposed infrastructure, formal planning begins as a preparation process with investment allocations for and design considerations. Once planning is accomplished, the design phase is set into motion. This phase begins with capability analyses. Organizational capability analysis and IT infrastructure capability analysis are conducted as precursors to the formal design of an IT infrastructure. Organizational and IT

infrastructure capabilities revolve around the notion of *change-readiness* – the ability to rapidly develop and deploy IT systems (Bharadwaj, 2000). With a positive assessment of capabilities, the formal design of the proposed IT infrastructure is put into effect. The final phase concerns the execution of the proposed design. Alternative technologies and configurations are assessed to decide on the most pertinent portfolio of infrastructure configurations along with a make versus buy decision. Once the IT infrastructure design portfolio is available for use, the deployment of the proposed infrastructure begins through formal implementation techniques.

12.1.3. HEDGING THE INFRASTRUCTURE DESIGN PORTFOLIO

IT infrastructure design is, as the results show, not a single infrastructure configuration but an assortment of configurations asserting various degrees of influence to match the organizational context. The design tries to serve the organization rather than serving itself, as a CIO duly notes, "…we typically attempt to align our IT infrastructure to corporate objectives…sort of setting a context for the infrastructure." The infrastructure design is a salient precursor to the actual IT infrastructure, as the same CIO relates, "…our [IT] infrastructure development closely follows our infrastructure design… our design essentially spells out our infrastructure." Altogether, the infrastructure design seems to beget the development of the actual infrastructure. The IT infrastructure design combines technical components, human IT skills, and intangible procedures and services to create overall IT capability as an organizational resource (Bharadwaj, 2000).

IT infrastructure design considerations vary over time although some aspects remain stable. One of them is the ongoing cost of acquiring or developing particular

infrastructure configurations. Less convergent infrastructure designs are easier to acquire, more commoditized, and priced competitively, making them less expensive to deploy. However, as convergence increases, so does cost. As one of the CIOs note, "Where else have you seen so much proprietary innovation? Different technologies, different standards…and then we try to make them talk seamlessly? Well, that's gonna cost." The munificence of proprietary innovations has undeniably led to an overly wide assortment of technologies and standards that are in use in organizations. From network protocols to computing platforms, the array of technological components is diverse yet segregated. Converging across a single technological domain (e.g computing, content, or communications) is hard enough, let alone converging multiple technological domains. Any attempt to do so through internal development or external vendors is resource and capital intensive, making them expensive artifacts. Still, infrastructure configurations are changing.

Proposed technical infrastructure considerations are diverse. There is a growing trend towards newer computing technologies, especially fuelled by mobile devices and open-source computing; along with that there is tremendous growth in a technical infrastructure related to the convergence of computing and communications technologies, especially in terms of network computing and mobile communications. According to most IT executives, considerable infrastructure capital outlays are being channeled towards virtual resource management platforms and interconnected computing clusters for combining the force of multiple servers, PCs, and workstations. The other area is that of mobile communications and ubiquitous computing fueled by the growth in wireless devices. Another notable infrastructure consideration is that of convergent content and

communication and content and computing technologies, albeit a low outlook for a less-convergent content infrastructure. The shift signifies a consolidation in the area of content technologies. The new outlook is no longer concentrated on data acquisition efforts only, but on content manipulation and content dissemination. Until recently, content was just accumulated to saturate the knowledge space. In a sharp twist in outlook, IT executives now see a newfound need for utilizing the knowledge space through analysis, visualization and communication of knowledge across the enterprise. Another significant change is evident is the relative drop in highly convergent infrastructure designs, especially the technical aspects of enterprise systems. A CIO fittingly claims, "…with enterprise systems…it is a patient wait towards fulfillment…reducing complexity, maintenance, and training are the only items in our agenda." The claim echoes the fact that commitment towards acquiring enterprise systems is giving way towards a stronger focus on using and maintaining the enterprise system with better and more trained HR.

The shift from a technical to an HR infrastructure is also resonant across most IT infrastructure configurations. Regardless of the level of convergence, finding HR to support these technologies becomes increasingly difficult. "HR costs are becoming prohibitive," exclaims a senior IT manager, "…supporting a Storage Area Network does not mean supporting this [convergent] technology only, we then have to see that HR is available to manage base [less-convergent] technologies too [content and communications]." The IT infrastructure design depicts the HR concerns. For most of the components and their configurations, HR considerations significantly outweigh technical infrastructure considerations. A CIO of a firm that had implemented an ERP system in

the past few years remarks, “Technical infrastructure costs are mostly one-time, but HR costs are ongoing and considerable…but when you decide to use such a technology, you have it coming…you have to factor it in your capital budget.”

12.1.4. APPRAISING IT INFRASTRUCTURE DESIGN VALUE

As previously alluded, the choice of an IT infrastructure design is productivity driven. The evolution of IT infrastructure has augmented its value-added spectrum. The emphasis is evolving from financial and operational efficiency-based metrics to become more information and strategy-based. Infrastructure convergence grew to augment value by encompassing multiple functions, processes, and information hubs together to create a more transparent system where disparate technologies across disparate processes could be integrated. Traditionally, a less-convergent infrastructure design was the technology of the times and was more focused on operational efficiencies in terms of automation, linking, and processing of information. Technological convergence grew in line with changes in the competitive landscape, with promise of strategic and operational quality benefits- generally intangible. The benefits of a partially-convergent infrastructure, albeit operational, are more inclined towards operational quality and strategy in terms of better and faster information availability and use. As the infrastructure design shifts towards greater convergence, the promise of benefits shifts ground. The effect now lies in terms of gaining competitive advantage as the meaningfully differentiating factor. Infrastructure convergence brings together the entire enterprise, increasing distributed access and analysis of organizational information for proactive maneuvers. Nonetheless, there is no rule-of-thumb regarding IT infrastructure design. Because an infrastructure is the basis for the alignment of IT and organizational capabilities, as alignment changes, so does IT

infrastructure design. As Bharadwaj (2000: 186) suggests, “A firm’s IT capability derives from underlying strengths in IT [technical] infrastructure, human IT resources, and IT-enable intangibles [services]. The IT [technical] infrastructure provides the platform to launch innovative IT applications faster than the competition; the human IT resources enable firms to conceive of and implement such applications faster than the competition; and a focus on IT-enabled intangibles [services] enables firms to leverage or exploit pre-existing organizational intangibles such as customer orientation and synergy in the firm via copresence and complementarity.”

12.1.5. DERIVING BENEFITS

While infrastructure benefits are well-grounded in their promise, the delivery of benefits remains contingent upon the type of environment a firm operates or chooses to operate within. Companies operating in stagnant environments are mechanistic, as in the case of some mature monopolies. The low levels of anticipated change leads these firms to focus more towards cost-cutting- aimed at increasing operational efficiency and therefore profitability. For companies operating in an environment marked by low dynamism, operational efficiency serves as a common denominator for cost-control, whether it is for increasing profits in a stagnant environment or reducing losses in a discontinuous environment. In contrast, an innovative environment, marked by low levels of complexity and high levels of dynamism, is a very customer-centric environment. Anticipating customer demand becomes a salient recipe for success, thus leading to a greater focus on operational quality that examines operational effectiveness. “Quality is our motto,” explains a CIO, “…the magic lies in knowing what your clients expect from you,…not tomorrow, or the day after, but a year from today…and that we what we try to

know from everyday operations." As complexity grows with dynamism, the environment becomes uncertain, and the focus shifts more towards achieving strategic productivity, increasing competitive advantage, identifying newer markets and opportunities, in an attempt to reduce the element of complexity and uncertainty. These productivity measures are inherently related to each other (See Table 13b for the symmetric latent variable correlations). They complement rather than supplant. Each is positively related to the other but the relationship between operational quality and financial productivity is the potentially strong. Industry seems to be gradually coming to terms with the evolution of productive measures from operational efficiency to operational excellence. The path to productivity is evolving after all.

