AN EXPLORATORY EXAMINATION OF CAUSAL MODELS FOR TELECOMMUNICATION TECHNOLOGIES, ORGANIZATIONAL STRUCTURAL ATTRIBUTES AND ORGANIZATIONAL PERFORMANCE IN THE U.S. MANUFACTURING SECTOR

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ABSTRACT

In the past decade there have been significant improvements in Telecommunications Technologies (TT). These have had a profound effect on contemporary organizational structures. In attempting to understand this, a few theoretical works have offered a contingent explanation. To extend these research efforts with empirical evidence, our study tested two alternative models to explain the relationship between TT, organization structure, and the organization's financial performance. Two models tested different scenarios based upon whether structural change leads to more TT use (the organizational imperative view) or vice versa (the technological imperative view. TT penetration, organizational structure (centralization, formalization, complexity, and integration) and organizational performance were examined using a survey of manufacturing organizations. The results of causal modeling show that the relationship between TT and organizational structure is better explained by the technology imperative, which TT leads to change in organizational structure: the more decentralized, more complex and more integrated organizational structures are the consequence of the higher penetration of TT. None of the models supports the notion that improved financial performance is a direct consequence of the link between TT and alternative organization structures. Although recent literature suggest that TT flattens corporate hierarchy, simplifies business structure and processes, and minimizes the use of conventional integrated mechanism, this study found that greater penetration of TT creates a need for more coordination and allows more complex and larger organization structures to evolve.

Keywords: telecommunication, organizational structure, IT impact

INTRODUCTION

Many believe that Telecommunications Technologies (TT) are a major driving force in

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organizational changes. Recent diffusion of Enterprise Information Systems such as Enterprise Resource Planning, Customer Relationship Management, and Human Resource Information System, which should be fully platformed on the TT, have clearly demonstrated that the rapid flow of information across inter- and intra-organizational boundaries is changing competition, business processes, controls, working relationships, and organizational structures. Furthermore, internal growth has pushed organizations to the point that they are reaching their limits of expansion (Joyce et al. 1997, Keen 1987). Dealing with this expansion often requires adding and/or decentralizing resources, procedures, and layers of staff that may not contribute to the core business.

Keen (1987) already noted twenty years ago that many organizations had reached a high degree of organizational complexity and, according to Keen (1987), begun to suffer from a myriad of "organizational pathologies" such as "antiquated business processes, field/headquarter tensions, ineffective teams and project work, depersonalization of management, poor communication and control, and blind obedience to bureaucratic procedures ." The use of TT has often been suggested as a remedy to reduce organizational complexity and create better coordination and collaboration. A number of researchers have suggested that TT combined with advanced decision making technology has been an important driving force for the increasing volume of information in the firm (Benjamin et al. 1984, Sullivan et al. 1987). Taking a step further, Keen believes there is a great need to study how, and if, TT can be expected to change organization structure and processes. However, little evidence has been reported that demonstrates a relationship between TT and organizational structure (George & King 1991).

In this study, I attempted to examine this relationship from the perspective of the information process view of organizational structure. Galbraith (1994, 1977, 1974) and others (Giddens 1984) have theorized that an organization may be regarded as an information processing entity and its structure is largely determined by the need to process more or less information depending on the level of task uncertainty. Based on this perspective, I explored the relationship between TT and organization structure, and its impact on organizational performance. However, it is not clear whether existing structure leads to more use of TT, or where the use of TT leads to changes in structure. These two alternatives have generated many theoretical and empirical studies and are referred to as the "organizational imperative" and "technological imperative (Markus & Robey 1988)."

While the debate has been continuously discussed in the IS research discipline due to its impotence (J.T. Jeang & I.S. Kim 1998), this argument between two alternative explanations between IT and organizational changes has not been fully empirically examined, resulting in many partial, conflicting conclusions. Before I look into more emergent approach to understand the linkage at the work unit or individual level (J.

Jeang & I.S. Kim 1998), a through empirical understanding at the organization level will provide a confirmative conclusion on this long-standing debate on the causality between TT and organizational changes. Here I reported an empirical study conducted to explore the three-way relationships based upon both imperatives.

MOTIVATION OF THE RESEARCH

Telecommunication Technology, Organizational Structure, and Information Processing Paradigm

Since the advent of computer use in organizations, there have been numerous attempts at identifying different types of Computer-Based Information System such as transaction processing systems, management information systems and decision support systems (Cheney & Dickson 1982, McLeod 1990). However, these categorization schemes focus primarily on computing technologies which had achieved widespread adoption by organizations prior to the emergence of TT in recent years. Huber (1984) has coined the term "C squared" technology, which denotes both computing and communication technology. According to his definition of "C squared" technology, computing technology is referred to as a combination of MIS, knowledge systems, and DSS, while communication technology entails any communication-related technology such as EDI, Intranet, local area networks (LAN), wide area networks (WAN), electronic mail systems, voice mail systems, radio-phones, videotext, and electronic conferencing. A number of researchers have discussed the different significance of computing and communication technologies to organizations (Burns & Stalker 1961, Keen 1986, Li & Ye 1999).

