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COMPETING WITH TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY: RIVALROUS RESPONSES TO STRATEGIC IT NETWORK APPLICATIONS AND THE DEGREE OF INNOVATION

A Thesis
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of
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Susan Ann Roth Garrod

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of
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This work is dedicated to my husband, Robert Joseph Borns,
and to my children, John Kenneth Garrod and Joanna Michelle Borns.

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ABSTRACT

Garrod, Susan Ann Roth Ph.D., Purdue University, August, 1998. Competing with Telecommunications and Information Technology: Rivalrous Responses to Strategic IT Network Applications and the Degree of Innovation. Major Professor: Arnold C. Cooper. Co-major Professor: Carolyn Y. Woo.

This research examines the question: "What aspects of strategic networked information technology (IT) applications increase responses from competitors and what aspects reduce their response?" Competitive behavior is observed by the public announcement of the actions and responses resulting when firms use networked IT to carry out innovative applications pertaining to their products, services, or core business processes.

Data were derived from published articles describing networked IT applications across multiple industries, accounting for a total of 124 "action" applications in the time period from 1993 to 1994, and a total of 513 "response" applications within a 2-year sliding window from the date of the action. The applications were classified into four types of innovations: product, service, process, and innovations that extend beyond the firm's boundaries. Independent variables measured factors attributed to the industry environment, the degree of innovation of the application, the extent of business functions integrated by the application, and the use of publicly available networks. A tobit regression model was used to analyze the number of single responses per key competitor, and a negative binomial regression model was used to analyze the total number of responses.

When controlling for the main and interaction effects of the different types of innovative applications, the results revealed that competitive responses vary according to characteristics of the competitive environment and the way in which the technology is used. This suggests that the firm can plan ways to reduce competitive responses to its networked IT applications. Innovative service applications appear to have the greatest potential for sustaining a competitive advantage, due to the difficulty that competitors

have in responding to these applications. Internal process innovations also appear to have the potential for sustaining a competitive advantage. Product innovations appearing in industries that are not traditionally information intensive are also able to sustain a competitive advantage, possibly due to the fact that competitors are less familiar with ways in which to use the technology. Finally, public telecommunications networks can be used successfully, and their use does not necessarily incite responses from competitors.

CHAPTER 1: INTRODUCTION AND STATEMENT OF THE PROBLEM

1.1 Motivation of the present research

This research focuses on the question: "*What aspects surrounding strategic networked information technology (IT) applications increase responses from competitors and what aspects reduce their response?*" Networked IT is defined as the combined use of telecommunications networks with computing hardware and software. The strategic use of networked IT depends on the firm's ability to gain a competitive advantage that is not immediately duplicated by its competitors. Those applications which are not imitated quickly create a strategic advantage for the firm initiating the application. Although eventually competitors may copy or even leap-frog the benefits of the initial application, it would be advantageous to know what factors in the competitive industry environment and what factors of the application itself bear upon the responses generated by competitors.

Until now, there is very little that strategy scholars can tell firms about competing with telecommunications and information technology (Earl, 1988). Although the uses of such technologies are diverse, the ability to gain a sustainable competitive advantage seems to be elusive (Bradley, 1993). The strategic aspects of the technology described in the literature are largely anecdotal in nature by focusing on 'best practice' firms, and the assessment that IT provided a competitive advantage was based on normative conclusions or exploratory observations (Brynjolfsson and Hitt 1996a; Cash and Konsynski, 1985; Clemons and McFarlan, 1986; Clemons and Row, 1988; Neo, 1988; Porter and Millar, 1985). Considerable research has been conducted from a management information science (MIS) or economic viewpoint of IT. Numerous researchers have found that it has been very difficult to show any financial value or productivity gains attributed to the investments in IT (Baily and Gordon, 1988; Banker, Kauffman and Mahmood, 1993; DeLone and McLean, 1992; Mahmood and Mann, 1993; McKeen and Smith, 1993; Weill, 1990).

Research with a rigorous strategic focus has been lacking, possibly due to a variety of reasons. On one hand, early case studies portrayed competitive advantage as something of a common occurrence. Later, when quantitative results were not confirming the expectations from the earlier case studies, one perception was that the technology could not support a competitive advantage since it could be easily purchased by any firm. Alternatively, perhaps the lack of research by strategy scholars was caused by the complexity and diversity of the technology itself. Consequently, there are important gaps in the literature regarding the *strategic application* of the technology within the firm's core business processes. It is not mere investment in the technology that is of value to a firm, but rather the firm's *organizational capability to use the networked IT that can convey a competitive advantage*.

A cross-disciplinary approach at the application-level of analysis is needed to assess the strategic use of networked IT. This includes an analysis of technological aspects as well as the competitive aspects surrounding the use of the technology. Because of the lack of such analyses, key competitive issues surrounding the use of networked IT have not been examined rigorously from the viewpoint of strategic management.

When addressing the research question from a strategic viewpoint, one can begin by asking three basic questions: a) Why would a firm need to invest in any networked IT; b) What does the firm actually do with the technology; and c) What is the response from competitors? The need for using networked IT can be examined starting with the firm's competitive environment. The strategic tasks carried out with the technology can then be studied by analyzing the firm's innovative uses of the technology to support its core business processes. Finally, the competitive response can be examined by attempting to observe the rivalry that results when competitors also use networked IT to gain a similar benefit, thus minimizing the competitive advantage gained by the innovating firm.

Competitive environments differ according to their characteristics that drive the need for information. Two critical dimensions of the environment are the uncertainty resulting from the unpredictability and volatility of crucial factors, and the complexity resulting from intricate relationships of interdependent tasks that must be controlled and coordinated. These dimensions create information demands as well as opportunities for firms to exploit the benefits of networked IT as a strategic resource.

The firm's ability to use networked IT to innovate its products, services, and processes is an organizational capability with strategic importance. The resource-based view provides the basis to evaluate the competitive advantage that can be gained as a firm uses networked IT in a way such that the benefits are not easily duplicated by competitors.

The sustainability of the competitive advantage is a function of the strategic value of the networked IT application and the ease that competitors may have in imitating the application. These conditions set the stage for rivalry to ensue between competitors, as firms have incentives and the ability to respond with their own networked IT applications.

This research focuses on strategic applications of networked IT as actions and responses of firms competing with this technology. A model is proposed and tested that attempts to shed light on incentives for rivals to respond and the ease in formulating a response. The results reveal how the specific characteristics of networked IT applications affect the responses generated by rivals.

1.2 Managerial relevance

As more firms use telecommunications and information technology as a basis for conducting business and structuring their organization, the question of how to compete with these technologies becomes increasingly important. Information technology can be used for many purposes. What is strategic about the technology is the way in which it is used, rather than how much is invested in the technology. Since managers have many choices concerning the uses of networked IT, it is important to understand more clearly how some applications may contribute to the firm's competitive advantage. The results of this research begin to describe how certain characteristics of the applications can impede competitors from responding with their own applications. In short, the findings of this research contribute to a better understanding of how to compete in a world that will be filled with electronic commerce and virtual corporations that exist in cyberspace, as well as traditional manufacturing firms that find that they are faced with competition enacted through telecommunications and information technology.

1.3 Contributions to the existing literature

This research reveals new insights for strategy scholars into the strategic aspects of networked IT through an analysis of competitive behavior based on the firm's organizational capabilities to deploy strategic resources. It examines, in a limited context, the extent to which the firm's capability to use networked IT in a strategic manner can potentially sustain a competitive advantage as suggested by the resource-based view. The application-level analysis of the research provides an assessment of strategic actions carried out with IT, and the results of these actions are closely tied to the responses which are also carried out with this technology. Unlike other IT research which does not have a direct linkage between a firm's use of information technology and the expected outcome, this research focuses on the direct influence of IT on rivalry. This level of analysis provides a better understanding of the ways in which networked IT plays a strategic role for the firm.

Another contribution of this research is that it focuses on the use of the information technology in strategic applications pertaining to the firm's core business processes. The majority of prior research examines the investment in IT, or its use in tactical or administrative applications rather than strategic applications. Hence, the level of analysis intended to examine strategic IT applications is a significant contribution to this continuing body of research.

Finally, this research requires merging concepts from previously distinct disciplines and accounting for the information-demands of the competitive environment. The model is based on literature from the disciplines of strategy, information technology, technological innovation, and rivalry. It also accounts for the impact of the information-demands of the environment in which the firm competes, and how these demands affect the incentives for rivals to respond. Finally, it considers the strategic aspect of networked IT as it is used in both coordinative and exploitive ways to streamline the firm's processes, as well as creating value through new products and services that are only possible through the application of this technology.

1.4 Overview of the dissertation structure

This dissertation consists of seven chapters. This first chapter sets the stage for the research by noting the conceptual highlights and relevance of the research. Chapter 2 describes the literature streams that support this research, and identifies questions left unexplored in prior research that become the focus of this research. Chapter 2 also provides a series of case summaries in order to illustrate how an application-level of analysis research can be conducted to study how firms appear to compete with their networked IT applications. Chapter 3 defines the key constructs of the research, their relationship in the conceptual model, and the hypotheses that are proposed for testing. Chapter 4 describes the operationalization of the constructs. Chapter 5 details the data sources and research methods. Chapter 6 describes the statistical analysis of the data and hypotheses testing. Finally, the results of the analysis are discussed in Chapter 7.

CHAPTER 2: LITERATURE REVIEW

The research question, "*What aspects surrounding strategic networked information technology (IT) applications increase responses from competitors and what aspects reduce competitive response?*," requires a careful development of the issues which contribute to the strategic nature of networked information technology. First some key terms are defined. Then, the literature review is organized beginning with a strategic perspective to establish the rationale for the firm's motivation to use the technology. It then proceeds to examine how firms use information technology, and finally it considers the responses expected of rivals. The chapter concludes with a summary of cases illustrating how firms appear to compete with their networked IT applications.

Information technology (IT) is defined as the computer and communications hardware and software for encoding, storing, processing and transmitting information (National Research Council, 1994; Porter and Millar, 1985). Telecommunications networks encompass a wide range of technologies that enable information to be transferred between the individual computing and communication devices (Cerf, 1991). Therefore, in this research, *networked IT is defined as the combined use of telecommunications networks with computing hardware and software.*

The *use of networked IT to support a specific task* is referred to as an *application.* Some applications are intended to improve the efficiency of the firm's operations by automating tasks and increasing the flow of goods (Chandler, 1977; Zuboff, 1988). Others enhance existing products or create new products or services (Monnoyer and Philippe, 1991; Swanson, 1994; Zuboff, 1988). Hence, the firm can derive value in various ways from its networked IT applications.