The path between IT-related capital outlays and productivity is not only winding but also long. The benefits of an IT infrastructure design take a while to mature. Return on capital outlays for IT infrastructure designs tend to average between 2 and 4 years. The more convergent the IT infrastructure design, the longer the time lag. Convergent technologies such as ERP systems serve as exemplars. A Meta Group survey of ERP implementations made a conservative estimate of a time lag of over two years. Moreover, convergent technologies such as ERP systems also suffer from steep learning curves, leading to longer implementation cycles and therefore longer time lags for returns from IT-related capital outlays.

Productive returns finally trigger feedback. The feedback is a function of the perceived difference between the real and expected productivity. For a majority of firms, significant differences in productivity seem to trigger changes in IT management. When FoxMeyer Drug's data-warehouse automation and SAP R/3 caused significant delays and

failed to deliver the necessary cost-savings after a three year time lag led to a revamping of IT management and resignation of the CIO. The concept of feedback moves the organizational process from being an ephemeral instance to a sustaining continuum. Simon (1981: 86) aptly notes that [organizational] systems, "…use feedback to correct for unexpected or incorrectly predicted events. Even if the anticipation of events is imperfect and the response to them less than accurate, adaptive systems may remain stable in the face of sizable jolts…"

Altogether, IT executives seem to be walking a tightrope. From facing steep costs of IT infrastructure design configurations, learning curves and time lags, lock-in-effects of technologies becoming obsolete faster than ever, managing external contingencies, on to accounting for productivity feedbacks- the list goes on. These are some of the issues that IT executives tackle- all in a day's work.

12.2. LIMITATIONS

No research is without its own set of limitations. It is always captive to and constrained by its underlying assumptions. This dissertation is no exception either. This section will focus on the limitations inherent to the conduct of this dissertation.

One limitation deals with the Delphi instrument. The overall response rate for the Delphi study was 44.9%. The rate compares favorably with the recommended Delphi rate of 40%-50% (Linstone and Turoff, 1975). Purposive, rather than random sampling was used to recruit recommenders who identified the potential panel of experts. The constraint of the number of recommenders available to us reflects upon our respondent sample. Sample selection bias stemming from the fact that the population sampled is not the population of interest does not seem to be an issue. This is evident from a moderate

response rate and absence of non-response bias. The respondents were senior IT executives and CIOs who were justifiably knowledgeable respondents for organizational and technical issues revolving around the IT infrastructure. These respondents also matched the intended sample frame, eliminating sample frame error.

The limitations, however, stem from three significant areas. Firstly, the Delphi study was modified to accommodate the time limitations of the respondents. As a longitudinal and iterative study, the involvement of participants through all stages is an obligated necessity. Given the gravity of the respondents' organizational position, a longitudinal Delphi survey entailed significant time commitments and may have precluded potential respondents from partaking the survey in its entirety. As a result, the Delphi was modified to incorporate a fewer number of iterations. Researchers validated the final set of factors by their frequency, rather than complete consensus. Although the final set of factors was validated by the Delphi panel, this modified approach partly digressed from the true sense of a Delphi study.

The Delphi was administered via email as an MSWord and/or a text attachment file. This second limitation revolves around technological problems because of problems in opening the attachments and threats related to email attachments. Due to email formats, a few Delphi respondents were initially unable to open their attachments, some due to MIME encryption processes used by ISPs. Furthermore, virus threats related to email attachments remained a concern for respondents and some initial apprehension was expressed in opening the email attachments.

Thirdly, the final stage of the Delphi involved the ranking of the factors by their decreasing order of importance. The final 4-5 factors were selected as the most pertinent

and included in the field IIP survey. This classifying mechanism based solely on the ratings provided by the panel narrows the focus to dominant effects only (Nambisan, et al., 1999). However, the opportunity cost of foregoing the non-dominant factors may be high and could perhaps provide a more granular understanding of the issue at hand. Although the dominant set of factors was used for the sake of parsimony, the inclusion of other factors may provide a more refined analysis.

Although careful attention was paid to the construction of instruments and scales, some of the scales were the product of a preliminary investigation and not prevalidated in referent literature. Further studies that use these scales may provide a more robust validation.

Few limitations are also related to the IIP survey. The IIP survey showed a 30.48% response rate. Sample frame error and selection errors were not evident because respondent participation was random from the sample frame. Moreover, there was no evidence of any non-response bias. However, non-response bias was only measured by organizational demographics, given that no other data was available. It may be possible that a bias may be explicated using some other discriminating variable. The same also holds true for non-response bias tests in the Delphi study.

Nonetheless, the main limitation of the IIP survey originates from the choice of sample frame. First, CIOs and senior IT executives were chosen as pertinent informants of the survey. However, given the positional onus of the senior IT managers as the specified sample frame, getting them to participate in the survey posed an ordeal and a lack of proper contacts resulted in a loss of potential participants. Secretaries or administrative assistants were the only conduits available as links to the source and any

miscommunication with the former was liable for the loss of the source. Furthermore, this indirect communication was a hindrance. The choice of the sample frame also led to a few delegations among the survey respondents. Given the tight schedule of CIOs, a few potential respondents delegated the IIP survey responsibility to an immediate subordinate. 24 of the 217 respondents (11.3%) seem to have delegated the completion of the survey to an immediate subordinate or peer who completed the survey on their behalf of the intended participants.

Another limitation closely associated with the choice of the sample frame is the lack of triangulation of responses. A pertinent consideration would be to include both the CIO and the CEO of an organization as potential participants. Individual responses from a technology executive and a corporate (business) executive within the same organization could provide a strong validation for the issue of IT infrastructure productivity and also triangulate the findings. However, the IIP survey used an IT executive as the sole informant for a participant firm. While a sole informant poses a limitation in terms of biased outlook, the choice is partly justified in terms of response rates. Triangulation of responses would have to incorporate two or more organizational informants. Given that these informants would have to be senior IT or business executives both of who operate within extremely tight schedules, non-response from any one of the participants would nullify the response of the other, leading to pairwise deletion and a drastic curtailing in the total number of respondents (cases/observations). However, the choice of IT executives as sole respondents for business and IT related issues may indicate a partial lack of understanding of business issues and a biased outlook towards particular types of productivity. While this threat is partly alleviated by the changing nature of

organizational positions where IT executives are viewed as corporate entities rather than functional managers, the limitation still remains.

Another significant limitation arises from trying to capture the complexity offered by the systems perspective. As a system, IIP is a victim to multiple contingencies. While this research uses IT management and organizational environment as internal and external contingencies, there may be other more important factors that significantly influence productivity. A failure to include all possible variables makes the posited framework vulnerable to spuriousness. However, for the purposes of this research, a more controllable and investigable set of parsimonious variables are used.

One more limitation arises from the use of “perceived” productivity for assessing future productivity benefits from a particular infrastructure design. The use of perceptions for decision-making within economic organizations has been questioned by economists such as Herbert Simon (1982). Contrary to classical economics’ presumption of “ratonality” within organizational decision-makers, Simon (1982) argues that these perceptions are not “completely rational” but “bounded.” Decision-makers’ (i.e., senior IT executives) perceptions cannot simultaneously process the exhaustive set of IT infrastructure portfolio alternatives and their consequent benefits. Moreover, with a plethora of available IT-related innovations, consequences are sometimes uncertain. Given these constraints, efforts towards rational perceptions’ are “bounded” or limited by the immediate logic of the organizational informant (Ibid). Perspectives under these conditions are often vague and contradicting. In such a scenario where simultaneous processing of all possible consequences of a decision is infeasible and unrealistic, executives rely on perceptions of future productivity benefits from a proposed

infrastructure design. However, such perceptions are inherently a result of their "bounded rationality." Perceptions of executives' thus satisfactorily rather than exhaustively determine future benefits. As a limitation, the gap between perception and reality could thus dramatically increase as a function of the bounded rationality of the organizational informant.