While the organizational significance of new TT has been emphasized in the literature (Huber 1990, Keen 1991, Malone & Rockart 1991, Massetti & Zmud 1995), most studies on the subject have been conceptual rather than empirical. Among the most notable conceptual studies to date are the works of Huber (1982) and Keen (1988, 1991). Focusing on the changes in organization structure and process, Huber describes how changes in environment cause changes in organizational capabilities, and how TT affects this adaptation process. He considers three aspects of organizational capabilities: decision-making, intelligence, and organizational design. In addition, he theorized on how technology-facilitated changes in organizational design may affect the quality and timeliness of intelligence and decision making in organizations. Table 1 summarizes some major tenets of his arguments.

Table 1. Summary of Huber's (1991) IT Impact Study

		Communications Technology	Decision Support Technology
Design Variables (Subunit Level)	Participation in decision-making	Increased	-
	Size and heterogeneity of decision units	Decreased	Decreased
	Frequency and duration of meetings	Decreased	Decreased
Design Variables (Organizational Level)	Centralization of decision-making	Contingent	Contingent
	Number of organizational authorization	Decreased	Decreased
	Number of nodes in the information-processing network	Decreased	Decreased

Keen also argues that the changes in the decision making structure and the level of participation in decision making can result from the diffusion of TT. Keen observes that simultaneous centralization-with-decentralization through TT permits organizations to acquire the benefits of both organizational forms (Gurbaxani & Whang 1991). According to Keen, organizational complexity such as complex managerial layers, administrative overhead and formal procedures can be simplified by employing TT.

Recent concepts of TT use, groupware, EDI, Intranet, and Enterprise-wide IS (ERP, CRM), make it even more incumbent to view TT in a more proactive role in effecting organizational change (Davenport 1993, Hammer 1990). This trend will move a mode of coordination from the old dichotomous "centralization and decentralization" to the design of organization structure which is independent of the limits of time and space. The advancements I have seen in TT to date are making many of our most confirmed hypotheses about organization structure outdated. This inevitably obliges us to investigate their distinct impacts on organizations, to facilitate the best fit between this new technology and organizations and thus to identify the linkage with firm's organizational performance.

Along with the research effort to investigate the linkage between TT and organizational changes in the IS field, many prominent organization theorists have adopted the notion that an organization may be viewed as an information processing entity (Huber & McDaniel 1986, Tushman & Nadler 1978) over the last several decades. Galbraith integrated the work of previous researchers (e.g., Burns & Stalker 1961, Woodward 1965, Hall 1972, Lawrence 1967), and theorized that observed variations in organization structure represent the diversity of organizational strategies to adapt to different level of information processing requirements. The better the fit

between information processing requirements and information processing capacity of the organization structure the less the Perceived Environmental Uncertainty (PEU) and accordingly the better the performance of the organization. Standard operating procedures and hierarchical referral for handling exceptions are seen as means for reducing organizational information processing requirements. On the other hand, lateral relations between different units via teams, task forces, integrating roles, etc., and investment in "vertical" information processing systems such as computers can be seen as ways to increase the information processing capacity of the organization.

One aspect of the information processing paradigm (IPP) of organizational structure that deserves special attention from IS researchers is the role of information technology, especially TT in facilitating organization structural change. The IPP theoretical perspectives may help explain how the use of TT influences the relationship between the perceived environment, organization structure and organizational effectiveness.

In this study, I tried to understand the relationship between the distinctive usage of telecommunication technology and organizational structure based on the IPP theoretical perspectives and to see its impact on organizational performance. This examination, however, is based on two alternative models of causality: one ascribes TT as the "cause" while the other considers TT as the "effect." The two alternative models described below, were tested to see the causal validity between the models.

Alternative Models of Causality in IS Research

The relationship between IT and the organization has been of major interest among IS researchers since the dawn of modern computing. (Whisler 1970). Markus and Robey (1983) discuss theories on this relationship in terms of beliefs about the nature of the causal relationship: whether IT leads to change in organizations (technological imperative), whether people act deliberately to design IT for intended objectives (organizational imperative), or whether changes surface unpredictably from the interaction of people, organizations and IT (emergent perspective). The organizational imperative takes the position that people design information systems to satisfy organizational information needs. Thus, IT is the dependent variable which is shaped by the organization's information processing needs and configured by managers' choices about how to satisfy these needs. This view assumes that systems designers can manage the impact of information systems by attending to both technical and social concerns. For the technology imperative, on the other hand, IT is the independent variable and organization the dependent variable. As such, the research is naturally focused on the "impact" of IT on organizations.

In addition to organizational and technology imperative, which represent the two dominant directions of causality in IS research, Markus and Robey also identified a third possibility: the emergent perspective, which views the uses and consequences of

IT as emerging unpredictably from complex social interactions. This perspective disagrees with the main assumptions of the other two views, which presume the causal relation as an independent-dependent relationship. Here the relationship between IT and organization can be mutual and bi-directional. With this mutual relationship, organizational validity is a property neither of the system itself nor of the organization in which it is used, but rather of the degree of fit or match between them (Markus & Robey 1983). Based on Gidden's (1984) theory of structuration, Orlikowski and Robey (1991) also emphasized the need to introduce the emergent perspective in the investigation of interaction between organization and IT.