The National Research Council (1994) reports that an insufficient amount of application-level research has been conducted in IT-related studies. The application-level focus is necessary in order to learn more about the nature of strategic uses of IT. With the lack of application-level research results upon which to draw, we do not know a great deal about how this technology is used in strategic ways, about the impact of the competitive environment on the use of the technology, and on the response of rivals. With an application-level analysis, there is a high degree of face validity that the scenario motivating the rival firms to respond using the technology is closely linked to the firm's initial actions carried out through its IT applications. Therefore, the goal throughout the literature review is to establish a conceptual model for conducting the application-level research.

Past research has focused largely on economic or market-power analyses of the strategic value of IT, because the focus of the research was on the relationship between a firm's IT investments and its financial performance (Bakos and Kemerer, 1992; Kettinger et al., 1994; King, Grover and Hufnagel, 1989). This research differs considerably by focusing on the how the technology is used in innovative and strategic ways, and assessing the competitive advantage as gauged by the response from rival firms. Therefore, the appropriate literature to support this research is a combination of the research streams derived from the resource-based view and organizational capabilities, information technology, diffusion of innovation, and competitive rivalry. In this chapter, we examine this literature to determine how strategic resources provide a firm with a competitive advantage, how information technology can serve as a strategic resource, and why firms might respond to a competitor's use of these resources.

2.1 Strategic resources and capabilities

The resource-based view of the firm suggests that a firm's strategic resources and capabilities are the sources of its competitive advantage. Strategic resources are the firm's endowment of unique and immobile resources, and they may convey strategic value to the firm because they stem from imperfect factor markets, asset flows, and asset stocks (Dierickx and Cool, 1989). They cannot be moved easily from one firm to another, and therefore they can lead to sustainable performance differences if managed properly. The conditions of resource heterogeneity and immobility enable a firm to earn above-normal rents when it uses its strategic resources in appropriate ways, thereby creating a competitive advantage.

The characteristics of the strategic resources are believed to determine the extent to which they can sustain a competitive advantage. Barney (1991) suggested that strategic resources are valuable, rare, socially complex, and causally ambiguous resources. Valuable resources reduce costs or increase revenues for the firm. Rarity stems from the unique ownership of the resources. Social complexity results when the resources are tied closely to the organizational structure and way of doing business, and when the configuration of the resources within the organization tends to evolve over time. Causal ambiguity is created when the way in which the resource generates value is not fully known, thereby making it very difficult to imitate.

The firm's capability to develop and use its resources is itself a strategic resource that is a source of competitive advantage (Collis, 1994). Organizational capabilities are unique to the firm because they are developed over time and are embodied in the way that the firm configures, coordinates, and deploys its physical and capital resources (Amit and Schoemaker, 1993). Consequently, they are immobile and cannot be easily transferred from one firm to another. The firm's capabilities can be evaluated according to their value and their degree of inimitability as they are used to transform inputs into outputs efficiently and in a way that can create a competitive advantage.

Grant (1996a) suggested that a firm's organizational capabilities are the true sources for sustainable competitive advantage because they represent the firm's ability to integrate tacit knowledge within its structure in order to perform value-creating tasks. The transferability of the firm's knowledge determines its inimitability and the extent to which it can sustain a competitive advantage. Knowledge which is easily encoded and transferred will not be a source of sustainable competitive advantage because it is highly mobile, whereas tacit knowledge that is embedded in the firm's processes and capabilities is not easily transferred and will be a more likely source of a sustainable competitive advantage.

Tacit knowledge differs from explicit knowledge in that it cannot be codified. It exists in the practical 'know-how' of the organization (Grant, 1996a), and it is revealed only through the firm's capabilities. Consequently, tacit knowledge is believed to be an important contributor to a firm's competitive advantage because it is the basis for the capabilities which are not easily transferred to rivals through imitation.

Capabilities that encompass a broad scope of knowledge transfer throughout the organization are causally ambiguous and therefore are especially difficult for rivals to imitate (Grant, 1996b). These capabilities are based on the broad integration of knowledge within the organization. Knowledge integration is a socially complex process requiring extensive coordination mechanisms which serve to create additional barriers to duplication. Consequently, capabilities that encompass the broad integration of knowledge across the organization are believed to be important sources of a sustainable competitive advantage because of their inherent inimitability.

The value of the firm's strategic resources, including its organizational capabilities, is influenced by the demands and opportunities within its competitive environment. However, the resource-based view provides minimal insight into the role that the firm's competitive environment may play in influencing the value of a firm's resources as they are used to create and sustain a competitive advantage. Therefore, we must consider the motivation for using particular resources as determined by conditions in the firm's environment.

2.2 Information demands in the competitive environment: demand uncertainty and information complexity

The firm's competitive environment creates the context in which it must leverage its resources through its organizational capabilities to create a competitive advantage. The competitive environment is determined by the firm's product market and consists of all factors external to the firm, including the competitive, social, political, economic, and technological factors. Firms competing in a particular industry must match the demands and opportunities of their environment with their strategy to gain a competitive advantage (Chandler, 1962). The environment is generally not controllable to any large extent by the firm. More specifically, and what is most important for this research, is that the competitive environment creates information demands and opportunities for the firm.

These demands and opportunities create the context for the firm to use its resources and organizational capabilities to achieve a competitive advantage.

The firm is confronted with information demands and opportunities which are determined by the uncertainty and complexity in its competitive environment. Environmental uncertainty pertains to the dynamics of the competitive environment, whereas information complexity pertains to the quantity of information that must be processed. By examining these opportunities and demands, one begins to understand the factors affecting the firm's motivation to invest in and use networked IT.

Uncertainty is defined as the lack of information (Daft, 1986; Daft and Lengel, 1986; Tushman and Nadler, 1978), and as the difference between the amount of information required and the amount possessed by the organization (Galbraith, 1977). Volatility of critical external factors creates environmental uncertainty (Mintzberg, 1979). Miller and Friesen (1983) refer to uncertainty as dynamism characterized by "the rate of change and innovation in the industry as well as the uncertainty or unpredictability of the actions of competitors and customers" (p. 222). Volatility in the firm's product market creates demand uncertainty which has significant implications for the firm's strategy and performance (Burgers, Hill and Kim,1993; Mills and Schumann, 1985; Wernerfelt and Karnani, 1987). Demand uncertainty arises due to unpredictable changes in buyer demand, and it can be caused by a variety of economic, technological, and product-related factors (Nohria and Ghoshal, 1994; Osborn and Baughn, 1990). A firm's ability to sense the demand variability and deploy its strategic resources appropriately is an important determinant of its competitive advantage.

Environmental complexity is defined as a large number interdependent factors (Mintzberg, 1979) and systems (Perrow, 1984) which impact the firm's operations. Bierly and Spender (1995) define complexity as a large number of highly interdependent subsystems with many possible combinations. There is little slack or buffer between the subsystems. Consequently, the subsystems interact with each other (Sanchez and Mahoney, 1996), and a perturbation in one factor causes a chain reaction in other factors (Garud and Nayyar, 1994).

Mintzberg (1979) proposes that in a complex environment, the firm's survival relies on its ability to process large amounts of information rapidly. The complexity increases with the number of information sources required by the firm, the number of business elements that must interact with these information sources, and the extent of the relationships between the business elements and the information sources (Haeckel and Nolan, 1993). Haeckel and Nolan (1993) suggest that firms must 'manage by wire' in order to meet the demands of the information complexity they are faced with. The firm's information requirements are also correlated with its size and scope, because the increasing size, strategic scope, and geographic scope increase its information sources (Egelhoff, 1991; Hagström, 1991).

Uncertainty and complexity are frequently confounded in the literature. Mintzberg (1979) defines 'hostile' environments as those with a high degree of dynamism, which created uncertainty and complexity. Such environments bombard the firm with severe information requirements, requiring that it simultaneously centralize its decisions in order to coordinate tasks and respond rapidly to the environmental changes, as well as decentralize its decisions in order to reduce complexity brought on by the information demands. Miller and Friesen (1983) define 'hostility' as the threat to the firm, the vigor and intensity in competition, and the volatility in the firm's primary industry. More recently, D'Aveni (1994) defined 'hypercompetitive environments' as those which are filled with a great deal of turbulence and complexity and which require rapid action on the part of firms.

Complexity and uncertainty are also confounded in empirical studies, thus preventing a precise analysis of the individual information demands on the firm (i.e. Lee and Leifer, 1992; Osborn and Baughn, 1990; Schoemaker, 1990). Ghoshal and Nohria (1989) defined 'environmental complexity' as a combination of technological dynamism created by product and process innovations in the industry, and the perceived competitive intensity in each of the firm's global markets. To further complicate matters, Galbraith (1977) defined 'uncertainty' in terms of the amount of information required, whereas Mintzberg (1979) defined 'complexity' in terms of the amount of information required.

Consequently, although it is agreed that the firm faces both uncertainty and complexity, we do not have a clear picture of how these forces uniquely affect the firm's ability to operate in its competitive environment. In addition, the research has not focused specifically on the issue of measuring the information demands of uncertainty and complexity in the competitive environment, although these demands are clearly stated in the theoretical arguments for the constructs. It is important to have a better understanding of how the firm can meet the information demands created by the uncertainty and complexity of its competitive environment, while also exploiting the information opportunities in that same environment.

2.3 Impact of information demands on the firm's strategy and processes

A firm's strategy is largely intertwined with its competitive environment. Chandler (1962) found that changes in the competitive environment forced firms to alter their strategy and their means of coordinating work in order to be successful. Part of the firm's strategic capabilities entail its ability to match the use of its resources to the demands and opportunities of the environment (Learned et al., 1965). The firm's competitive environment moderates the value of its strategic resources because it establishes the constraints and conditions which determine the earning potential of its resources. In particular, environmental uncertainty and complexity create considerable demands on the firm to be flexible to unpredictable changes and to process large amounts of information in an efficient manner.