A further set of limitations arise from the association of IT infrastructure design and organizational productivity. Although the inquiry focused on the specification of an organization's proposed IT infrastructure design and its corresponding perceived productivity, the limitation lies in the assumption behind this association. The assumption is that the proposed IT infrastructure is a sufficient explanation for its corresponding productivity. However, the infrastructure design is rarely the only infrastructure- rather it complements existing IT infrastructure designs. Therein stems the limitation. When a particular type of productivity is associated with a particular type of infrastructure, is that productivity a complete outcome of the proposed infrastructure design or is it the result of a cumulative IT infrastructure design, augmenting existing designs to create the perceived productive potential? In a similar tone, the IIP framework assumes that the mediators and moderators involved constitute the major intermediaries and influences. However, there may be other factors deemed missing in the framework- the inclusion of which could lead to a finer understanding of the path between IT-related capital outlays and organizational productivity.

Lastly, this dissertation is limited in its approach towards a time lagged essence of productivity. Although the issue of time lags between IT-related capital outlays and organizational productivity is asserted in the IIP framework, data collection using the IIP

survey resorted to a cross-sectional, rather than a longitudinal technique. This constraint posed by this cross-sectional technique partly robs the IIP framework of its incorporation of time lags. As Nambisan, et al. (1999: 384) note, “The potential for method bias arises from contemporaneous measurement of independent and dependent variables from the same source in the same questionnaire.” The IIP survey uses semantics (proposed, perceived) to denote time lags. Despite the fact that such a semantic circumvention is pre-validated in referent literature, the limitation remains. A longitudinal survey could alleviate the concerns but response rates and temporal constraints inherent to such a survey implicate the use of semantics in a cross-sectional survey as a more prudent alternative.

12.3. CONTRIBUTIONS

12.3.1. CONTRIBUTION TO PRACTICE

While research and practice is rife with anecdotal evidences regarding the path between IT-related capital outlays and organizational productivity, there have been few empirically grounded discussions of how synergistic interactions of co-present subsystems allow the pieces of the productivity puzzle to fit together. Even so, the puzzle shows a loose fit. This section talks about the contributions and future directions that can be attributed to the future development and advancement of theory and practice. Extensions, uses, and refinements of the proposed framework are proposed for creating a more snugly-fit puzzle.

This research establishes IT infrastructure design as an important link in the path to productivity, defines and describes the role of this mediator, and explores the aspects of moderation in creating an IT infrastructure and generating returns from it. The IIP

framework integrates and operationalizes fragmented concepts to provide a unifying basis not previously available for theorizing and designing studies. A novel research design consisting of a Delphi study as a precursor to a field survey was introduced and implemented. New instruments were created that are effective in describing IT infrastructure productivity, and systematic progress has been made towards metrics for the subsystems and the system in general. The empirical results provide an extensive description of IIP with findings representative of a considerable corpus of practitioners from diverse industries, with different infrastructures, capital outlays, management styles, environments, and lastly, productivity foci. As such, the research has attempted to provide a comprehensive account of the IIP framework, avoiding prior key limitations of theoretically and conceptually constrained frameworks.

This dissertation most clearly establishes itself as a practical, relevant, and interesting area of IT research. In what began with Grover and Sabherwal's (1989: 243) finding of "a disconcerting gap between what the IS executives consider as important and what is actually researched," the call for relevance and currency in IT research spans over one and a half decades. "A great deal of the academic research conducted in information systems is not valued by IT practitioners," bemoans Sean (1998: 23), "…the work is not relevant, reachable, or readable."

Among the issues that hold relevance for practitioners and researchers, one of the most notable has been that of IT productivity, IT management, and infrastructure (Westfall, 1999). This dissertation accommodates these three issues, develops a conceptual framework, and empirically investigates the model. This model prescribes a detailed and disaggregated perspective of the IIP framework that practitioners can

incorporate within their own organizations. The ability to systematically map organizational factors to a validated framework is a welcome relief for companies. These firms spend millions on IT but are unable to trace the paths to productivity. Knowing the how, when, and where of IIP allows organizations to justify infrastructure design choices and its corresponding time lags. In an age of pervasive IT, its value is distributed across the enterprise. Given that spreadsheets do not tell the whole story of IT value, multiple valuation considerations are needed to trace where specific productive returns lie for particular infrastructure design initiatives. The IIP framework assists in these valuation attempts through a systematic disaggregation and classification of productivity. Finally, understanding productivity contingencies allows organizations to realize how particular management styles and environmental considerations potentially affect IT value. The fact that IT infrastructure designs are sensitive to management styles and choice of productivity is sensitive to environmental conditions provides a fresh view of the constraints and conditions inherent to the productivity process. Once organizations are able to discern the locus of value, matching the pieces becomes a matter of logic rather than a case of conjecture. If diagnoses are detailed and systematic, remedial solutions are faster and more effective.

12.3.2. CONTRIBITION TO RESEARCH

This dissertation substantially contributions to the IT research community. A modular systems perspective is imported and introduced as the underlying theoretical platform on which the conceptual IIP framework is developed. The use of a modular systems perspective allows a fresh view of the IT infrastructure productivity system as a configurable interaction of its subsystems, examinable at several degrees of

disaggregation and detail. Such a view permits the researcher to assess the system at multiple levels of analysis.

Simon (1981: 22) had justifiably noted "to design … a complex structure, one powerful technique is to discover viable ways of decomposing it into semi-independent components corresponding to its many functional parts. The design of each component can then be carried out with some degree of independence of the design of others, since each will affect the others largely through its function and independently of the details of the mechanisms that accomplish the function." On that premise, the use of the systems model to develop the IIP framework brings to the fore a dynamic interplay among the antecedent, mediator, moderator, and outcome subsystems. Simon (1981: 22) also proposed that "An early step toward understanding any set of phenomena is to learn what kinds of things there are in the set - to develop a taxonomy." The IIP framework similarly develops taxonomy to classify subsystems into components.

Having developed a systems view and taxonomy of the IIP phenomenon, the IIP framework was then put to test. The IIP framework was empirically investigated beginning with a systematic operationalization of the constructs. A two-phased research design beginning with a Delphi followed by a field survey was used to for field observations. The Delphi added a qualitative understanding as a precursor to the quantitative survey instrument. Following the data collection, a path analytic approach was used to decipher the patterns within the proposed interplay. In addition, an implicit use of a time-lagged view of productivity coupled with a sense of continuity through feedbacks was also used to map the system dynamics. Further, the non-reductionist

comprehensiveness of the model serves as a stepping stone for future rationalistic and empiricist pursuits.

12.4. FUTURE DIRECTIONS: WHERE DO WE GO FROM HERE?

The future directions for this research are related to theory deliberation and empirical refinement aimed at extending and refining the proposed ideas and findings. The IIP framework presented is, albeit comprehensive in its theoretical outlook, admittedly modest in its process of empirical investigation, therefore calling for further extension:

⇒ Detailed examination of the moderating factors: To investigate elements that define IT management and the organizational environment, this research developed a 2x2 classification matrix for each of the moderators. Four categories were used to define each moderator. Specifically, these four categories provided a parsimonious set. While parsimony does reduce chances of Type II errors (retaining a false null hypothesis) and overestimation, it sometimes does understate legitimate diversity. For example, IT management and organizational environment are examined as in terms of low versus high social and strategic alignment and low versus high dynamism and complexity, respectively. Yet, there is a distinct possibility that there are finer threads of distinction rather than a mere low/high. This may have led to inadvertent omission of other categories that may deserve scrutiny. A simple inclusion of a complementing intermediate dimension, e.g. medium, immediately leads to a 3x3 matrix and nine distinct categories. As moderators can have varying influences, their further development seems a logical research sanction for a refined categorization of the moderators in the IIP framework.