The two dominant directions of causality in IT research: the technology imperative and organizational imperative have been explicitly or implicitly the basis of much of IS research on IT-organization relationships. While the IT implementation literature is mainly based upon the organizational imperative, the traditional IT impact research assumes the technological imperative. The essence of the technological imperative is conveyed by the word "impact." This positions technology as an independent variable, which determines and affects the behavior of organizations. Markus and Robey point out that while the technological imperative has been applied for a long time and produces some rigorous arguments; empirical research has generated contradictory findings on several aspects of computer impact (Attewell & Rules 1984, Kling 1978, Kling 1980, Robey 1977).

Consistent with the organizational imperative, the IS "implementation" research focuses on investigating the organizational determinants of IT effectiveness. Davis et al. (1984) characterize this view as "the impact of the organization on the computer" to accentuate its mirror-image relationship with the technological imperative.

The distinction between the technological imperative and the organizational imperative is also discussed by Swanson (1987), who distinguishes between research which identifies determinants of information systems use, and research which examines the effects of its use. Swanson also points out that researchers have paid relatively more attention to determinants than to effects of information systems use. This trend may be due to the maturity level of some major information technologies, or the beliefs among IS researchers and practitioners that a more proactive view of information systems is required (Davis et al. 1984). That is, the organization must plan and choose the organization role that IS will play.

Based on the work of Markus and Robey and Swanson, I can distinguish the "IT impact" with "IS implementation" research as shown in Table 2. The contrast between IT implementation and IT impact research helps us to position the present study in the context of IS research tradition.

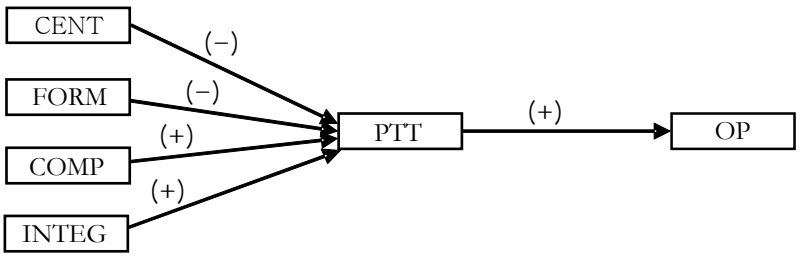
Table 2. IT Impact vs. Implementation

	IT Impact	IT Implementation
Markus & Robey (1988)	Technology Imperative	Organizational Imperative
Swanson (1987)	Explanatory focus on effects of IS	Explanatory focus on determinants of IS

RESEARCH MODELS AND PROPOSITIONS

Based on the discussion above, two alternative models of causality were developed to explore the relationship between TT, organizational structure and organizational performance in the context of the IPP theoretical perspectives. The model based on the organizational imperative is portrayed in Figure 1, and the technology imperative, Figure 2. While competing in terms of causality, both models can be explained by the Information Processing Paradigm.

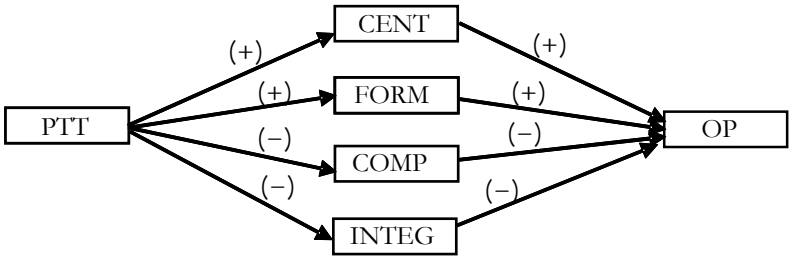
Figure 1. Model 1: Organization Imperative View



CENT: Centralization
FORM: Formalization
COMP: Structural Complexity
INTEG: Integration
PTT: Penetration of Telecommunication Technology
OP: Organization Performance

As the two alternative models were developed to explore rather than confirm patterns of relationships, no specific hypotheses are stated. Instead, I examined a set of propositions regarding the relationship between organization structure, TT and organizational performance.

Figure 2. Model 2: Technology Imperative View



CENT: Centralization
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Model 1: Organizational Imperative View of TT's role in IPP

As depicted in Figure 1, the information processing paradigm may be utilized to explain the relationships between organizational structure, TT penetration, and performance. The basic tenet of the IPP is that the greater the uncertainty of the task, the greater the amount of information that has to be processed by decision makers in the organization. To reduce uncertainty, organizations can be designed to enhance its information processing capacity (Daft & Lengel 1986, Tushman & Nadler 1978) or to process increased information load. To adapt to different levels of task uncertainty, an organization may adopt organic or mechanistic structure to adjust its information processing capacity over time.

Compared to mechanistic structure, organic structure is characterized by:

(i) less centralization of decision making
(ii) less formalization of rules and procedures
(iii) more complexity resulting from the varieties of strategies and products
(iv) more reliance on integration mechanism across units

Research in IPP indicates that organic structures are able to deal with greater amounts of information than mechanistic structures (Huber & Daft 1987) and eventually leads to better organizational performance.

Centralization refers to the extent that the locus of decision-making is located at the top and a hence lack of participation from a lower level personnel in the organization (Hage & Aiken 1967). Formalization is the extent to which the roles and

activities of the various organizational actors are clearly documented and reported by way of written rules and procedures (Ramamurthy 1990). In this study, complexity refers to the number and variety of different goals, market strategies, technologies, and products with which the organization interacts. Although somewhat different in context, specialization (Routamaa 1985), professionalization (Hage 1980), technocraftization (Miller & Friesen 1982), and complexity (Pugh et al. 1968) are interchangeably used in organization literature. In this study, specialization, differentiation, and professionalism are considered together to represent the complexity of an organization (Zaltman et al. 1973). The fourth structural variable, Integration, reflects the degree to which the activities of separate actors in the organization can be coordinated through formal coordination mechanisms. The main emphasis was given to the mechanistic overlays of different functions in the organization (Miller & Friesen 1982). The level of utilization of coordination mechanisms -- like liaison personnel, task forces, and steering committees -- was captured using three items developed by Miller and Friesen (1982).