Uncertainty and complexity have long been recognized by organizational theorists as forces which create the firm's information demands. However, their analysis of the firm's response to these demands was not from the point of view of its strategy but rather its structure and communication processes (i.e. Chandler, 1962; Galbraith, 1977; Mintzberg, 1979; Thompson, 1967; Tushman and Nadler, 1978). Miller and Friesen (1983: p. 230) write: "Organizations may be viewed as information processing systems whose viability depends upon their ability to master the challenges posed by their environments."

A hierarchy of organizational communication mechanisms have been used to analyze the increasing coordination needs of the firm's interdependent tasks. Galbraith's hierarchy (1977) consisted of rules and programs, hierarchical referral, goal-setting and planning, vertical information systems, and lateral relations. A very similar coordination hierarchy was proposed by Tushman and Nadler (1978), consisting of rules and regulations, formal information systems, special reports, planning, direct contact, integrators, and group meetings.

These hierarchies formed the basis of analyzing the firm as an 'information processing' entity. However, the focus of this early coordination research overlooked the strategic aspect of information processing: the ability for the firm to exploit information as a potential source of competitive advantage and to gather information from the environment, specifically customers. Coordination mechanisms were seen only as sources of efficiency for use within the firm's value chain, and not organizational capabilities that could provide a strategic advantage.

Economists have examined the relationship of demand uncertainty and a firm's flexibility as a way to explain how small firms compete against large ones. Mills and Schumann (1985) found that in stable markets firms benefit from their scale economies of production and achieve low fixed costs, whereas in volatile markets they benefit from owning flexible production technology which incurs variable costs. Scott, Highfill and Sattler (1988) demonstrated that flexible resources are valuable in an environment with uncertain demand volume. Fiegenbaum and Karnani (1991) essentially repeated the research of Mills and Schumann (1985), when they demonstrated that output flexibility created a competitive advantage for small firms in their empirical study of 3000 firms in 83 industries over a 9-year sample period. Cost inefficiencies were offset by volume flexibility, and such flexibility was most valuable to firms in volatile, capital-intensive industries. Flexibility had no strategic value in an industry with a stable demand. These findings justified the explanation of how small firms could successfully compete against large firms.

Wernerfelt and Karnani (1987) proposed that environmental uncertainty created strategic timing and resource trade-off issues for the firm. Within a certain environment, a firm can optimize its resources. In an uncertain environment, however, a firm must consider when to act and with which resources, and a strategic advantage might be gained through flexibility in allocating resources and conducting business.

Grover and Goslar (1993) studied the correlation between a firm's environment, organizational structure, and its pattern of adopting telecommunications technologies. Their findings suggest that there is a relationship between the environmental uncertainty facing the firm, its decentralized structure, and its likelihood to adopt telecommunications technologies. Their measurement of environment, however, is based on Miller and Friesen's (1983) definition of perceived environmental uncertainty, which they define as a result of combined increases in heterogeneity, dynamism and hostility. Therefore, this research confounds the measures of 'uncertainty' and 'complexity' as they are defined in this research. They found that as environmental uncertainty increased, firms were more likely to evaluate new telecommunications technologies and implement them widely within their organization. Data collection was accomplished through surveys to Information System directors and vice presidents of firms selected from the Standard and Poor's Corporate Guide and the Information Week 500 listing.

Miller and Shamsie (1995) tested the moderating effects of the firm's environment on its property-based versus knowledge-based resources in the film industry. Their research suggests that the firm's knowledge-based resources are more valuable than property-based resources in the uncertain environment, and that property-based resources are the more valuable in the stable and certain environment. The firm's knowledge-based resources are organizational capabilities developed over a span of time, and which have wide applicability to be used in a variety of scenarios caused by the changing environmental demands.

In summary, strategic resources sustain a firm's competitive advantage if they are valuable and inimitable. Organizational capabilities that integrate knowledge are difficult to imitate. When there is uncertain demand, the firm's resources that are most valuable are those which enable it to adapt rapidly to environmental changes. In complex environments, the firm's resources must enable it to coordinate the information and control the interdependencies that it faces. The firm's organizational capabilities can be used to meet the information demands and opportunities within its competitive environment if those capabilities can be channeled to process and exploit information. Theoretically, it can be argued that if firms have the capability to use modern information technology, they in effect have harnessed these resources to exploit the opportunities and meet the demands of environmental complexity and uncertainty (Haeckel and Nolan, 1993; Scott Morton, 1991). The analyses of the firm's resources in uncertain and complex environmental contexts have not explicitly taken into account the capability of information technology. This theory is explored in this research. Let us now turn to the information technology literature to examine how information technology may be used as a strategic resource.

2.4 Information technology

It has long been suggested that information technology (IT) plays an important strategic role for the firm. Bell (1979) described knowledge and information as the "strategic and transforming resources" (p. 26) of firms in the 'post industrial society,' also known as 'the information age.' He described information technology as the fuel for economic growth, replacing capital and labor which had fueled the growth of firms in the industrial ages. These claims are supported by the fact that from 1980 through 1990, the investment in computer hardware and telecommunications equipment in the U.S. alone amounted to over $2 trillion (Roach, 1997).

Information technology (IT) is defined as the computer and communications hardware and software for encoding, storing, processing and transmitting information (National Research Council, 1994; Porter and Millar, 1985). Telecommunications networks enable information to be transferred between the individual computing and communication devices. As stated earlier, networked IT is defined in this research as the combined use of telecommunications networks with computing hardware and software.

Networked IT applications result when firms use the technology to perform a task. Some applications are intended to improve the efficiency of the firm's operations by automating tasks and increasing the flow of goods (Chandler, 1977; Zuboff, 1988). Others enhance existing products or create new products or services (Monnoyer and

Philippe. 1991; Swanson. 1994; Zuboff. 1988). In a report by the U.S. Department of Labor. networked IT is cited as the most profound technology to reshape work since steam power (McConnell. 1996). It has altered the way firms respond to demand. it has increased the variety of products and services sold. it has created new products and services. it has enabled firms to gather information about their sales and share information with suppliers and customers. and it has lead to the globalization of industries.

A unique aspect of networked IT. unlike earlier technological innovations. is its versatility in both manufacturing and service industries. Declining cost as well as versatility has resulted in the increased use of networked IT in widely dispersed industries. such as banking. power utilities. retailers. manufacturers. and health care providers. The same. or very similar. computer tools and telecommunications networks can be used to transact financial processes. gather sales information from stores. share information with suppliers. and analyze market data (McConnell. 1996). The U.S. Department of Labor also notes that the technology has also created a yet-unclassified market which they refer to as the 'home market' where consumers at home. via their computers and public telecommunications networks. can access and exchange information throughout the world.

The use of IT is driven by a combination of 'technology push' and 'competitive pull' (Venkatraman. 1991). 'Technology push' refers to the significant performance improvements in the processing capabilities of IT. which have been accompanied by tremendous cost reductions (Cortada. 1996; Jonscher. 1994). Processing power. memory capacity. and transmission speeds have risen on the order of 10.000 times in performance-per-dollar-spent over the 30-year period from 1955 to 1985 (Cortada. 1996). Over this same time period. the total annual investment in IT in the U.S. has increased almost 40 times (Roach. 1997). Therefore. for the amount they spend. firms are purchasing an ever increasing amount of information processing power. The cost-performance improvements of IT have increased its attractiveness as a capital investment and have created opportunities for firms to replace other resources with information technology (Scott Morton. 1991).

Another important attribute of the 'technology push' of IT is its applicability to both the production and coordination tasks of the firm. IT can be used to support the production of goods, services, and information as well as the firm's coordination tasks within its processes, and in this way it becomes difficult to separate coordination tasks from production. With this dual role of coordination plus production, IT alters the traditional relationships of time and space, and it enhances the firm's memory capacity (Scott Morton, 1991; Yates and Benjamin, 1991). For instance, networked IT can be used to shrink time to zero or establish a more convenient time frame for coordinating tasks. It can also shrink distances to zero, therefore making distance irrelevant for information flows. Its effects on time and space result in a high degree of flexibility and adaptability in the firm's processes (Yates and Benjamin, 1991).

The 'competitive pull' of IT is created by firms attempting to leverage their IT resources in order to create a competitive advantage. The National Research Council (1994) found that service firms invested in IT for the purpose of expanding market share, preventing catastrophic loss in market share, increasing flexibility, improving quality and stability of internal operations, improving quality of products, and improving quality of customer interactions.

Closely associated with 'competitive pull' of the technology, competitive rivalry appears to increase as more firms use IT (Venkatraman, 1991). When IT supports product and process innovation, other firms often respond, frequently with additional uses of IT (National Research Council, 1994). For instance, they alter the nature of their products by enhancing or differentiating them, they offer new services that complement their original products, they create new market opportunities, and they alter their value chain and the configuration of value systems linking firms (Yates and Benjamin, 1991). The competitive responses carried out through the use of IT change the nature of competition between firms in an industry.

The IT literature provides explanations for how IT has been used as a substitute for other resources, especially human resources. It also identifies the expanded capabilities of the technology when it is connected via communications devices to form a network. The use of IT results in an increased demand for more IT, which leads to competitive issues surrounding its use for a firm to participate in an industry. The explanations, however, are largely technological, and they overlook many aspects of the technology that would come to light if the research had been conducted from the vantage point of strategy. While the technological explanations for the competitive role of IT are important, but they do not answer questions about how firms can sustain a competitive advantage with IT.

2.4.1 Strategic role of networked information technology

The strategic role of IT is described by Porter and Millar (1985), who state: "Information technology is transforming the nature of products, processes, companies, industries, and even competition itself, ... altering relationships among companies ... and rivals. ... [I]t alters industry structures and it spawns entirely new businesses". (p. 149) Similarly, many others have suggested that IT can reduce costs, increase growth, speed distribution, and customize products for customers (i.e. Cash and Konsynski, 1985; Clemons and McFarlan, 1986; Keen, 1988; McFarlan, 1984). Although some IT applications may involve an isolated computer performing a task, networked IT applications are seen as being the most powerful because they can extend the firm's processes beyond its own boundaries (Cash and Konsynski, 1985).

Networked IT applications establish linkages within the firm and across the firm's boundaries to its customers, suppliers, distributors, and partners. Some argue that the value of the networked IT applications lies in the geographic distribution of the linkages and the information flows they create, rather than in the endpoints or 'nodes' of the network (Hepworth, 1990). The linkages supported by IT enable it to distribute tasks across multiple business functions and organizations without regard for the geographic location of those functions. In addition, the linkages can be reconfigured according to changing demands for the network services.