⇒ Filling in missing pieces from this research: Why do particular infrastructure configurations lead to particular types of productivity? Or is there another mediating variable that leads to a better understanding of the relationship between IT infrastructure and productivity? Bharadwaj (2000) forwards a line of reasoning where IT infrastructure design is a precursor to IT capability rather than productivity. "Firms that are successful in creating superior IT capability in turn enjoy superior …performance" (Ibid: 176), he notes, leaving open the question of whether the model needs a second mediator in explaining productivity better. Another issue is that of the constrained assumption of linearity. Are the proposed relationships linear, or will a non-linear model provide a better and stronger fit index? Finally, a more detailed study of time-lags is needed. A longitudinal survey would be a welcome instrument design that could assess real versus perceived productivity. These are some of the potential missing pieces that researchers can address in the near future.

⇒ Shifting the levels of analysis for IIP productivity: This research uses the organization as its primary level of analysis. However, because both IT and productivity are pervasive, there is need for both micro and macro level studies. While micro-level studies can examine the productivity from the context of an information worker, macro-level studies can trace economy-wide ramifications of IT infrastructure capital outlays. Furthermore, while micro-level studies can shed more light on the individual demographics and personality as moderators, macro level studies can provide insights on the moderating effects of socio-political factors. Even more, the perspective could be shifted to accommodate contexts by

organizational functions, processes, among others. Because the effects of capital outlays in IT capital stock are visible from the individual to the economy, extended investigations are necessary.

⇒ Shifting philosophical assumptions: A shift in the philosophical assumptions can provide a refreshing view of IT infrastructure productivity. In an attempt to develop and test theory for a predictive understanding of the phenomenon, this research has been led by positivistic assumptions. The assumptions are rooted in formal propositions, operationalization of constructs, hypothesis testing, and inferential findings from a designated sample frame (Orlikowski and Baroudi, 1991). However, a richer insight of the productivity process can be derived from a shift in philosophical assumptions from positivism to interpretivism. Contrary to positivism, interpretivism views the productivity process as a socially constructed phenomenon, unique to and reflective of the context. Interpretivism is therefore a function of assigned meanings and beliefs particular to an organization, its members, and its functions. Given that IT infrastructure productivity is a derivative of factors embedded in organizational factors such as nature, culture, and context, a more interpretive understanding of these issues is called for. Identifying the finer issues that surround the productivity process will elicit newer meanings and a new-found understanding and clarification of its presumed ambiguities.

12.5. CONCLUSION

So there we have it- the saga of IT infrastructure productivity that began with disappointments and ambiguities has partly been mitigated by the IIP framework. This dissertation began by an assessment of existing literature on IT productivity that revealed

an array of conjectures, anecdotes, gaps, and a lack of a framework. Significant milestones that followed have been accomplishments in their own right. Building on prior research, a framework depicting the process of IT infrastructure productivity was introduced as a modular and configurable systems model; consequently, research instruments were developed and validated; and finally, a path diagram was used to empirically assess the theoretical framework and confirm/disconfirm the hypotheses. The IIP framework detailed subsystem interactions to define the sequence of events leading to the accomplishment of productivity. The framework was applied as a basis for productivity diagnosis, management prescription, infrastructure considerations, and environmental appraisal.

The findings confirm that IT infrastructure productivity is a journey, not a bivariate correlation between IT capital outlays and productivity. The journey signifies a process influenced by internal and external factors and mediated by the design and development of an IT infrastructure. Each of these factors cumulatively constitutes the productivity equation. The factors, or subsystems, are important, serving to explain, justify, perpetuate, and structure productivity. Organizations that overlook these individual subsystems are frequently stumped in their productivity assessment. While IT-related capital outlays may be large, they may not be effectual in delivering productive promises. Management, Infrastructure design, and environmental mechanisms remain attributable for ascertaining productive benefits. The interplay among factors and contingencies affirms the philosophy of equifinality- where there no universally correct antecedent, but only an appropriate design and understanding of the significance and impact of contextual variables. In the end, organizational systems "…are concerned not

with the necessary but with the contingent - not with how things are but with how they might be - in short, with design" (Simon, 1981: 8).

Finally, the title of this dissertation "Where have all the flowers gone?" begs an answer. This research, amidst both its coherence and complexity, corroborates that capital outlays in IT do not necessarily follow a road to dusty death. Rather, the flowers are there- blooming in unexpected places. In the dawn of the industrial revolution, Franz Kafka had alleged that "productivity is being able to do things that you were never able to do before." In that regard, IT has been productive. "...Information technologies have begun to alter the manner in which we do business and create value, often in ways not foreseeable even five years ago," remarks Alan Greenspan (1999), thus confirming the allegation. In an age where productivity metrics have succumbed to convention rather than innovation, the postulate that follows is clear. We need to look hard and far to trace where and how IT adds value. Our findings concur with Greenspan's remarks- leading us to rethink how and where one needs to measure productivity and output. Once we shift our productivity evaluation from measures rooted in an industrial age mindset (Berndt and Malone, 1995), only then can we find the flowers. They are present- transient and unconventional though they may be in shape and form. We as researchers have an onus to trace where they blossom. It is a sincere onus that goes beyond serving an organization to serving our discipline itself. In essence, this research calls for a paradigm shift in metrics and mindset. Only then can flowers bloom in graveyards. And only then will we ever learn.

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APPENDIX I: INSTRUMENTS

A. DELPHI-BASED QUESTIONNAIRE ON IT-INFRASTRUCTURE PRODUCTIVITY

Information Systems and Decision Sciences (ISDS) Department

Louisiana State University Study Information Sheet

You have been invited to participate in a study about information technology and organizational productivity. Your participation is important because you are in a position that oversees the allocation and use of IT within your organization. Our goal is to help companies make better decisions about how IT investments relate to productivity by pointing out the important issues involved in the process.

We need input from senior IT executives such as yourself who are well-informed in both IT and business issues to get a true picture of the process. Your participation is voluntary and very important to us. Please do keep in mind that this study is iterative and will be conducted in three phases over the next three to four months. The answers provided will be confidential. If you believe that you are not an appropriate candidate for this study, have time limitations, or you choose not to participate, please intimate us accordingly.

Completing this questionnaire will take about thirty minutes; when you are done, please email the answers as an attachment. To learn more about this study or receive a summary of the results, please contact the principal investigator, Pratim Datta, via email at pdatta2@lsu.edu. Thank you for sharing your knowledge, insights, and time.

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1. Organizations measure productivity in multiple ways and forms. While some measures are extremely standardized, others are not. For example, while financial and operational efficiency measures are highly standardized, operational quality and strategic productivity.

   A. What are 3-5 important financial/accounting measures that can be used to understand IT productivity?
   B. What are 3-5 important operational efficiency measures that can be used to understand IT productivity?
   C. What are 3-5 important operational quality measures that can be used to understand IT productivity?
   D. What are 3-5 important strategic measures that can be used to understand IT productivity?

2. What management qualities do you seek in IT executives hired to develop IT infrastructure? Please identify 4-5 qualities that you feel are important.

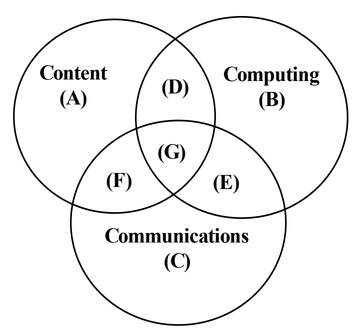
3. What measures are used to define the size of your organization’s IT infrastructure? Please identify 3 measures.