I developed a measure of TT penetration (PTT) by gauging the extent to which *standard business applications* in the firm are using telecommunications technology. Telecommunications technology was defined in the study instrument as any communication-related technology for moving data, such as Internet, electronic data/document transfer, electronic mail systems, or local area network. This definition was confined to the computer-supported telecommunication technology. Thus, conventional communications media such as telephone or telex were excluded. A list of 26 business applications that utilize recent TT developments were compiled based on, Cron and Sobol's (1983) software capability types, Raymond's (1985) computerized applications in small manufacturing firms, and Weill's (1989) list of business applications for computerization. A 7-point Likert scale ranging from "no use" to "widely used." was attached to each of the 26 applications to identify the extent to which TT was utilized in this application. For each application, a "not relevant" response was added in case a task was not relevant for a sampled company.

To measure a firm's organizational performance contingent upon the relationship between TT and organizational structure, I focus on the economic dimension of organizational effectiveness. The reference field most concerned with organizational effectiveness, i.e., strategic management, has a rich set of relevant measures. I adopted several such measures used in notable recent empirical studies in strategic management (Venkatraman 1991). These include: return on assets, liquidity, return on stockholder's equity, net profit position and overall financial performance.

As indicated in Figure 1, four organization structural characteristics are included in Model 1: centralization, formalization, complexity, and integration. Consistent with the causality of the organizational imperative, these characteristics are assumed to influence the penetration level of TT in the organization which, in turn, would help to

determine organizational performance. Because the organic structure is decentralized, less formalized, more complex and integrated, more time, effort, and energy is consumed in order to coordinate the independent units and is less amenable to managerial control. With this structure, the need to share information increases because more information is necessary to coordinate the diverse activities typically found in this structure (Daft & Macintosh 1981). In other words, over time an organic structure has a need to increase its information processing capacity. Similar to this argument, Fiedler et al. (1996), Ferioli and Migliaree (1996), and Lee and Leifer (1992) have demonstrated a more direct relationship between IT metrics and metrics representing organizational structure.

One way to enhance an organization's information processing capacity, according to Galbraith (1973), is to invest in "vertical information systems," and employing computers is mentioned as one means for achieving this. While investing in traditional computing technology may be the norm 20 years ago, the use of TT becomes much more prevalent today and is deemed particularly suitable for addressing the potential problems in organic organizations where the need for coordination is especially high. With higher penetration of TT to alleviate its potential problems, as depicted in the model, better organizational performance can be expected to follow. Further, more reliance on TT will provide an efficient communications channel with less internal and external coordination cost which can be expected to improve internal and external operational efficiency and effectiveness, with eventual manifestation in the firm's financial performance.

There has been some contradictory evidence on whether increased investments in IT enhance productivity (Kudyba et al. 2002). However, more recent studies such as Menon et al. (2000) and Bharadwaj (2000) and Torben and Segars (2001) showed the use of IT to enhance communication is associated with higher financial performance in large organization. It could also be that investment in IT, especially TT, has now reached and passed a threshold level so that it can contribute to organizational output positively.

In sum, the model explores the mediating effect of TT penetration on the relationship between organization structural characteristics and its performance. Based on the organizational imperative, I postulate that the breadth and depth of TT use in an organization will stem from the intended structural changes to support and alleviate the increased information requirement in the organic organization structure, and thus lead to better organizational performance. I seek to explore the possibility that the mediating model involving TT penetration level will explain a firm's organizational performance better than the direct relationship between organization structure and performance.

Accordingly, the following proposition is presented which consists of five parts (1.1 through 1.5):

Proposition 1.

Higher penetration level of telecommunication technology is a result of these organization structural characteristics:

(i) less centralization of decision making (1.1)
(ii) less formalization of rules and procedures (1.2)
(iii) more complexity resulting from the varieties of strategies and products (1.3)
(iv) more reliance on integration mechanism between organization units (1.4)

Additionally, the high penetration of TT, in turn, leads to better organizational performance (1.5)

Model 2: Technology Imperative View of TT's role in IPP

Studies on direct causal links between IT and structural changes are not new. It was anticipated many years ago in Huber's works. Using partial correlation analysis to control for relevant environmental dimensions, Pfeffer and Leblebici (1977) concluded two decades ago that the effect of IT on structural complexity and integration is more likely to be one of causality rather than covariation with the dimensions of the organization's environment.

Huber postulated that the need for information processing capacity increases during periods of increased environmental turbulence and complexity. As the environment grows more turbulent in recent years, IT investment, especially organizational computing networking (Kock, 2000) has indeed increased enormously. This proactive use of TT, as can be seen in Figure 2, is the basis for Model 2 which assumes the technology imperative and a direct impact of telecommunication technology on organizational structure, in contrast to Model 1 that views the level of TT penetration being a consequence of organizational change. Rather than reactively facilitating the change, this model sees the possibility of applying TT purposefully to orchestrate changes in decision-making structures in the organization, as vividly demonstrated by Huber in this quote:

...as administrators and their advisors learn about whatever functional effects of advanced information technologies on organizational design and performance may accrue, more and more of the effects will be the outcomes of intentions (Huber 1990).