Information technology is clearly not the only strategic resource within a firm, but it can be used in combination with the firm's other resources in order to carry out tasks. Venkatraman (1991) describes the increased opportunities for exploiting networked IT in innovative applications that transform the firm's business processes which may be based on non-IT resources. The ability for IT to transform processes increases as it integrates more tasks within the firm, as well as processes that extend across the firm's boundaries. When IT is used to integrate tasks within the firm and across its boundaries through the horizontal or vertical linkages supported by the technology, it can radically transform businesses processes and even redefine the strategic scope of the firm.

By considering both the strategy and IT literature, it appears that the sustainability of a competitive advantage supported by networked IT is based on the integration of tasks that exploit this technology in combination with the firm's other resources in a way that is unique as compared to applications developed by competitors. This now requires examining the strategic value of IT in the context of environmental information demands and opportunities for using the technology to determine the likelihood that it is capable of sustaining a competitive advantage in a given environment. This issue is an important conceptual thread as we consider the applications and characteristics of networked IT.

2.4.2 Types of strategic applications of networked information technology

There are many different types of strategic applications of networked IT. According to the National Research Council (1994), the variety of uses stems from differences in industry structure, regulation, timing of IT introduction and the adaptability of the firm's products and processes to change through IT. The National Research Council labeled industries as being 'information intensive' when the outputs of that industry were based on information. Their research found that IT is used very differently across industries and even in firms within the same industry. The performance results of firms using IT varied dramatically as well. Some uses of IT are essential for participating in the industry, as businesses could not even function without the basic IT infrastructure in place for telephone and transaction processing. However, innovative applications of IT could enable a firm to become a strategic leader in its industry.

In order to analyze the ability for networked IT to sustain a competitive advantage, it is necessary to consider its strategic value and its inimitability. Generic IT cannot sustain a competitive advantage because it is not a unique and immobile resource. Computer hardware and software can be purchased easily and telecommunications networks are becoming increasingly available world wide. With the tremendous cost reduction and availability of public networks, financial hurdles are minimal for using the technology. The inimitable attributes of IT are created only when a firm leverages the value of the technology by customizing its use to transform its businesses processes (Robertson, Swan and Newell, 1996). This requires embedding IT within the firm's value chain as part of its production and coordination tasks. When a firm integrates IT in its tasks, the benefits are not easily imitated by others because the technology becomes an integral part of the organizational capabilities carried out within the firm's value chain.

Organizational capabilities supported by information technology are difficult for other firms to imitate for several reasons. First, as with other organizational capabilities, the ability to use IT within its business processes represents an organization's tacit knowledge for using this technology to perform its tasks. This tacit knowledge can only be imitated through direct observation, and imitation through observation can be impeded by the causal ambiguity and social complexity of the tasks which involve extensive knowledge integration between business functions (Grant, 1996b).

Secondly, the application involving IT is generally a socially complex task, involving multiple business functions and possibly multiple locations. The social complexity can contribute to the inimitability of the application due to the extent to which it is embedded in the firm's business processes. The networked IT application consists of a combination of linkages and nodes. The linkages are the communications channels that allow information to be shared within the value chain, and the nodes are the endpoints of the linkages where work is conducted. For instance, at one node the work might be a manufacturing process, at another node it might be data analysis conducted at a workstation, and at yet another node it might be sales or reservations supported by a database of information. The way in which the combination of the linkages and the work at the nodes is performed constitutes the organizational capability supported by networked IT. The subtasks of the capability are distributed throughout the organization as a complex system, and they may even change with time. Consequently, the system is difficult to view in its entirety, and therefore it creates a unique organizational capability that cannot be easily observed and duplicated by rivals.

Considerable ex ante ambiguity surrounds strategic applications of IT. The National Research Council found that firms had great difficulty knowing in advance whether or not the strategic uses of IT would create a competitive advantage, because they could "change a firm's entire competitive or risk posture within a industry, affecting many different elements of customer, cost ,and competitive relationships simultaneously – not just revenues or costs." (National Research Council, 1994: p. 13). In particular, the Council reported that seemingly incremental changes to the firm's products or processes could have profound strategic results if they led to further changes and business transformation. Consequently, strategic applications of IT may focus on cost-reduction through innovative means of reducing cycle times, improving information handling such as billing and logistics, creating new or improved services, and customizing services (National Research Council, 1994).

Jarvenpaa and Ives (1990) found in their empirical research that the strategic value of IT applications, as suggested by the references made regarding IT by CEOs in their letter to shareholders, varies with the information demands of the industry. They studied 88 firms in four industries (banking, publishing, petroleum and retailing) over a 15-year period, and concluded that the strategic impact of IT varies across industries. Jarvenpaa and Ives did not measure the information demands of the industry, but based their research on general assumptions of the industry's use of IT. The banking and publishing industries are very information-intensive. Their product is information, the firms have considerable long-term experience in using IT, and they invest a large percentage of their operating budgets on IT. In the retailing industry, IT is used largely for cost-cutting, efficiency and reliability. In the petroleum industry, firms have little experience in using IT, with the exception of oil exploration firms. Their products are not time dependent and IT is not seen as having a large strategic role.

Jarvenpaa and Ives found that the number of references to IT by CEOs in the publishing, banking and retailing industries in the letter to shareholders were statistically equivalent, while the number of references by CEOs in the petroleum industry lagged far behind. Based on differences regarding the specific applications described by the CEOs, they concluded that firms in these industries use IT differently. Banking and publishing firms use IT primarily to support their products, whereas retailers and petroleum firms use it primarily to support their processes. The few times that IT was mentioned by CEOs in the petroleum industry, it was considered a "major event of the year." In all cases, though, the applications described by the CEOs focus on the firm's products or processes related directly to its industry, its customer linkages, and IT applications that made it possible to offer new products or to engage in new processes. CEOs did not discuss administrative nor decision support systems, and apparently did not consider these systems to be strategic. The degree to which the firms used IT strategically correlated with the information content of their products as classified by Jarvenpaa and Ives.

Powell and Dent-Micallef (1997) examined the relationship between IT and the performance of retail firms, where IT was used for home-office and in-store communications. In their research, they integrate constructs from the resource-based view and IT literature to propose that the competitive advantage of IT is based on how it is used to leverage the firm's complementary human and business resources. Human resources were defined as open organization, open communications, organizational consensus, CEO commitment, organizational flexibility, and IT-strategy integration. Business resources were defined as supplier relationships, supplier-driven IT, IT tranining, process redesign, teams, benchmarking, and IT planning. The technology resources were defined as computer hardware, software, and the linkages between the home office and the stores. All measures were perceptual, gathered from executives, home office employees, and in-store employees with five-item Likert-type scales. Powell and Dent-Micallef hypothesized that firm performance, as well as IT performance, would be positively related to the human and business resources complementary to IT, but that the IT resources alone would have an insignificant relationship on performance. Their research found a positively significant relationship between the perceived IT performance and several factors in human, business, and technology resources. However, for perceived overall performance, there was only a positive significant relationship with human resource factors. While they discussed competitive advantage, their research did not measure this by assessing any type of competitors' performance or responses.

Kambil and Short (1994) found that firms which used networked information technology to integrate tasks had greater opportunities to differentiate their products and services by leveraging the technology. By comparing the business network prior to electronic integration to that which existed after electronic integration, they found that the roles in the network had expanded, providing firms with greater opportunities to create a competitive advantage. Tax preparation firms that participated in electronic filing found new ways of competing by coordinating tasks and exploiting complementarities across closely related product markets that previously were too costly to exploit. The expanded roles and the new linkages within the business network increased its size and complexity. However, electronic integration also altered competition within the network as the firms used it to transform their products and processes and engage in new strategic roles in the network.

While Kambil and Short justified the need for electronic integration through a discussion of turbulence in the competitive environment and the reduced buffers between the firm and its environment which lead to a greater interdependence with the environment, they did not explicitly measure the environmental uncertainty or complexity facing the firm. They instead focused on the role of electronic integration and the firm's business network for transforming its products and processes based on the interdependence with the environment, so as to exploit the changing market demands.

While some IT investments can create a competitive advantage, not all do. As the technology has evolved and firms have invested at different rates and in different products, a firm may find itself with IT resources that are not capable of communicating with other systems or which are not suited to the firm's current strategy. This situation may occur, for instance, when firms merge and they have incompatible systems, or when different systems are developed for distinct tasks without a plan for firm-wide systems integration. Such IT systems create a competitive disadvantage for the firm if it is not able to overcome the problem of incompatible networked technology (Haeckel, 1996). Incompatible IT devices can only form isolated islands of automation if they cannot be networked across multiple business functions and across the firm's boundaries. The competitive advantage supported by IT requires that the firm is able to leverage the flexibility and powers of coordination that are created by the linkages supported by the networked IT applications.

Haeckel (1996) describes how Westpac Bank Corporation of Australia overcame such a disadvantage of mismatched IT networks to develop a new IT infrastructure in order to compete in a rapidly changing environment. The goal of Westpac was to use IT to offer innovative financial products in a shorter amount of time than was previously possible. Their new strategy focused on sensing and responding to the changing demands of customers. Consequently, although they had prior experience in electronic banking services, their new strategy required the firm to develop IT capabilities to integrate knowledge across interdependent banking units and business functions. They focused considerable effort on automating the development of software required in crucial business processes, as well as software that enhanced the financial products and services. Flexibility within the innovation of the firm's processes and products was achieved by standardizing on modules and linking the modules only when needed for the specific product or task. This enabled Westpac to offer customized products and services.

Another factor limiting the observed strategic role of IT is that not all firms which invest in IT actually exploit its capabilities. Jaikumar (1986) found that many IT-intensive manufacturing technologies are underutilized when firms deploy them to support low cost strategies. Although the cost-saving aspects of this technology are generally the principle means by which they are justified when initially adopted as technological innovations (Pennings, 1987), they do not account for the full benefits that can be gained. In order to exploit the technology, the low-cost benefits should be combined with its flexibility in manufacturing processes. Unfortunately, firms often overlook the ability of the technology to support flexibility in their production strategy. Jaikumar suggests that the strategic importance of IT-intensive manufacturing, such as flexible manufacturing systems (FMS), can be realized only when firms link the 'islands of automation' together to form manufacturing networks. However, such linkages require not only the networking technology but also considerable process innovation.