4. Characteristics or conditions of the environment outside of a firm also impact a firm’s productivity. Please identify 3-5 factors that define your organizational environment.

5. IT infrastructure in organizations can be divided into three categories, namely, **computing** (systems and processor architecture), **communication** (networking architecture), and **content** (data and information architecture). As the infrastructure converges, technologies intersect two or more infrastructure categories, e.g., segments D, E, F, and G (see diagram below). From the diagram below, segment A, B, and C signify less-convergence; D, E, and F represent partial-convergence; and G represents high-convergence. IT infrastructure in an organization is therefore a portfolio of technologies spanning varying degrees of convergence. Each technology may span across one or more of the three categories of computing, communication, and content. The table below indicates the major technologies in an organization. Please mark using an “x” the corresponding categories that each technology represents (remember that a technology can belong to one or more categories). As an example, distributed database technologies offer a convergence of communications and content because it is allows accessing content over digital networks.

   In addition, if the list below is missing infrastructure technologies that you feel should have been included, kindly mention them in the blank cells provided and mark them likewise.

Organizational IT Infrastructure Configurations



Please mark using an "x" one more corresponding categories that each infrastructure technology represents.

Infrastructure Technologies		**Infrastructure Categories**	
Major Technologies	**Content**	**Computing**	**Communication**
Example: Distributed Databases	**X**		**X**
File Systems and Databases			
Database Management Systems (DBMS, RDBMS, OODBMS)			
Client/Server and Distributed Databases			
Data Mining and Warehousing			
Database Administration			
Data Storage (Media and Drives)			
Telecommunications Hardware			
MAN, WAN, and Internet Technologies			
Enterprise Systems			
Network Management			
Enterprise Networks			
Enterprise Communication Technologies			
Security and Cryptography			
Wireless Networks			
Storage Networks			
Internet Development			
Enterprise Security Systems			
Systems Development (Programming Tools)			
Application Development			
Distributed and Internet Systems			
Systems Design and Modeling (Process and Logic Modeling)			
Enterprise Systems			
Virtual Reality Hardware			
Mainframes and Mid-Range Systems			
Mobile Devices			
Biometrics			
Virtual Reality Software and Applications			
Personal Computers/ Workstations			
Input and Output Devices			
Thin Clients			
Storage Area Networks			
Knowledge Management Systems			

B. IT INFRASTRUCTURE DESIGN AND PRODUCTIVITY FIELD-SURVEY QUESTIONNAIRE

Information Systems and Decision Sciences (ISDS) Department

Louisiana State University Study Information Sheet

We are a team of researchers at Louisiana State University investigating the apparent "productivity paradox" related to Information Technology (IT) infrastructure investments in organizations. While IT is viewed as a critical and pervasive force in organizations, there remains much debate on how much growing IT investments are a result of hope or hype. Because little is known about the specific relationship between particular IT infrastructure configurations and productive consequences, understanding this relationship lies at the core of maximizing productive potential of IT investments.

In tide with ongoing information technology (IT) investments, senior IT executives such as yourself have the onus of justifying investments with requisite returns. Your participation is particularly valuable in helping us gather a comprehensive view of how specific infrastructure designs translate into specific productivity, while illuminating the role IT management and the environment plays in the translation. The goal of this "IT Infrastructure Design and Productivity" survey is to help IT executives make better decisions by understanding the varying role of IT management, the environment, and IT infrastructure configurations on productivity.

This research framework attempts to dispel IT infrastructure investment myths to illuminate the conditions, consequences, and challenges faced by companies in generating productivity from particular IT infrastructure designs

Completing the questionnaire will take about thirty to forty minutes; when you are done, please submit the survey by clicking on the submit button at the end of the questionnaire. We hope that you will choose to participate in this survey, however your participation is completely voluntary. If you have any questions about the survey or to learn more about this study, please email the principal investigator (Pratim Datta) or contact us using any of the e-mail addresses given below.

We thank you for your time and participation in this research. We shall provide you with the basic results upon completion of the survey. Thank you for your knowledge and insights. Completing the questionnaire will take about thirty to forty minutes; when you are done, please submit the survey by clicking on the submit button at the end of the questionnaire.

---

1) Before beginning the survey, first read the Informed Consent Form below and then indicate your consent to participate.

<u>INFORMED CONSENT FORM</u>
This survey questionnaire is intended to provide information about the relationship between IT infrastructure design and productivity in an organization. Your individual responses will be kept confidential. In presenting any data collected from this questionnaire, we will preserve individual and organizational anonymity. Your participation in this study is purely voluntary, and you may stop at any time.

__Yes, I choose to participate in this survey

Part I. Preliminary Information

2) What is your organization's primary business activity at your location?

Manufacturing
Service
Manufacturing and Service
Rather not say
Other (please specify)

3) What kind of organization are you?

Corporation
Franchise
Rather not say

4) What is the geographic range of your business?

Local
Regional
National
Global
Rather not say

5) What best describes your current position?

Chief Information Officer
Senior Information Systems (IS) Management
Senior Non-IS Management
Other

6) How long have you been in your current position?

Less than 1 year   Between 1 and 5 years   More than 5 years   Rather not say

7) What, in your estimate, is the total annual revenue for your organization (worldwide)?

$10 Million to $100 Million (US)
$100 Million to $500 Million (US)
$500 Million to $1 Billion (US)
Over $1 Billion (US)
Rather not say

8) How much, in your estimate, does your entire organization spend annually on Information Technology (IT) goods and services?

Less than $100,000 (US)
$100,000 to $500,000 (US)
$500,000 to $1 Million (US)
$1 Million to $10 Million (US)
$10 Million to $100 Million (US)
Rather not say

Part II. IT Infrastructure Investments

Investments in IT infrastructure provide the primary capital and resource inputs for future productivity.

The following section relates to dimensions of IT investments. Please indicate the level of IT infrastructure investments in your company.

---

9) In your estimate, IT operating expenditures constitute what percentage (%) of your company's total operating expenditures? (Please provide the most recent estimate)

Less that 1% of Operating Budget
Between 1% and 5% of Operating Budget
Between 5% and 10% of Operating Budget
Between 10% and 15% of Operating Budget
Between 15% and 20% of Operating Budget
More than 20% of Operating Budget
Do not know
Rather not say

10) In your estimate, IT capital expenditures constitute what percentage (%) of your company's total capital expenditures? (Please provide the most recent estimate)

Less that 1% of Total Expenditure
Between 1% and 5% of Total Expenditure
Between 5% and 10% of Total Expenditure
Between 10% and 15% of Total Expenditure
Between 15% and 20% of Total Expenditure
More than 20% of Total Expenditure
Do not know
Rather not say

Part III. IT Management

Given the prevalence of IT, the importance of IT management cannot be overemphasized. No longer isolated by a functional role, IT has become a pervasive force - encompassing multiple functions and deeply embedded in the organizational fabric. The role played by IT management has also evolved likewise.

The following section examines multiple dimensions of IT management in a company. Please indicate how you perceive IT is managed in your company.

---

11) In our organization, IT and Business executives are mutually informed about each other's objectives (shared domain knowledge).

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

12) In our organization, the level of informal communication between IT and business executives is high.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

13) Our organizational structure can be perceived as flexible.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

14) The level of informal participation between IT and Business executives in our organization is generally high.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

15) IT and Business executives in our organization are generally supportive of each other's efforts.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

16) In our organization, IT appraisal and planning are well-coordinated between IT and business executives.

Strongly Disagree   Disagree   Slightly Disagree   Slightly Agree   Agree   Strongly Agree

17) In our organization, the level of formal communication between IT and Business executives is generally high.