This technology imperative view was shared by Keen (1987):

The very idea of using telecommunications for business innovation means not automating the status quo but explicitly trying to change entire aspects of the organization or its interactions with its business environment. Communications technology is viewed as a major element in managing and creating changes in the business process.

Keen believes that the simultaneous centralization-with-decentralization through telecommunication technology permits organizations to acquire the benefits of both organizational forms, and that managerial layers, administrative overhead, formal procedures and other organizational complexities can be simplified by employing TT. Huber describes how changes in environment cause changes in organizational capabilities, and how TT affects this adaptation process. He considers three aspects of organizational capabilities: decision-making, intelligence, and organizational design. In other studies, he focuses on those technology-facilitated changes in organizational design that affect the quality and timeliness of intelligence and decision making. Table 1 summarizes some major arguments that become a basis for our propositions below.

The direct effects of organizational structure on organization performance, as indicated in Model 2, can be also explained from the perspective of the information processing paradigm. The greater information sharing capacity made possible through TT penetration in an organic structure supports the need for additional information interpretability and the demand for more information sharing. By dramatically reducing the costs of coordination and increasing information processing speed and quality in the organic structure, people can coordinate more effectively, operate more efficiently, and make better decisions, leading to better organizational performance.

Based upon these conceptual and theoretical arguments stemming from Model 2, I see two possible developments: 1) the organic structure would be an unavoidable choice of structural change in many firms to cope with environmental complexity and uncertainty, which would eventually lead to a myriad of organizational pathologies; 2) to relieve these pathologies, there will be explicit intentions in organizations to simplify the complex organic structure through the use of TT. That is, the greater information sharing capacity of TT make it possible to regress an organic structure to a newer advanced form of mechanistic design that retains simplicity and flexibility along with the merit of tighter control.

While George and King (1991) among others have discussed the contingent nature of the centralization/decentralization debate, the proposition below explores TT impacts based on notions of organizational simplification put forth above. Proposition 2 explores the impact of TT on organizational structure and performance:

Proposition 2.

Higher penetration level of Telecommunication technology in organizations will lead to these organization structural characteristics:

(i) more centralization of decision making (2.1)
(ii) more formalization of rules and procedures (2.2)
(iii) less complexity with fewer varieties of strategies and products (2.3)

(iv) less reliance on integration mechanism between organization units (2.4).

Additionally, the more centralized (2.5), more formalized (2.6), less complex (2.7) and less integrated (2.8) organizational structure will, in turn, lead to better organizational performance. The two alternative models of causality, as presented above, incorporated conceptual and theoretical elements from the Information Processing Paradigm, as well as the works of Huber and Keen.

RESEARCH METHOD

Measurement of research variables was carefully planned. Previously validated instruments were used either directly or modified for many of the items contained in the questionnaire. Others were developed from a review of the literature. There are three groups of research measures: organizational structure, telecommunication technology penetration, and organizational performance (refer to Table 3). Operationalization of these variables is provided in the Table 3.

The survey sample was drawn from U.S. based manufacturing firms. The manufacturing industry was chosen for several reasons. First, IT investment in the manufacturing sector has traditionally been lower than in other sectors 1], and the pressure to invest in TT should be strong (Weill 1989). Secondly, due to commonality in requirements, drawing sample from the same sector should enhance the interpretability of the PTT variable. Finally, unlike the service sector that operates with diverse business processes, the manufacturing sector has relatively homogeneous business processes and organizational structures, further simplifying the analysis and interpretation of study results. The sample frame of the study consists of 515 firms in the Southeast and East-Coastal area with a minimum of 200 and a maximum of 5000 employees.

As the study's major constructs are at the organizational level, I seek to gather responses of key top executives to capture the characteristics of these constructs. Responses from two top executives in each organization were sought in order to improve the response rate.

Following the initial mailing, 87 usable responses from 84 different companies were received. Subsequently a follow-up questionnaire was sent to the 431 non-responding companies. This yielded 77 additional responses from 73 companies, raising the total response to 164 from 153 companies, resulting in a final response rate of 30.5%. Multiple responses (mostly two responses) were received from only 11 firms. For the purpose of analysis, only the higher ranked officer's response in these 11 samples were used to represent those firms' general opinion after testing and confirming the similarity of response patterns. The results of analyzing these 164 responses are presented in two steps. Before presenting main research findings on

testing the two sets of propositions, I first reported results the validity and reliability assessment of research constructs.