2.4.3 Value of IT resources moderated by the information demands of the environment

The strategic value of IT is enhanced when it is used to respond to the information demands in the environment. The firm can derive value in various ways from its networked IT applications to meet the demands of uncertainty and complexity within its environment. To meet the information demands of the industry and the environment. networked IT can be used by the firm as a production technology as well as a coordination technology (Venkatraman, 1991). Thus, information is a valuable resource in an 'information intensive' environment which is created when the firm is faced with significant levels of demand-related volatility and complexity.

2.4.3.1 Environmental uncertainty

As described earlier. demand-related volatility creates uncertainty. and firms with flexible resources are more successful in such environments than others. Networked IT resources can provide such flexibility in the firm's manufacturing processes as well as administrative and coordination processes throughout its value chain (Sethi and Sethi. 1990). The networked IT can also create flexibility in the value chain by rapidly reconfiguring its linkages. thus enabling the firm to shift its productive capacity as needed in response to demand variations.

A firm's networked IT constitutes flexible production technologies which enable it to handle demand volatility. Sanchez (1993) reports that investments in the firm's information infrastructure enable it to be more flexible in the face of environmental uncertainty, and Grover and Goslar (1993) report that a firm's investments in telecommunications technologies correlate with the demands of the environment. Haeckel and Nolan (1993) discuss the importance of acquiring information about changing customer needs in order to adjust to the demand volatility. Clemons and Row (1993) also observed that uncertainty is reduced by IT due to the increased information provided about the various demand conditions.

Zaheer and Zaheer (1995) examined how currency trading firms used their global electronic currency exchange networks to respond to the rapidly changing environmental conditions. In this industry, the firm's performance is determined by its information flows into and through the organization. It must have access to timely global information and it must integrate information rapidly through its operations in order to negotiate currency trades. The firm's capability to use its networked IT determined its degree of alertness to changing currency demands and the speed at which it could respond. The speed of response enabled it to exert a greater competitive influence on the market.

2.4.3.2 Information complexity

Environmental information complexity is another demand-related information driver that enhances the strategic value of the firm's networked IT. As described earlier. complexity requires that large amounts of information be processed rapidly by the firm (Mintzberg, 1979). Information complexity requires that the firm coordinates many interdependent external sources of information as part of its core business functions in order to enhance the efficiency of its operations (Haeckel and Nolan. 1993). The complexity creates coordination demands on the firm and increases the strategic value of IT to handle the complexity. In the case of industries where the product itself is information. such as banking. finance. and insurance. the strategic demand for IT is very high because it can perform the dual role of coordinating processes and transporting the products of the firm (Porter and Millar. 1985; Jarvenpaa and Ives. 1990; Swanson. 1994).

Networked IT supports vertical and horizontal coordination applications with speed and processing capabilities that are unmatched by traditional organizational coordination mechanisms. and it has changed the way business is conducted between and within firms (Yates and Benjamin. 1991). As a coordination mechanism. networked IT can be combined with other production and transportation technology to match supply with demand and reduce inventories and slack. The availability of modern telecommunication networks extend the opportunities to use IT worldwide as an economically feasible coordinating mechanism for small firms as well as large (Jonscher. 1994; Rockart and Short. 1991).

Networked IT can coordinate the firm's tasks by altering time and distance relationships of interdependent activities. which has led to new means of managing the organization and conducting work through extensive intrafirm and interfirm linkages supported by IT (Davidow and Malone, 1992; Rockart and Short, 1991). These linkages enable the firm to share expertise, decision making, responsibility and work tasks across the organization and beyond, without regard to location. Cross-functional teams can be assembled on demand to conduct work activities, and then they can be reconfigured as new demands dictate. Vertical linkages to suppliers, partners, and distributors enable the firm to coordinate and control activities beyond its borders. Business processes can be re-designed to allow for the emergence of a 'virtual corporation' structured largely on the coordination capabilities of networked IT through intrafirm and interfirm linkages (Davidow and Malone, 1992).

When firms apply their IT resources as coordination mechanisms, they are often able to expand operations to a wider geographic scope and process a greater number of transactions (Monnoyer and Philippe, 1991). Multinational corporations carrying out global activities use networked IT extensively to coordinate their operations (Bartlett and Ghoshal, 1993; Egelhoff, 1991; Hagström, 1991) In fact, the use of networked IT to coordinate such activities is recognized as the means which enabled these multinational corporations to expand globally (Chandler, 1990).

Networked IT allows firms to carry out more interdependent tasks among an increasing number of business units. This increases the complexity facing the firm and requires additional coordination through linkages between the interdependent business functions (Jonscher, 1994). The coordination requirements extend beyond the firm to the customers and suppliers, and they provide new opportunities for the firm to serve its customers through the linkages created by networked IT. Hence, IT is both a driver of complexity as well as a resource used to meet the demands of the complexity. In other words, "technologies create needs that only more of the technology can fulfill" (Attewell, 1994, p. 47) to meet the demands of coordinating the interdependent relationships.

It can be seen how IT creates additional demands as it coordinates interdependent functions by examining what occurs when tasks are automated with IT. Zuboff (1988) defines task automation as resulting when human labor is replaced with computing and networking technology. When networked IT is applied to tasks, it transforms them from a physical domain to the "abstract domain of information" (Zuboff, 1988: p. 23).

Through automation, the cost of labor is traded for the cost of information and processing (Wilson, 1993). The automated systems produce goods more rapidly, but they also require rigid instructions in the form of computer programs in order to achieve the tight degree of coordination between tasks. The speed of the operation and the tight coordination ripple throughout the firm's value chain, creating further demands of coordination and control using IT (Hayes and Jaikumar, 1988). This results in a greater level of information complexity facing the firm (Bradley, 1993; Kettinger, Grover, Guha and Segars, 1994), caused by the high degree of interdependencies between the activities linked together with the networked IT (Lawless and Finch, 1989). As a result of these many factors, while networked IT is used to automate tasks, it also increases the information demands on the firm.

The demands for using networked IT also extend to the industry. The use of information technology enables firms to expand their global scope, enhance the service and quality of their products, reduce costs, and increase the speed of getting products to market (Rockart and Short, 1991). Task automation has also shortened business transaction cycles, and it has made time a critical factor of competition (Keen, 1988; Wang and Seidmann, 1995). Although automated processes are more efficient than manual tasks, they also are likely to create additional information demands that can only be met by using more information technology because of the speed at which they generate information to be processed and the variety of information sources involved in the automated process (Rockart and Short, 1991). When the automated process requires fewer interdependent tasks than the original process, the complexity of the task is reduced because fewer linkages between tasks are required. However, in general the automated tasks create new or different linkages between a wider array of business functions because of the speed and processing capabilities of the technology (Kambil and Short, 1994; Zaheer and Zaheer, 1995).

When firms automate tasks, they can use the technology to establish linkages that were never before possible. The most common linkages that are established are between the firm and its customers, suppliers and distributors. Customer linkages enable it to exchange information for customized order processing and service delivery (Gilmore and

Pine. 1997; Levy. 1997; Pine. 1993. 1996). Supplier linkages enable the firm to support rapid delivery of components and reduce its own inventory holding costs (Lampel and Mintzberg. 1996; Levy. 1997). Distributor linkages support rapid delivery of the product to the customer. With the establishment of these linkages. firms are meeting the demand of the environment while reinforcing their interdependency on the information sources. Thus. while networked IT is used to automate tasks. it drives the need for further use of the same technology (Hayes and Jaikumar. 1988: Jonscher. 1994; Venkatraman. 1991).

There are many examples of industries where IT has been used to automate tasks. One well known example is in the airline industry. where the use of IT is "associated with competitive leadership and with survival as complexity has increased" (National Research Council. 1994: p. 7). Air traffic control systems. ticketing. sales. capacity and load management systems. logistics planning. sales. marketing. maintenance and safety are all examples of where IT is vital to the survival of firms in the industry. as well as a source of competitive advantage. Industry deregulation and structure have had an impact on the importance of IT in the operation of airlines. in order to improve the efficiency and reduce the cost of providing their service.

In telecommunications. IT provides the basic infrastructure for services offered by the industry. and it is fundamental for processes such as "operations management. billing. customer service. product differentiation and new product development" (National Research Council. 1994: p. 8). Again. deregulation of the industry heightened the impact of the role of IT by encouraging a diverse array of services to be offered and by altering the industry structure. Firms relied on their networked IT resources in order to enhance the efficiency of their operations as well as provide new services. The competitive reach of firms has been broadened by a combination of the capabilities of the technology as well as changing regulatory structures. The boundaries between the originally defined industries of telephone. TV. and data services are becoming increasingly blurred as providers are offering many of the same services to customers.

In the retail and wholesale trade industries. firms depend on IT to process transactions. collect and analyze sales data. coordinate purchases and sales. reduce inventories. and speed products through the supply chain from manufacturers to the end customers. Firms rely on global IT networks to "improve the cost, quality, and timeliness of their offerings" (National Research Council, 1994: p. 9). Changes in industry structure were brought about by the ability of innovative firms to use IT to alter the bargaining power of retailers versus suppliers. In some cases these changes allowed retail and wholesale functions to merge, thus broadening the competitive behavior of firms beyond their original industry. Some firms became general merchandising or supermarket and grocery operations, while others became highly specialized in a particular segment of the market. The common element in these applications of networked IT is that the innovative firms used the technology to significantly increase the amount and speed of information flow in order to improve their efficiency and reduce costs. This use of IT caught other retailers and wholesalers by surprise, whose networked IT systems were not easily adaptable to the new configuration implemented by some firms. Consequently, while some firms were using IT to innovate their processes and change the configuration of information flow within the value chain, other firms found it difficult to convert the use of their existing IT investments to respond to these competitive threats (National Research Council, 1994).

The health care industry relies extensively on IT in the areas of diagnosis and therapy, but less so in the area of business operations (National Research Council, 1994). Tele-medicine services are also exploiting the capabilities of networked IT to reduce time and distance limitations that have been based largely on the location of highly specialized experts. The networking technologies can now extend the reach of these experts throughout many medical facilities. The technology was vital for meeting the demands of the "complex reporting requirements" of the industry (National Research Council, 1994: p. 9), and without such technology, the costs of meeting these demands would increase substantially. However, at the time of the National Research Council study, the health care industry was not using IT as well as other industries to improve efficiency and reduce cost of providing service across the board, and this was seen as an area of future potential for increase use of the technology.