Strongly Disagree   Disagree   Slightly Disagree   Slightly Agree   Agree   Strongly Agree

18) In our organization, the level of strategic control (monitoring, reporting, and accountability) is generally high.

Strongly Disagree   Disagree   Slightly Disagree   Slightly Agree   Agree   Strongly Agree

19) In our organization, IT management has an objective understanding of IT and business policies/strategies.

Strongly Disagree   Disagree   Slightly Disagree   Slightly Agree   Agree   Strongly Agree

20) In our organization, IT management expertise is well aligned with organizational objectives.

Strongly Disagree   Disagree   Slightly Disagree   Slightly Agree   Agree   Strongly Agree

---

Part IV. IT Infrastructure Design

The transition from an industrial to an information age has been marked by technological fusion-converging traditionally fragmented concepts of computing, content, and communication. Companies have discretionary control over their individual IT infrastructure design configuration (Operating-level, Application-level, and Personnel). There is no "single best design"; instead, an organizational infrastructure design consists of a portfolio of technologies at varying levels of convergence.

Using a portfolio ranging from less-convergent to highly-convergent technologies, the following section asks you to identify your proposed IT infrastructure design. Please indicate how much of your proposed IT infrastructure will be committed towards a particular technological configuration.

---

21) Indicate the level of your proposed IT infrastructure design that, in your estimate, will consist of computing-related technologies (CPUs, PCs/PDAs, systems, I/O devices, Operating Systems)?

	Significantly Low or None	Somewhat Low	Moderate	Somewhat High	Significantly High
Technical (Hardware and Software) (Operating and Application Level)					
Personnel (Development, Implementation, Maintenance, Training, and Support)					

22) We will be able to reap necessary productivity from this infrastructure component within…

Less than 1 year 1-2 years 2-4 years 4-5 years More than 5 years

23) Indicate the level of your IT infrastructure design that, in your estimate, will consist of content (data and information)-related technologies (Databases, File Systems, DBMSs)?

	Significantly Low or None	Somewhat Low	Moderate	Somewhat High	Significantly High
Technical (Hardware and Software) (Operating and Application Level)					
Personnel (Development, Implementation, Maintenance, Training, and Support)					

24) We will be able to reap necessary productivity from this infrastructure component within…

Less than 1 year 1-2 years 2-4 years 4-5 years More than 5 years

25) Indicate the level of your proposed IT infrastructure design that, in your estimate, will consist of communication (networking)-related technologies (Routers, Network OS, Network Management)?

	Significantly Low or None	Somewhat Low	Moderate	Somewhat High	Significantly High
Technical (Hardware and Software) (Operating and Application Level)					
Personnel (Development, Implementation, Maintenance, Training, and Support)					

26) We will be able to reap necessary productivity from this infrastructure component within…

Less than 1 year 1-2 years 2-4 years 4-5 years More than 5 years

27) Indicate the level of your proposed IT infrastructure design that, in your estimate, will consist of technologies used to move and manage content over distributed networks (Distributed/Networked Data/Content Management) (e.g. E-Commerce/Internet technologies, EDI, Distributed Databases, Storage Area Networks)?

	Significantly Low or None	Somewhat Low	Moderate	Somewhat High	Significantly High
Technical (Hardware and Software) (Operating and Application Level)					
Personnel (Development, Implementation, Maintenance, Training, and Support)					

28) We will be able to reap necessary productivity from this infrastructure component within…

Less than 1 year 1-2 years 2-4 years 4-5 years More than 5 years

29) Indicate the level of your proposed IT infrastructure design that, in your estimate, will consist of technologies that will use significant computing (processing) power to process and manipulate data/content (e.g. Mainframes, Mid-Range Systems and OS, Biometrics, Data Mining and Manipulation, Forecasting).

	Significantly Low or None	Somewhat Low	Moderate	Somewhat High	Significantly High
Technical (Hardware and Software) (Operating and Application Level)					
Personnel (Development, Implementation, Maintenance, Training, and Support)					

30) We will be able to reap necessary productivity from this infrastructure component within…

Less than 1 year 1-2 years 2-4 years 4-5 years More than 5 years

31) Indicate the level of your proposed IT infrastructure design that, in your estimate, will consist of technologies used to manage computing systems in a distributed/networked environment (e.g. Distributed processing, Networked Security, Cryptography, Thin Clients).

	Significantly Low or None	Somewhat Low	Moderate	Somewhat High	Significantly High
Technical (Hardware and Software) (Operating and Application Level)					
Personnel (Development, Implementation, Maintenance, Training, and Support)					

32) We will be able to reap necessary productivity from this infrastructure component within…

Less than 1 year 1-2 years 2-4 years 4-5 years More than 5 years

33) Indicate the level of your proposed IT infrastructure that you estimate consists of technologies that use computing/processing power to manage data/content over communication networks (e.g. Enterprise Systems, Servers, Groupware)

	Significantly Low or None	Somewhat Low	Moderate	Somewhat High	Significantly High
Technical (Hardware and Software) (Operating and Application Level)					
Personnel (Development, Implementation, Maintenance, Training, and Support)					

34) We will be able to reap necessary productivity from this infrastructure component within…

Less than 1 year 1-2 years 2-4 years 4-5 years More than 5 years

Part V. Company Environment

A company operates as a part of a changing environment. The environment consists of buyers, suppliers, markets, governments, among others. Environmental attributes therefore play an exceedingly important role in influencing organizational productivity.

The following section tries to identify the properties of your organization's proximal environment. Please indicate how you would characterize the attributes of your operating environment.

35) The adoption of technology in our organizational environment by customers, suppliers, and markets is relatively high.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

36) The diffusion of technology in our organizational environment by customers, suppliers, and markets is relatively high.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

37) Our organizational environment is marked by the availability of venture capital for entrepreneurial activities.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

38) In our organizational environment, market demand for product/service innovations is generally high.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

39) The habits/preferences of our organizational customers are volatile and fluctuating.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

40) In serving heterogeneous markets, our information processing needs are also heterogeneous and diverse.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

41) Our organizational environment, in general, is marked by a high degree of economic instability/fluctuation.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

42) Our organization has a fluctuating supplier base.

Strongly Disagree Disagree Slightly Disagree Slightly Agree Agree Strongly Agree

Part VI. Organizational Productivity

Achieving requisite returns from IT infrastructure investments and design is imperative. Because IT is pervasive, so is productivity. Given that productivity cannot be relegated by type, but occurs across a spectrum- it is essential to identify all the essential dimensions.

The following section tries to understand the productive consequences that you perceive may arise out of your proposed infrastructure. Please rate your perception of productive potential from the proposed IT infrastructure.

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43) I perceive that the proposed IT infrastructure design will...

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Decrease inventory holding costs in the near future.					
Result in shorter product/service cycles by reducing "Work-in-Process" (WIP) time in the near future.					
Result in lowering total variable costs (Production/Development/Service/Personnel) in the near future.					
Reduce marginal costs of production in the near future.					
Significantly lower "total costs of ownership" (TCO) (capital expenditure costs and ongoing maintenance) of organizational resources in the near future.					
Significantly increase inventory turnover in the near future.					
Increase our "Return on Investment" (ROI) in the near future.					
Result in higher "Return on Assets" in the near future.					
Increase ""Earnings" before Interests and Taxes" per employee (EBIT per employee) in the near future.					
Significantly improve organizational work environment (e.g. collaboration, telecommuting, flexible workplace) in the near future.					
Add significant value to existing customer/supplier relationship in the near future.					
Result in improved and secure information exchange (communication) in the near future.					
Significantly reduce training time in the near future.					
Significantly improve product/service quality in the near future.					
Significantly enhance management planning/decision making in the near future.					
Increase strategic/competitive advantage for the organization in the near future.					
Potentially increase our organizational capability for product/process innovations in the near future.					
Result in increased organizational flexibility in the near future.					
Help our organization identify/tap global markets in the near future.					