Table 3. Operationalization of the Research Constructs

Constructs	Item Description	Reliability
Centralization (CENT)	- new product introduction - capital budgeting - pricing policies - entrance to new market - major changes in manufacturing process - personnel policy	0.81
Formalization (FORM)	- extent of rules/procedures documentation - reliance on rules and procedures - tolerance level of rule violation	0.71
Complexity (COMP)	- number of different product line - diversity of production technology - diversity of marketing strategies - number of different departments	0.70
Integration (INTEG)	- frequency of interdepartmental committees - frequency of interdepartmental task force - frequency of liaison personnel	0.72
Organizational Performance (OP)	- overall financial performance - operational cost efficiency - return on assets - corporate liquidity - return on stockholder's equity	0.85
Penetration of Telecommunication Technology (PTT)	- average level of depth in TT use - average level of width in TT use - number of years in TT use	0.80

STUDY RESULTS

Validity and Reliability Testing for Research Constructs

Even though this study adopts or adapts the validated and reliable instruments used in earlier research, the requirements of validity and reliability demand that I examine these issues under the guidelines suggested in the literature (Churchill 1987, Cronbach 1951, Hair et al. 1987, Kerlinger 1964, Nunnally 1958). As mentioned earlier, the constructs were derived through extensive literature review and were measured by the existing list of items for which the validity and reliability were established. The critical analysis of the measures by academic experts in the field, and the pretest with field

practitioners were used to satisfy this content validity requirement.

All of the multiple items adopted for the organizational performance and the organization structure constructs had established acceptable reliability and validity level from past research. However, in an effort to improve the appropriateness of the instrument items in the context of the current study, some questions were slightly altered in wording and style. The reliability measurements, using the Cronbach Alpha coefficient, were examined and presented in Table 3. Nunnally suggests that when a previously validated instrument has been adopted, a higher cut-off value of 0.7 may be used. All four measures (centralization, Formalization, complexity, and integration) for the organizational structure, organizational performance and the PTT scales had Alpha values ranging from 0.70 to 0.85.

A series of measurement models were tested to ensure the construct validity of the six major constructs (Dillon & Goldstein 1984, Segars & Grover 1993). Validity of PTT and organizational performance constructs were tested using two one factor, congeneric measurement models. The four organizational structure constructs was applied to a four-factor measurement model. A summary of test results shows strong support for the measurement properties of all six constructs - validities and reliabilities (refer to Table 4).

Table 4. Findings in Validity testing of the Research Constructs

Constructs	Fit Indices	Validity
Organization Structure Centralization (CENT) Integration (INTEG) Complexity (COMP) Formalization (FORM) indicators	GFI → 0.906 AGFI → 0.865 Bollen IFI → 0.932 CFI → 0.929	Convergent Validity: In this four-factor model, all significant z-values (at 0.01) are observed for all 15. Discriminant Validity: Four constrained models (by fixing one of any possible correlation between factors at 1.0) and the unconstrained model were compared in terms of chi-square values. In each of these comparisons, the chi-squares are highly significant at 0.05 level.
Organizational Performance (OP)	LISREL GFI → 0.957 LISREL AGFI → 0.870 Bollen IFI → 0.969 CFI → 0.968	Convergent Validity: In this one-factor model, all significant z-values (at 0.01) are observed for all 5 indicators.
Penetration of Telecommunication Technology (PTT)	A perfect fit due to just-identification	Convergent Validity: In this just-identified, one factor analysis with three indicators, all significant z-values (at 0.01) are observed for the indicators.

Testing Research Propositions

The EQS program was used with all the constructs and the relationships posited from Model 1 and Model 2 (refer to Figure 3 and 4). EQS, along with LISREL, has been a leading Structural Equation Modeling program that provides a simple approach to specification, estimation and testing of path models for covariance structure (Bentler & Wu, 1995). To make the figures more informative, the measurement components, error of measurement were omitted from the path diagrams. The parameters for Model 1 were estimated using the Maximum Likelihood (ML) method, which in the first attempt resulted in the satisfactory fit of the data (chi-square = 275.76, d.f = 219; p = 0.006). Table 5 presents the key findings of Model 1. A goodness-of-Fit Index (GFI) of 0.87, an Adjusted Goodness-of-Fit Index (AGFI) of 0.83, Bollen Fit Index (BFI) of 0.95, Comparative Fit Index (CFI) of 0.95 and a Root Mean Square Residual (RMSR) of 0.04 also supported the results of the chi-square test (Hayduk, 1987) in Model 1. In Model 2, a similar, satisfactory fit was found (Table 5).

Table 5. Findings for Structural Equation Model 1 and 2

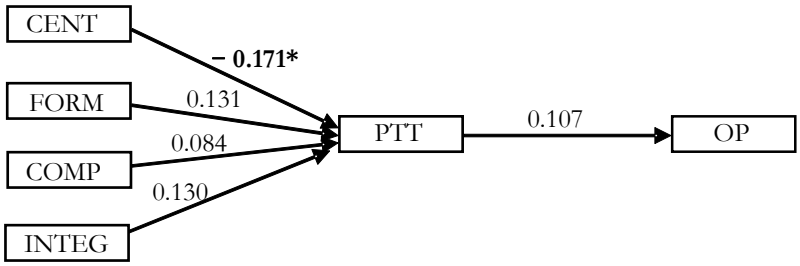
	Model 1	Model 2	Recommended values* Fit Indices
Chi-squre/d.f.	1.259	1.258	< 3.0
Bollen (IFI)	0.951	0.952	> 0.90
LISREL GFI	0.866	0.829	> 0.90
LISREL AGFI	0.832	0.869	> 0.80
Standardized RMR	0.027	0.026	< 1.0
Comparative Fit Index	0.949	0.950	> 0.90

* Segar and Grover [75]

A path analysis was conduced and an examination of path coefficients (see Figure 3) show that only Proposition 1.1 was supported in Model 1, indicating that decentralized organization structure may lead to more use in telecommunication technology. No direct relationship between PTT and OP constructs was found.