The financial industries have been long-time users of information technology. In banking, the use of IT has "enabled increases in the volume of transactions as well as the development of new products; applications have ranged from back-office (check and accounts) processing, mortgage and loan application processing, and electronic funds transfer to more strategic innovations such as automated teller machines and new kinds of securities" (National Research Council, 1994: p. 10). Networked IT has even enabled financial service institutions to establish linkages that control banking and investments world wide, thus reducing an individual nation's ability to control its currency value. Some have made references to the financial community operations being based on the information standard, rather than the gold standard. Networked information technology is used to "manage trillions of dollars in daily transactions by the securities markets of the world, functions that physically could not be handled without IT" (National Research Council, 1994: p. 10). IT has also altered the competitive behavior across industries, as banks, securities dealers, and insurance agencies compete by offering many of the same types of services to consumers. Such competition broadens the reach of competition across the original narrowly defined industries into broader industry categories.

The insurance industry is similar to the banking industry in that it relied on IT for many years to support the transaction processing requirements of the back-office operations, such as claims processing and account updating. However, IT has moved into new areas by enabling agents to access information on-demand from the field, if necessary, in order to improve the efficiency of providing services to customers. Furthermore, IT has also enabled insurers to provide new services, such as managed health care and customized insurance products, on an national basis. In general, IT is credited with increasing the efficiency, scale, and accuracy of providing these services (National Research Council, 1994).

The impact that networked IT has on competition is dependent on the value of the technology as well as its inimitability. While there is considerable evidence that the networked IT applications can take many forms, and that their strategic value is expected to differ according to the environmental contexts in which they are used, we still need more information regarding the characteristics of the applications that impede rivals attempting to duplicate the benefits of the applications. The link between the application, its strategic value, and rivalry is an area that requires further investigation because of its direct impact on a firm's competitive advantage over other firms. A firm's competitiveness often depends on its ability to keep up with innovations in products and processes (Pavitt, 1990). To gain further insight into this area, we now turn to the literature on the diffusion of innovation in order to identify factors pertaining to the innovative use IT and how that use spreads through a population of firms.

2.4.4 Diffusion of IT innovation

Organizational innovation is defined broadly as a product, service, or process that is new to the business unit of a firm (Daft, 1978; Swanson, 1994; Tushman and Nadler, 1986). The diffusion of IT innovation pertains to the trend of organizations adopting IT applications to support their products and processes. Swanson (1994) is the first to develop a typology of IT innovation among organizations, based on the works of Rogers (1983), Daft (1978), Robey (1986), and Zmud (1982) which pertain to the diffusion of technological innovation in general.

Swanson (1994: p. 1072) defines IT innovation as "innovation in the organizational application of digital computer and communications technologies (now commonly known as information technology or IT)." He develops a typology of IT innovations in order to account for their impact on the organization's products and services, as well as the impact on the organization's administrative and technical processes. Product innovations alter an organization's product domain, and process innovations create new procedures, methods, or responsibility in existing domains (Zmud, 1982). Administrative process innovations affect internal control, coordination, and structures, whereas technical process innovations change the work processes and technologies used to create the firm's product and services (Robey, 1986). The degree of the product or process innovation affects its ease of diffusion throughout the industry.

Swanson's typology defines three types of IT innovations which span the firm's value chain. The first type (Type I) changes the nature of the IT work of the organization, altering administrative and technical processes related to the IT functions in the firm. Examples of this first type of innovation include the organization and leadership structure of the MIS department, adoption of particular programming techniques, and adoption of particular computing and networking technologies. The second type (Type II) extends the application of IT to change the nature of the general administrative work of the firm. Examples of this type of innovation include accounting systems, data processing systems, executive information systems, and decision support systems. According to Swanson, both Type I and Type II innovations primarily affect the firm's operations and have only second-order effects on its strategic operations.

The third type of innovation in Swanson's typology (Type III) changes the nature of the firm's core business functions. Type IIIa innovations have a direct impact on technological processes, Type IIIb innovations alter products and services, and Type IIIc innovations affect horizontal and vertical integration with other firms. Examples of Type IIIa innovations include material requirement planning systems, early airline reservation systems, and computer integrated manufacturing systems. Examples of Type IIIb innovations are the later airline reservation systems and remote customer order systems. Examples of Type IIIc innovations include electronic data interchange systems, interorganizational supplier-buyer systems, and later types of airline reservation systems linking airlines with other organizations. Type III innovations are strategic because they potentially affect the firm's business and are likely to create a competitive advantage for firms who initiate the innovations (Swanson, 1994). Each of the Type III innovations requires a high degree of integration between the firm's functions, its configuration from one firm to another is unique, and they are imitable only through observation. Consequently, they are a result of unique and immobile organizational capabilities and can be a potential source of sustainable competitive advantage.

As an innovation is adopted by subsequent firms, it evolves and takes on additional innovation characteristics. These additional innovations within a specific Type III innovation can be described in terms of increasing degrees of innovation by categorizing the evolution as incremental, synthetic, and discontinuous (Tushman and Nadler;1986). Incremental innovation is based on small changes to the products or processes involved. Synthetic innovation is a result of new combinations or re-combinations of existing products or processes. Discontinuous innovation occurs when there are significant changes in products and processes.

The nature of the diffusion of Type III innovations through industry is believed to have a critical impact on competition. The first firms to adopt a Type III innovation in an industry are likely to gain a competitive advantage over others (Swanson, 1994). Other firms mimic actions of successful organizations, further increasing the legitimacy of the innovation (DiMaggio and Powell, 1983). However, once a Type III innovation has become institutionalized, or adopted by many firms in the industry, it becomes a requirement for competitive parity and survival in the industry and is no longer a source of competitive advantage (Swanson, 1994). Consequently, the extent to which a Type III innovation can sustain a competitive advantage is dependent on the likelihood and speed of other firms adopting it at well.

Several factors pertaining to the IT applications affect the diffusion of such innovations in an industry. With regard to the applications, Swanson indicated that Type III innovations are more likely to be adopted by firms when they have a strategic value to the firm within its competitive environment. As the degree of innovation increases (such as the case with incremental, synthetic and discontinuous innovations) the speed of diffusion decreases because of the increased costs to make changes in the firm's existing technology, increased uncertainty regarding the value of the innovation, and increased learning requirements for the organization (Tushman and Nadler, 1986). Incremental innovations are believed to diffuse more rapidly because they can be adopted incrementally in the organization, whereas synthetic and discontinuous innovations are believed to diffuse more slowly because they require radical changes to organizational processes (Pennings, 1987). Incremental innovations are also likely to diffuse more rapidly because they do not require a large amount of organizational learning (Ali, Krapfel and LaBahn, 1995). Firms can rapidly bring to market those product innovations that require only simple technological changes to existing products. We are seeing now the widespread reliance on modular production techniques that are based on incremental or synthetic innovations that occur through the recombination of existing product components (Lampel and Mintzberg, 1996).

The nature of linkages required by an innovation also plays a significant role in the diffusion of the innovation. An innovation that requires tight linkages within the firm's processes is considered 'tightly integrated' because of the extent of knowledge coordination that must occur between tasks. It requires strong intrafirm linkages between the appropriate functions and operating units (Pavitt, 1990). An integration that requires extensive knowledge integration within a firm is expected to diffuse more slowly across the industry because of its impact on existing firm processes (Pennings, 1987). For instance, innovations in processes that complement the technologies are believed to occur more slowly than innovations pertaining directly to the technology because technological innovations are more observable whereas process innovations are more deeply embedded in the organizational processes (Damanpour and Evan, 1984).

Issues regarding the network externality aspects of innovations supported by IT must also be considered. 'Network externality' refers to the scenario when the economic benefits of resources are based on a system of compatible resources, and when the value to individual users is dependent on the size of the installed base of users of the system. (Katz and Shapiro, 1985). The value of the network to each user also increases as the number of locations it serves and the users it connects increases (Saloner and Shepard, 1995). [Liebowitz and Margolis (1994) advocate reserving the term 'network externalities' for the situation when market failures occur due to monopolistic or oligopolistic powers exerted by some users who control the network, and they describe the more general situation as 'network effects.' However, Katz and Shapiro (1994) use both terms interchangeably in reference to the situation when the value of membership in a network increases when another member joins and enlarges the network.]

Although many goods exhibit network externalities, the opportunities to exploit the benefits of network externalities are especially prevalent with networked IT resources. The value to each individual user connected to a telecommunication network increases as the number of users and geographic scope of the network increases. Airline reservation systems, banking automated teller machine (ATM) networks, and many applications that rely on the World Wide Web are examples of networked IT applications which exhibit 'network effects.'

Competing with products that exhibit network effects requires careful consideration of issues pertaining to coordination with others within the network and compatibility with the existing installed base (Katz and Shapiro, 1994). The network effects are generally associated with 'demand-side' economies of scale, as a user connected to the network can exploit the geographic scope of the network if the products are compatible with the system in place. Innovations supported by networked IT diffuse more rapidly through the industry as the potential network scope of the innovation increases because of the network effects (Saloner and Shepard, 1995). However, innovations that are not compatible with the installed network are less likely to diffuse because of the switching costs created (Farrell and Saloner, 1986). Consequently, discontinuous innovations are expected to diffuse more slowly through the network, or possibly not at all, because of the inertia that prevents their acceptance in the network (Farrell and Saloner, 1985). On the other hand, incremental and synthetic innovations should diffuse more rapidly because they maintain compatibility with the installed network base and because they can be adopted by users across the network.

Saloner and Shepard (1995) found that as the size of an ATM network increased, banks are more likely to adopt the innovation because of the subsequent benefits of the large network. In addition, banks with many branches are more likely to adopt ATM sooner than other banks because their own geographic scope benefited from the network.

Farrell and Saloner (1986) found that when an installed base of goods formed a network, the network effects inhibited innovation. The inertia of the existing network caused innovations to diffuse only gradually, and the innovating firms bore a significant cost due to the incompatibility of their innovation with the existing network. Some firms rely on these switching costs when initially creating a network to attract users, as a means of retaining users. However, the network inertia also means that only incremental innovations are likely to diffuse, as they are likely to remain compatible with the existing network.