Part VII. Feedback from Productivity

Achieving productivity from a proposed IT infrastructure design is not a punctuated event but triggers a feedback for future organizational changes.

Please check one or more dimensions that feedback from productivity seeks to revise and change in the near future. If you feel that a potential feedback dimension is missing, please specify it in the text box provided.

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44) In our organization, deviations between "perceived" and "real" productivity from a particular IT infrastructure configuration...

__Serve as a feedback for changes in future IT investments
__Serve as a feedback for changes in future IT infrastructure design
__Serve as a feedback for changes in future IT management
__Other (please specify) ____

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45) If you have any other comments related to IT infrastructure productivity, please relate...

APPENDIX II: DETAILED RESULTS OF THE STRUCTURAL MODEL

Inner Model Statistics for Hypotheses H1-H3

Hypothesis	Latent Predictor Construct	Latent Predicted Construct	Path Coefficient Matrix	LV Correlation Matrix	Psi/Inner Res Matrix	R-Sq. Mult. Corr. Matrix	Variance Contribution
H1	IT-related Capital Outlays	Operational Efficiency	0.19	0.07	0.72	0.28	1.33%
		Financial Productivity	-0.25	-0.15	0.67	0.33	3.75%
		Operational Quality	-0.36	-0.31	0.64	0.36	11.16%
		Strategic Productivity	0.28	0.05	0.43	0.57	1.40%
H2	IT-related Capital Outlays	Communications	0.08	0.32	0.44	0.56	2.56%
		Content	0.17	0.34	0.54	0.46	5.78%
		Computing	0.14	0.26	0.32	0.68	3.64%
		Content/Communication	0.18	0.34	0.43	0.57	6.12%
		Content/Computing	0.31	0.11	0.43	0.57	3.41%
		Computing/Communicat	0.27	0.19	0.34	0.66	5.13%
		Content/Computing/ Communications	0.41	0.23	0.52	0.48	9.43%
H3	Communications	Operational Efficiency	0.13	0.14	0.64	0.36	1.82%
		Financial Productivity	0.09	0.35	0.56	0.44	3.15%
		Operational Quality	-0.11	-0.28	0.67	0.33	3.08%
		Strategic Productivity	0.14	0.19	0.43	0.57	2.66%
	Content	Operational Efficiency	0.18	0.16	0.32	0.68	2.88%
		Financial Productivity	0.07	0.28	0.35	0.65	1.96%
		Operational Quality	0.08	0.27	0.37	0.63	2.16%
		Strategic Productivity	0.23	0.17	0.44	0.56	3.91%
	Computing	Operational Efficiency	0.15	0.24	0.61	0.39	3.60%
		Financial Productivity	0.19	0.12	0.67	0.33	2.28%
		Operational Quality	-0.09	-0.37	0.74	0.26	3.33%
		Strategic Productivity	-0.16	-0.34	0.7	0.3	5.44%
	Content/ Communications	Operational Efficiency	0.36	0.32	0.45	0.55	11.52%
		Financial Productivity	0.31	0.36	0.42	0.58	11.16%
		Operational Quality	0.62	0.06	0.49	0.51	3.72%
		Strategic Productivity	0.4	0.13	0.33	0.67	5.20%
	Content/Computing	Operational Efficiency	0.61	0.31	0.39	0.61	18.91%
		Financial Productivity	0.23	0.27	0.37	0.63	6.21%
		Operational Quality	0.73	0.36	0.41	0.59	26.28%
		Strategic Productivity	0.39	0.12	0.4	0.6	4.68%
	Computing/ Communications	Operational Efficiency	0.68	0.21	0.42	0.58	14.28%
		Financial Productivity	0.33	0.37	0.45	0.55	12.21%
		Operational Quality	0.42	0.11	0.46	0.54	4.62%
		Strategic Productivity	0.37	0.3	0.31	0.69	11.10%
	Content/Computing/ Communications	Operational Efficiency	0.62	0.18	0.37	0.63	11.16%
		Financial Productivity	0.53	0.1	0.33	0.67	5.30%
		Operational Quality	0.69	0.33	0.43	0.57	22.77%
		Strategic Productivity	0.78	0.18	0.42	0.58	14.04%

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Inner Model Statistics for Hypothesis H4 (Continued…)

Hypothesis	Latent Predictor Construct	Latent Predicted Construct	Path Coefficient Matrix	LV Correlation Matrix	Psi/Inner Res Matrix	R-Sq. Mult. Corr. Matrix	Variance Contribution
H4	IT Investments &	Communications	0.51	0.15	0.31	0.69	7.65%
Interaction	Functional Mgmt	Content	0.58	0.42	0.28	0.72	24.36%
Effects		Computing	0.63	0.32	0.24	0.76	20.16%
between		Content/Communications	0.37	0.2	0.36	0.64	7.40%
IT Capital Outlays		Content/Computing	0.13	0.08	0.31	0.69	1.04%
and IT		Computing/Communications	0.22	0.11	0.38	0.62	2.42%
Management		Content/Computing/	0.14	0.3	0.29	0.71	4.20%
on		Communications					
IT Infrastructure	IT Investments &	Communications	0.38	0.14	0.27	0.73	5.32%
Design	Centralized Mgmt.	Content	0.43	0.06	0.23	0.77	2.58%
		Computing	0.12	0.2	0.34	0.66	2.40%
		Content/Communications	0.31	0.12	0.35	0.65	3.72%
		Content/Computing	0.58	0.37	0.28	0.72	21.46%
		Computing/Communications	0.51	0.26	0.26	0.74	13.26%
		Content/Computing/	0.74	0.23	0.37	0.63	17.02%
		Communications					
	IT Investments &	Communications	0.64	0.3	0.33	0.67	19.20%
	Decentralized Mgmt	Content	0.73	0.16	0.31	0.69	11.68%
		Computing	0.67	0.31	0.35	0.65	20.77%
		Content/Communications	0.24	0.04	0.39	0.61	0.96%
		Content/Computing	0.34	0.34	0.3	0.7	11.56%
		Computing/Communications	0.19	0.38	0.28	0.72	7.22%
		Content/Computing/	0.26	0.05	0.45	0.55	1.30%
		Communications					
	IT Investments &	Communications	0.35	0.25	0.23	0.77	8.75%
	Coordinated Mgmt.	Content	0.26	0.3	0.27	0.73	7.80%
		Computing	0.27	0.17	0.38	0.62	4.59%
		Content/Communications	0.71	0.13	0.28	0.72	9.23%
		Content/Computing	0.76	0.26	0.22	0.78	19.76%
		Computing/Communications	0.78	0.34	0.19	0.81	26.52%
		Content/Computing/	0.54	0.17	0.21	0.79	9.18%
		Communications					

Inner Model Statistics for Hypothesis H5 (Continued…)