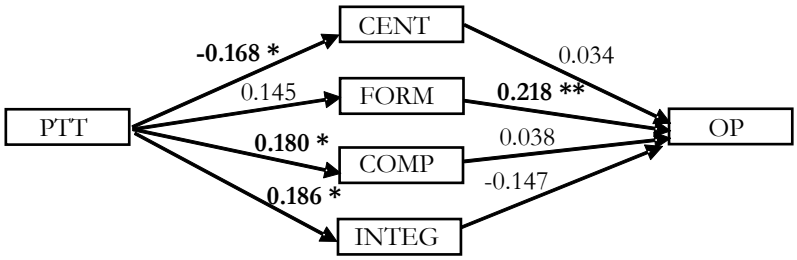
In Model 2, while the four significant relationships were found at 0.1 level (Figure 4), only one proposition, Proposition 2.6, was confirmed as posited. The relationships posited in Proposition 2.1, 2.3, and Proposition 2.4 are found significant but opposite to the posited directions. In other words, the more decentralized, more complex and more integrated organizational structure is consequences of higher penetration of TT. Formalization was the only structural variable that is not affected by PTT. Further, this construct is the only factor linked significantly to organizational performance.

Figure 3. Model 1: Standardized Path Coefficients



CENT: Centralization
FORM: Formalization
COMP: Structural Complexity
INTEG: Integration
PTT: Penetration of Telecommunication Technology
OP: Organization Performance
*Significant at 0.1 level

Figure 4. Model 2: Standardized Path Coefficients



CENT: Centralization
FORM: Formalization
COMP: Structural Complexity
INTEG: Integration
PTT: Penetration of Telecommunication Technology
OP: Organization Performance
*Significant at 0.1 level
**Significant at 0.05 level

In summary, none of the models was thoroughly confirmed in terms of the relationships posited. Model 1 has only one significant relationship confirmed linking

PTT and decentralization. This relationship, however, was confirmed reversibly in Model 2, opposite to the direction proposed. In Model 2, while significant relationships exit between many structural variables (CENT, COMP, and INTEG) and PTT, only one relationship was found significant between organizational structure (formalization) and performance. These unanticipated and curious findings were interpreted and discussed in details in the next section to develop new insights into the phenomenon.

DISCISSION OF FINDINGS

The findings derived from the causal modeling on the two alternative models have produced surprising and interesting results. Generally, the findings did not provide extensive support to either model. I first discuss the relationships between PTT and the various structural variables.

Telecommunication Technology and Organizational Structure

For Model 1, only one of five proposed relationships received support. Higher level of decentralized decision making was found to create more need for telecommunication applications. Other structural conditions such as formalization, complexity and integration, do not lead to more or less use of TT in the organization. These results suggest that investment in TT may be a deliberate strategic decision, rather than a response to certain organization structural inducement. The preeminence of strategic information systems in the past decade (Kettinger et al. 1994, Lederer & Sethi 1988) has served to establish the bi-directional link between IS strategy and corporate strategy, both conceptually (Lyles 1979) and empirically (Earl 1993, Pyburn 1983). When including TT as a part of the strategic IT investment to gain competitive advantages, the major concern is doing whatever necessary to achieve the strategic goals and objectives. Whether the structural conditions in the firm facilitate the pursuit of these strategic initiatives may not play a significant role in the decision process, either explicitly or implicitly.

Many significant relationships, however, are found in Model 2, which was based on the technology imperative view of TT on organizational structure. Interestingly, most results are contrary to predictions made in Proposition 2. As a result of TT penetration, three of the four structural variables have been significantly altered. Specifically, the significant linkages indicate that higher penetration of TT would facilitate:

- the decentralization of decision making power, thus empowering lower level personnel to respond more quickly to changing conditions.
- the development of greater complexity with more varieties of strategies and products

- more use of integration mechanism between organization units.

These changes, in IPP terminology, would increase the information processing capacity of the organization. According to Galbraith, centralization of decision would require more "vertical referral" which places a heavy information processing burden on the organization's hierarchy. Decentralization, therefore, should provide much needed relief and provide the opportunity to reallocate the processing resources to other useful purposes, thus raising the overall information processing capacity of the organization.

For organizational complexity, the "coordination intensity" is inherent, and only organizations with higher information processing capacity can afford to be complex. Finally, according to Galbraith, use of integrative mechanisms such as task force, project teams, etc. is one of the means for increasing an organization's information processing capacity without altering its fundamental structural form.

It is possible that the "supply" of TT power may have created its own "demand." The enhanced capabilities to process more information, handling more exceptions, and reduce internal coordination costs, have over time made the organization more complex and differentiated. This is consistent with the theory proposed by Malone and Rockart (1991) on the impact of computer and networks on organization. Observing the impact of automobile on society, Malone and Rockart have demonstrated that the impact of reduced coordination cost due to the use computer and network, like earlier generations of technologies such as automobile, undergoes three orders of effects. The first order effect of reducing coordination cost is simply the substitution of IT for human coordination, where menial tasks such as check and payroll processing are automated to replace millions of clerical workers. For the second order effect, organizations seek out new opportunities to apply IT, attempt tasks that were not possible with human coordination, and thus increase the overall amount of coordination required in the organization. As coordination requirements continue to grow, the organization may even find it necessary to add more workers and management layers, to take on more complex tasks that were not necessary before. Eventually, however, organizations would recognize the possibility of leveraging advanced IT and fundamentally altering structure to enhance its information processing capacity. The development of "coordination intensive" structures represents the third order effect of IT on organizations. For example, the coordination of 10,000 salespeople through hand-held computer, databases, and EIS at Frito-Lay is based on a coordination-intensive structure fundamentally different from the traditional layered hierarchy. The establishment of case managers and cross-functional teams in many business process reengineering initiatives (Davenport 1993), often enabled by TT-based coordination technology, also correspond to this third order effect.