In summary, the literature from the areas of strategy, information technology, and innovation provides us with general guidelines regarding the strategic role of networked IT. In industries where the products have a high information content, firms are likely to use IT in strategic applications. However, this does not preclude IT from being used strategically in other industries. The environment moderates the value of the specific IT application and the network of linkages that it supports within the firm, as well as those between the firm and its customers, suppliers, distributors, and other partners. Linkages are valuable in uncertain and complex environments because they enable the firm to gather information and adapt rapidly to changing demand conditions and they enable the firm to coordinate and control interdependent factors. The sustainability of the competitive advantage created by the IT applications is determined by the speed with which they diffuse to other firms. There is evidence suggesting that the speed and extent of diffusion is a function of the degree of innovation, the extent of knowledge integration encompassed by the application, and the network synergistic effects that surround the use of IT. However, the literature stops well short of explaining how specific characteristics of the networked IT application, carried out in a particular competitive environment, affect its strategic value and inimitability.

Let us now turn to the competitive rivalry literature to examine, in general, what incentives firms have to engage in rivalry and what factors facilitate the exchange of actions and responses between firms. Rivalrous behavior is the means by which this research assesses the sustainability of the competitive advantage created by a firm's ability to use networked IT.

2.5 Competitive rivalry

Rivalry is an exchange of actions and responses between firms that compete for the same group of customers (Chen, 1996). Firms engage in rivalry in order to enhance their strategic position relative to others in the industry (Porter, 1991). When a firm initiates an action, competitive responses may be provoked for the purpose of limiting the advantage that the initiating firm might gain from that action. A firm's strategic actions are played out in the dynamic competitive maneuvers between competitors (D'Aveni, 1994), and therefore the exchange of moves and countermoves between firms reveals the nature of the rivalry between the firms (Caves, 1980; Porter, 1980; Smith et al., 1991). The firm's sustainable competitive advantage is determined by its strategic moves and the responses of its competitors.

Rivalry can be examined directly by observing the action/response dyad that occurs between firms. Chen, Smith and Grimm (1992) analyzed the competitive action/response dyad of firms in the airline industry. Their findings indicate that the strategic importance of the application is determined by the threat that it poses for competitors and the competitive advantage that it creates for the initiating firm.

Competitors respond to strategic actions in order to protect themselves from the impending threat or to limit the initiator's advantage that might be gained from the application. The responses could attempt to imitate the initial action, thereby negating any 'uniqueness' factors which might allow a firm to earn rents. Responses could also try to duplicate the benefit or gain a greater benefit for themselves with some other approach. This type of response would 'leap-frog' the initial action to gain a greater advantage, or 'substitute' other resources to achieve a similar benefit.

According to Chen (1996), awareness, motivation, and capability are the three conditions required to create a competitive response. First, firms must be aware of their competitor's actions in order to respond. A firm is aware of the actions of its competitors through its boundary spanning activities and processes that extend beyond its borders.

Second, they must be motivated to respond based on the importance of the action. Rivals are motivated to respond when there is an incentive created by the strategic value of the action. The strategic value is influenced by the relationship of the action to the firm's product and by the moderating effects of the environment. According to Spatt and Sterbenz (1985), rivalry itself motivates further rival responses. Rivalry reduces the time for firms to learn about the value of an investment. The number of rival responses as the speed of response increases.

Finally, firms must have the organizational knowledge and resources to be capable of forming a response. The likelihood of response, therefore, is also determined by the 'ease of response' which is dependent on characteristics of the action's inimitability. Firms formulate a response to an action generated by a competitor if it is easy for them to do so. Chen and Miller (1994) found that competitors are able to respond quickly to applications that are highly visible and which are easiest to respond to. In contrast, they found that actions that are less visible, distributed, and difficult to imitate provoke fewer responses. Therefore, a method of sustaining the competitive advantage created by an action is to implement it in a distributed fashion so that the precise source of the advantage is not clearly visible or easily understood.

Let us now examine aspects of competitive rivalry carried out through a firm's IT applications, and the characteristics of those applications that make them difficult to imitate. The literature on the diffusion of IT innovations suggests that the inimitability of an action can be affected by factors pertaining to the type and degree of innovation involved. Additionally, the strategic resources and organizational capabilities literature suggests that the inimitability of an action is affected by organizational factors such as the extent to which the action requires broad tacit knowledge to be integrated across the firm, thus contributing to the causal ambiguity and social complexity of the action as observed by rivals.

MacMillan, McCaffery and Van Wijk (1985) studied competitors' responses to easily imitated commercial banking products as a function of the product characteristics. Many of the banking products were based on IT applications, such as Merrill Lynch's Cash Management Account. They found that technical barriers were not the major impediments to imitation. Rather, the rivals' responses were delayed by organizational factors, such as changes in organizational routines and whether or not the product fit into the existing organizational structure. They found that the time lag for competitors to respond was positively associated with the complexity and radicality of the product. Radicality was defined as the extent to which the product required new procedures and routines, suggesting the degree of innovation required for implementation. Complexity was defined as the extent to which the product was built upon interdependent organizational procedures, suggesting the degree of knowledge integration required for implementation. These characteristics contributed to the inimitability of the new products launched, and therefore made it more difficult for rivals to respond.

Spatt and Sterbenz (1985) developed a model which demonstrates that rivalry increases as more firms respond to an innovation. As rivalry intensifies, it reduces the learning time available to firms because of the pressure to 'jump in' when competition is based on an innovation. With reduced opportunity to learn, firms are more likely to innovate in smaller degrees. Incremental innovation allows a firm to still compete with rivals by adopting the innovation, and it reduces its learning demands that are exacerbated by the rivalry.

Consistent with the model by Spatt and Sterbenz (1985), Hannan and McDowell (1987) found that the adoption of automated teller machines (ATMs) occurred more rapidly as the number of cumulative adoptions increased. The rapid adoption by firms in the industry was explained as a form of rivalry. As argued earlier, ATM adoption can also be explained according to network effects. Consequently, a firm's network-based actions are a recognized form of rivalry. The likelihood and rapidity of response increased as more firms adopted ATMs.

The manufacturing literature suggests that firms have considerable difficulty imitating the benefits of networked IT applications within their manufacturing operations. During the tremendous increase in global competition in manufacturing that began in the 1980s, it was largely perceived that foreign competitors were gaining their advantage through the use of IT in their manufacturing processes (Hayes and Jaikumar, 1988). In spite of U.S. firms being able to observe foreign competitors using IT in manufacturing processes, the U.S. firms were not able to duplicate the benefits largely because they were using the technology in the wrong way. The firms had similar or identical technologies at their disposal, however their use of the technologies was very different. The U.S. firms generally replaced older manufacturing machines with programmable automation technology, but they did not alter the tasks or the processes. The firms used the flexible manufacturing technologies for high-volume production, rather than for high-variety low-volume production, and in doing so, the flexibility of the programmable automation was not exploited (Jaikumar, 1986).

The difficulty encountered in exploiting the new technology was often not a limitation of the technology, but rather a limitation caused by managerial techniques for organizing work and making decisions within the organization (Hayes and Jaikumar, 1988). This evidence suggests that applications which require changes to organizational processes and the integration of knowledge across the firm are more difficult to imitate because of the causal ambiguity and the social complexity of the application embedded within the organization (Grant. 1996b).

Once a particular IT application has been institutionalized in an industry. it creates the conditions for mere survival in the industry. Dean and Snell (1996) studied early adopters of IT-based machine tool technology and found that the value of the technology was moderated by industry competition. Increased competition reduced the performance relationship with IT. largely due to the likelihood that there was widespread imitation and that most all firms are gaining similar benefits through the use of the technology. The impact of the technology was highest for firms pursuing a 'quality' strategy and weakest for those pursuing a low-cost strategy. They found it odd. though. that the strategic potential of the technology was largely underutilized. as few firms used it to support revenue-production.

The rivalry literature suggests that a wide variety of factors may influence responses from rivals. These factors include the degree of visibility of the action. the degree of threat posed by the action. the ease of responding or imitating an action. the organizational capabilities to respond. the ability for the firm's structure to support change. the ability to integrate new tasks with existing organizational routines. and the ability to add new products or services to a firm's existing product line.

There are still open questions as to what the firm generating the action can do to reduce the likelihood of competitors' responding rapidly. The extant literature suggests that by keeping actions discrete. difficult to understand. and difficult to imitate. the firm initiating the action can sustain the competitive advantage. There is no indication regarding the influence of the environment on the rivalrous behavior. Furthermore. none of the studies explicitly examined networked IT applications. Some examined ATM networks. which only amounted to installing the cash machines. or to IT-related bank products. which did not explicitly require a network. Therefore. we do not know how the rivalry might vary with distinct types of networked IT applications. Consequently. there are many unanswered questions concerning the characteristics of the networked IT application that have an impact on the sustainability of the competitive advantage provided by that application.

The next section describes cases where networked IT has been used by firms in an attempt to sustain a competitive advantage. These case summaries illustrate the types of situations that would provide the information necessary to conduct application-level research to study how firms compete with their capabilities to use networked IT in an attempt to gain a competitive advantage.

2.6 Cases: Rivalry enacted through information technology

There are many examples of firms competing on the basis of their capabilities to use information technology. IT has been used by firms to engage in intra-industry as well as inter-industry competition (Keen, 1988). Airlines, for instance, engage in intra-industry rivalry with their computer reservation systems that give them the ability to control prices and fill seats on planes (Gimeno, 1994). Merrill Lynch initiated inter-industry rivalry with its development of the Cash Management Account, which was a competitive attack on banks. The following section describes key aspects of cases where firms compete based on their capabilities to apply networked IT.

Calyx and Corolla (Applegate and Gogan, 1995) sells fresh-cut flowers by mail, and is the classic example of a 'virtual organization.' IT is used to innovate the firm's processes through interfirm linkages with flow growers, shippers, and credit card firms. Its key partners include Federal Express, American Express, MasterCard, and independent flower growers. This use of networked IT enables it to ship flower directly to customers, therefore reducing the cycle time offered by traditional florists. The value added chain, from Calyx and Corolla to the customer, is a series of telecommunications linkages and a supply management system. Intermediate tasks that are not adding value have been eliminated; this also eliminates the buffers provided by those intermediate tasks. The result is a complex web of tightly coordinated relationships that are required to maintain high levels of quality and customer service.