Hypothesis	Latent Predictor Construct	Latent Predicted Construct	Path Coefficient Matrix	LV Correlation Matrix	Psi/Inner Res Matrix	R-Sq. Mult. Corr. Matrix	Variance Contribution
H5	LCI & Stagnant	Operational Efficiency	0.46	0.14	0.43	0.57	6.44%
Interaction	Environment	Financial Productivity	0.59	0.12	0.41	0.59	7.08%
Effects		Operational Quality	0.18	0.31	0.37	0.63	5.58%
between		Strategic Productivity	0.11	0.19	0.23	0.77	2.09%
IT Infrastructu	LCI & Discontinuous	Operational Efficiency	0.61	0.2	0.61	0.39	12.20%
Design &	Environment	Financial Productivity	0.52	0.09	0.57	0.43	4.68%
Environment		Operational Quality	0.27	0.09	0.63	0.37	2.43%
Types		Strategic Productivity	0.16	0.06	0.67	0.33	0.96%
on	LCI & Uncertain	Operational Efficiency	0.25	0.18	0.52	0.48	4.50%
Productivity	Environment	Financial Productivity	0.07	0.18	0.54	0.46	1.26%
		Operational Quality	0.73	0.23	0.57	0.43	16.79%
		Strategic Productivity	0.62	0.12	0.37	0.63	7.44%
	LCI & Innovative	Operational Efficiency	0.34	0.31	0.44	0.56	10.54%
	Environment	Financial Productivity	0.3	0.23	0.41	0.59	6.90%
		Operational Quality	0.57	0.11	0.47	0.53	6.27%
		Strategic Productivity	0.45	0.21	0.38	0.62	9.45%

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Inner Model Statistics for Hypothesis H5 (Continued…)

Hypothesis	Latent Predictor Construct	Latent Predicted Construct	Path Coefficient Matrix	LV Correlation Matrix	Psi/Inner Res Matrix	R-Sq. Mult. Corr. Matrix	Variance Contribution
H5	Computing/Content	Operational Efficiency	0.66	0.18	0.47	0.53	11.88%
Interaction	& Stagnant	Financial Productivity	0.53	0.2	0.42	0.58	10.60%
Effects	Environment	Operational Quality	0.32	0.23	0.53	0.47	7.36%
between		Strategic Productivity	0.31	0.09	0.5	0.5	2.79%
IT Infrastructure	Computing/Content	Operational Efficiency	0.52	0.29	0.29	0.71	15.08%
Design &	& Discontinuous	Financial Productivity	0.47	0.06	0.18	0.62	2.82%
Environment	Environment	Operational Quality	0.12	0.21	0.27	0.63	2.52%
Types		Strategic Productivity	0.15	0.21	0.22	0.56	3.15%
on	Computing/Content	Operational Efficiency	0.39	0.11	0.43	0.57	4.29%
Productivity	& Uncertain	Financial Productivity	0.11	0.08	0.48	0.52	0.88%
	Environment	Operational Quality	0.63	0.04	0.42	0.58	2.52%
		Strategic Productivity	0.56	0.23	0.37	0.63	12.88%
	Computing/Content	Operational Efficiency	0.12	0.15	0.32	0.61	1.80%
	& Innovative	Financial Productivity	0.36	0.26	0.37	0.63	9.36%
	Environment	Operational Quality	0.46	0.26	0.36	0.64	11.96%
		Strategic Productivity	0.42	0.24	0.41	0.59	10.08%
	Computing/Comm	Operational Efficiency	0.54	0.11	0.44	0.56	5.94%
	& Stagnant	Financial Productivity	0.51	0.13	0.47	0.53	6.63%
	Environment	Operational Quality	0.32	0.26	0.43	0.57	8.32%
		Strategic Productivity	0.33	0.09	0.37	0.63	2.97%
	Computing/Comm	Operational Efficiency	0.49	0.15	0.46	0.54	7.35%
	& Discontinuous	Financial Productivity	0.44	0.07	0.51	0.49	3.08%
	Environment	Operational Quality	0.16	0.17	0.52	0.48	2.72%
		Strategic Productivity	0.12	0.24	0.32	0.68	2.88%
	Computing/Comm	Operational Efficiency	0.12	0.15	0.37	0.63	1.80%
	& Uncertain	Financial Productivity	0.17	0.06	0.36	0.64	1.02%
	Environment	Operational Quality	0.7	0.26	0.34	0.66	18.20%
		Strategic Productivity	0.67	0.31	0.47	0.53	20.77%
	Computing/Comm	Operational Efficiency	0.14	0.06	0.39	0.61	0.84%
	& Innovative	Financial Productivity	0.39	0.16	0.33	0.67	6.24%
	Environment	Operational Quality	0.63	0.31	0.43	0.57	19.53%
		Strategic Productivity	0.61	0.29	0.31	0.69	17.69%
	Content/Comm	Operational Efficiency	0.41	0.29	0.28	0.72	11.89%
	& Stagnant	Financial Productivity	0.54	0.14	0.27	0.73	7.56%
	Environment	Operational Quality	0.28	0.23	0.22	0.78	6.44%
		Strategic Productivity	0.08	0.18	0.26	0.74	1.44%
	Content/Comm	Operational Efficiency	0.67	0.19	0.41	0.59	12.73%
	& Discontinuous	Financial Productivity	0.57	0.26	0.29	0.71	14.82%
	Environment	Operational Quality	0.03	0.24	0.55	0.45	0.72%
		Strategic Productivity	0.08	0.27	0.34	0.66	2.16%
	Content/Comm	Operational Efficiency	0.13	0.23	0.46	0.54	2.99%
	& Uncertain	Financial Productivity	0.39	0.04	0.52	0.48	1.56%
	Environment	Operational Quality	0.8	0.17	0.41	0.59	13.60%
		Strategic Productivity	0.71	0.16	0.44	0.56	11.36%
	Content/Comm	Operational Efficiency	0.38	0.18	0.38	0.62	6.84%
	& Innovative	Financial Productivity	0.38	0.12	0.41	0.59	4.56%
	Environment	Operational Quality	0.77	0.25	0.34	0.66	19.25%
		Strategic Productivity	0.73	0.12	0.35	0.65	8.76%

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Inner Model Statistics for Hypothesis H5 (Continued…)

Hypothesis	Latent Predictor Construct	Latent Predicted Construct	Path Coefficient Matrix	LV Correlation Matrix	Psi/Inner Res Matrix	R-Sq. Mult. Corr. Matrix	Variance Contribution
H5 Interaction Effects between IT Infrastructu Design & Environment Types on Productivity	Comp/Cont/Comm & Stagnant Environment	Operational Efficiency	0.65	0.13	0.51	0.49	8.45%
		Financial Productivity	0.6	0.22	0.48	0.52	13.20%
		Operational Quality	0.09	0.27	0.55	0.45	2.43%
		Strategic Productivity	0.21	0.14	0.58	0.42	2.94%
	Comp/Cont/Comm & Discontinuous Environment	Operational Efficiency	0.68	0.09	0.34	0.66	6.12%
		Financial Productivity	0.44	0.29	0.29	0.71	12.76%
		Operational Quality	0.32	0.15	0.36	0.64	4.80%
		Strategic Productivity	0.07	0.26	0.31	0.69	1.82%
	Comp/Cont/Comm & Uncertain Environment	Operational Efficiency	0.51	0.29	0.23	0.77	14.79%
		Financial Productivity	0.1	0.12	0.22	0.78	1.20%
		Operational Quality	0.67	0.17	0.26	0.74	11.39%
		Strategic Productivity	0.88	0.25	0.21	0.79	22.00%
	Comp/Cont/Comm & Innovative Environment	Operational Efficiency	0.64	0.05	0.37	0.63	3.20%
		Financial Productivity	0.59	0.26	0.33	0.67	15.34%
		Operational Quality	0.85	0.2	0.4	0.6	17.00%
		Strategic Productivity	0.76	0.2	0.41	0.59	15.20%

VITA

Pratim Datta received his Bachelor of Arts (Hons.) in English and economics from the University of Calcutta. He has worked as an Information Officer with the Mining, Geological, and Metallurgical Institute of India and as a Shop Manager with Mobus Engineering in Australia. Pratim completed his Master of Business Administration with an emphasis in information systems from the University of South Alabama and has a Master of Science in information systems from Louisiana State University. His research has been accepted in both journals and conference proceedings. In addition, Pratim is also a published poet and photographer.

The degree of Doctor of Philosophy will be conferred at the December 2003 commencement.