Given that TT has existed, on average, only 7.2 years among the responding

firms, it is very likely that the significant links in Model 2 may be a manifestation of the second to third order effect described by Malone and Rockart. After some initial "bread and butter" applications, these organizations were no longer content with mere substitution of TT for human coordination, and began to venture into novel applications where human coordination was not practical. These new applications, with high levels of coordination capability, eventually create need for more coordination than can be handled by the current organizational structure. As a result, the organization must expand its information processing capacity within the existing structural constraints, i.e., by becoming more complex, decentralizing decisions, and adopting more integrative mechanisms. Malone (1997) refers to these coordination intensive organizations as "cyber-cowboys" (dispersed but connected subunits) that are made feasible with contemporary low cost TTs by allowing benefits of decentralized decision making as well as centralized control.

Thus, when a firm is undergoing the second to third stage, as is most likely the case with the sample organizations in the current study, the impact would be manifested in a variety of mechanisms to contain the mounting complexity resulting from a proliferation of TT applications. In fact, in an interview conducted 30 years after the publication of their seminal paper on the impact of computing (1958), Leavitt and Whisler said:

I believed the trend toward decentralization was a response to increasing complexity. I was convinced that given the right tools to deal with the complexity, managers would recentralize. I saw the computers as one of those tools

Findings related Proposition 2 can be best explained by the above observation, which is consistent with the second to third order effect theorized by Malone and Rockart. The various organizational simplification efforts suggested in Proposition 2 might then reoccur as decentralized integrated structures start leading to their own pathologies and demand further organizational simplification.

Influence on Organizational Performance

None of the propositions regarding the organizational performance construct were found significant except for FORM and OP relationship. Therefore, the propositions underlying the two models, that either technology-induced structural changes or organization-induced technology change will lead to better organizational performance level, are generally not supported. These results suggest that financial performance can not be simply explained by the Information Processing Paradigm alone, and the fit between the information processing requirement and the matching structural mechanism may not benefit the organization's financial performance.

CONCLUSION

First of all, the study's external validity is limited. It may be possible to generalize the results within the manufacturing sector. However, it is not valid to extrapolate these results to the service sector, public sector or to manufacturing companies that are extremely small or large. While the research model was theorized to be causal, the data collection approach adopted was "cross-sectional". This creates problems for causal inference since the "effect" data are captured at the same time as the "cause" data in cross-section research. Despite the additional efforts taken in the measurement and causal analysis using EQS, the results, thus, cannot be concluded as truly causal. For better causality testing, future studies can adopt the longitudinal research designs by following a number of firms over time and discovering the extent to which structure is explicitly shaped by technological change.

While the intention of this study was more selective than exhaustive by adapting the information processing paradigm as a main theoretical basis, the general picture provided by the study is insufficient to incorporate other important contingent variables. It is important to note that IT should be assessed and compared with regard to broader managerial contexts. That is, firm size, market condition, organization culture, power structure, or organizational munificence each constitutive different dimensions in which to evaluate any role of TT in structural changes. A monolithic application of TT concepts at the firm level without regard to these factors is likely to be incorrect and incomplete. This observation leads to the conclusion that more focused investigation in a broader context is necessary in order to better understand the proposed relationships in the paper.

To conclude, it is hoped that this research provides a much-needed empirical evidence in building a theoretical framework within which to assess the impact of IT in general and TT in particular on organizations' structural adaptation and consequently on organizational performance. The study broadens earlier studies by focusing on the newer more powerful set of TTs rather than the arguably more "passive" information processing technologies. These newer technologies are argued to have a more direct impact on structural attributes. The results of causal modeling show that the relationship between TT and organizational structure is better explained by the technology imperative, which TT leads to change in organizational structure: the more decentralized, more complex and more integrated "coordination intensive" organizational structures are the consequence of the higher penetration of TT. None of the models supports the notion that improved financial performance is a direct consequence of the link between TT and alternative organization structures. Although some recent literature suggest that TT flattens corporate hierarchy, simplifies business structure and processes, and minimizes the use of conventional integration mechanisms, this study found that greater penetration of TT expands the need for coordination and allows more complex and larger organization structures to

evolve. This outcome may indicate that the use of TT allows organizations to manage coordination intensive structures that are required to cope with response to environmental challenges.

On a final note, the contrast between the IPP paradigm's predictions and more contemporary notions of structural adaptations is interesting. I suspect that the impacts are indeed cyclical where pathologies evolve based on the increasingly poor fit between organizational structure and technology. New structural adaptations then emerge to take care of these pathologies. While I did not test this, it seems that a more dynamic understanding of structure-TT relationships might be warranted.

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