Federal Express (Neo, 1988) began its business in 1973 based on extensive intrafirm linkages to track customer packages and deliver them overnight. IT was used to create innovative coordination and control applications that were novel at the time of their introduction, linking customer ordering, billing, shipping, and transportation systems in a closely integrated fashion. The largest customers had terminals at their locations to process and track their orders. In November of 1994, Federal Express began allowing customers to access information regarding package tracking directly via the Internet, providing additional customer value (Rayport and Sviokla, 1995). Six months later, United Parcel Service (UPS) responded with a similar package-tracking service on the Internet (Bloch, et al., 1996). DHL announced plans to offer a similar service, but not until mid-1996, due to technical integration problems in their organization. Rivals responded rapidly to Federal Express's innovation to allow all customers access to the package tracking information via the Internet.

American Hospital Supply (Applegate and Gogan, 1995; King, et al., 1989; Neo, 1988) used networked IT to innovate its ordering and inventory control processes through customer and intrafirm linkages. Order-entry terminals were placed in customer locations (hospitals), and customers entered their orders directly. The system allows customers to check inventory stock as well as ensure that the order was accurate. The responsibility of order entry is transferred to the customer, and orders are filled more rapidly.

The American Hospital Supply (AHSC) capability to use IT evolved into ASAP Express when the company was purchased by Baxter Travenol in 1985 (Applegate and Gogan, 1995). Extensive interfirm linkages were established using General Electric Information Services (GEIS) to further innovate hospital supply ordering by creating an electronic marketplace. Baxter/AHSC more recently expanded its IT capabilities to support innovative product offerings by creating an electronic commerce service to hospitals, entitled OnCall. This electronic commerce service is based on extensive interfirm linkages with numerous partners including Bergen Brunsweig, Boise Cascade, Eastman Kodak, and TSI International.

McKesson Corporation (Neo, 1988; Turban, et al., 1996) developed their Economost order entry and distribution system which was based on using networked IT to create linkages to customers (pharmacists and drug stores) and intrafirm linkages between McKesson's order, distribution, and warehouse functions. The customers were relatively small, and through Economost, McKesson could provide them with the size advantages of larger retail chains by reducing the costs of the goods they sold. The

Economost system innovated McKesson's internal processes as well as the product it offered customers. It provided customers with the capability to track their own sales. verify the accuracy of orders. identify which products needed ordering. and place customized orders which even arrived pre-tagged with the selling price and shelf location on the product. Thus. McKesson created an information-based service for managing the stock at its customers' locations.

Frito-Lay, Inc. (Linder and Mead. 1986; Wishart and Applegate. 1987) a division of PepsiCo, Inc.. was the first to equip its sales force in 1985 with hand-held computers to automate the sales process. The technology was very rare. and a small computer firm built the devices to Frito-Lay's specifications. The national roll-out of the hand-held computers took place from 1987 through 1988. The project was based on applying networked IT to innovate its business processes. largely by automating functions and creating intrafirm linkages between the sales force. warehouse. and headquarters.

The hand-held computer allowed the salesperson to enter order data while in the retail store. The computer automatically priced and printed the order. Order information collected all day from retail stores was downloaded at the end of the day to the warehouse minicomputer. which transmitted the information regarding the order to headquarters for further processing. This system replaced an existing sales transaction processing system. reduced the number of errors in orders. and improved the efficiency of the sales force.

Wal-Mart (Clemons and Row. 1993; Laudon and Laudon. 1996) developed networked IT applications to innovate its inventory and ordering processes through interfirm linkages to suppliers and intrafirm linkages between stores. purchasing. inventory. and delivery operations. Wal-Mart developed an inventory replacement process that reduces its inventory and enables it to control the interrelated tasks of meeting sales demand at individual stores and ordering products from suppliers. The order process for new stock begins with the sale of each product to a customer. At the point of sale. the transaction is logged and transmitted to a computer at Wal-Mart headquarters. The orders are transmitted from there to the suppliers. such as Proctor & Gamble. who fill the orders to meet the individual store demands. Some deliveries are made by the suppliers directly to the individual stores. relieving Wal-Mart of the internal distribution of its stock. The volatility in demand is controlled through these linkages with real-time orders being placed in response to actual sales; inventories are not based on long-term projections and orders. This type of system has been referred to as 'just-in-time' (JIT) or 'quick response logistics management.' These systems rely on electronic data interchange (EDI) which are based on standards to automate the computer communication functions between firms.

The interfirm linkages between the value chains of Wal-Mart and its suppliers change the bargaining power that the retailer has with those suppliers in order to obtain goods when needed at a favorable price (Clemons and Row, 1993). For the suppliers, the Wal-Mart coordination ensures that their production capacity is allocated to the products in demand. The suppliers have found, though, that linkages have resulted in their relative loss in bargaining power to demand a higher price for goods (Clemons and Row, 1993).

Wal-Mart's rivals such as K-Mart and Sears have responded with similar systems, but they have had difficulty in changing their organizational processes to coordinate tasks via the system of intrafirm and interfirm linkages supported by networked IT. Their processes rely on more traditional buffers between interdependent processes, such as warehousing and inventory stock, whereas Wal-Mart has reduced or eliminated such buffers between its functions.

7-Eleven in Japan (Turban, et al., 1996) uses networked IT to support process innovations within its sales analysis, ordering, distribution and stocking functions. Shelf space is at a premium in the Japanese 7-Eleven stores. After carefully analyzing customer sales data, it became apparent that there were time-dependent trends regarding the type of merchandise purchased throughout the day. 7-Eleven alters its stock to meet this variation in demand. It also determines the products to carry in each store, the shelf space devoted to each product, and the ordering requirements so that stock does not run out. Orders are transmitted from each store to the main distribution point and then to suppliers. The suppliers deliver the products organized according to the individual store needs.

SKI Ltd. (Turban, et al., 1996) is a ski resort in Burlington, Vermont, that manages its demand volatility through innovative networked IT applications based on extensive intrafirm linkages supported by the technology, beginning with snow monitoring and continuing through to promotional offerings. The resort operates ski slopes, a stadium with scheduled events, and a lodge. Weather and snow conditions are monitored by sensors in various locations and analyzed to determine which slopes should be open for skiing. Scheduling is coordinated through the analysis of stadium events, snow conditions, and lodge reservations to determine what promotions should be offered at what times. The ski season has been extended by analyzing the scheduling demands, which served to justify the expense of artificial snow production. Customer profiles are analyzed to determine the frequent customers and to provide a personalized level of service. Employee locations are monitored so that personnel can be shifted as needed throughout the vast operations of the resort. Daily information is available on the costs and revenues of all operations so that continual adjustments to be made.

Mark III (Turban, et al., 1996) has altered its van conversion processes to rely on networked IT to reduce the time required to customize a van to only seven days. The van conversion process begins with the customer order, where information about the vehicle and the conversion requirements are logged into a hand-held computer. This information is transferred to the engineering, manufacturing, financial management and management reporting functions of Mark III in order to prepare for the conversion process even prior to receiving the vehicle. Much of the conversion requires custom components manufactured in-house. Throughout the conversion process, the activities at each manufacturing work station are monitored and transmitted to other stations in the network via wireless communications. This tight integration of multiple functions is used to schedule materials, tools, and personnel, as well as eliminate inventories. After-sales customer service information is also managed through this system to ship replacement parts within 24 hours and to analyze those that require design modifications.

Merrill Lynch (Neo, 1988) developed a networked IT application based on product and process innovations. They launched their Cash Management Account that allowed an account holder the services of a bank and brokerage firm combined, with electronic access and control. The system required considerable intrafirm linkages to coordinate many individual firm tasks, and it also required interfirm linkages to a bank partner, BancOne, to offer the checking and credit portions of the Cash Management Account service. When it introduced the product in 1979, it took competitors five years to respond with a similar product. According to McFarlan (1984), this delayed response was due to the intense integration of products and information that formed the Cash Management Account.

Citicorp (Neo, 1988) developed innovative IT applications in the 1970s that resulted in ATM networks and Citicorp's Global Transaction Network. The ATM network created customer linkages and allowed the customer to perform tasks that originally required a human teller. The Global Transaction Network created intrafirm linkages to Citicorp sites in 140 cities in order to provide timely investment information to its global operations. These two separate applications are based on process innovations supported by interfirm and intrafirm linkages.

Bank of America, Nations Bank, and Wells Fargo Bank offer electronic home banking and financial services (Applegate and Gogan, 1995). Competition in electronic banking is based on linkages to customers and intrafirm linkages to provide a rich array of financial services. Competitive responses are not limited to firms in the financial industries. While Microsoft was prevented from entering into electronic banking, it is likely that a less powerful computer firm (Apple Computer, perhaps?) would have won the favor of the Justice Department to engage in such inter-industry rivalry. Future rivalry from known and unknown competitors can be expected (Applegate and Gogan, 1995).

Dow Jones (Neo, 1988) created a networked IT application to innovate its production and delivery processes by broadcasting the information via satellite and printing the paper simultaneously in multiple locations. This also allowed it to print separate versions of the paper, targeted for the Asian, European and North American markets. Following that, it used networked IT to offer a new product: Dow Jones News/Retrieval Service.

Gannett Corporation (Neo, 1988) created the U.S.'s first national newspaper for the masses – *USA Today* – also through satellite transmission of its information to multiple sites for distributed production and distribution. Although this IT application is very similar to Dow Jones, the two firms are not direct rivals due to the separate markets they serve. To this day, *USA Today* is not challenged as a nationally distributed mass-market daily newspaper in the U.S.

Dun and Bradstreet (Neo, 1988) has numerous information-service companies, including D&B Credit Report, Moody's Investor Service, and A.C. Nielson. It sells information products, and uses networked IT to continuously 'mine' its data to produce customized reports for specific applications and distribute them electronically.

AMR Corporation (Applegate and Gogan, 1995; Hopper, 1990; Neo, 1988) is famous for its innovative uses of networked IT to create its SABRE computerized reservation system. According to Neo (1988), the development of SABRE was actually a competitive response when independent travel agents in the U.S. tried to create a national reservation service. SABRE began in 1963 as a set of intrafirm linkages that innovated the firm's processes to maximize loadings and profits on its airplanes, and interfirm linkages to travel agencies to sell tickets.

A primary source of SABRE's power is its ability to handle vast numbers of transactions through the intrafirm linkages and customer linkages. According to Hopper (1990: p. 120), in 1963, SABRE processed data that was equivalent to "85,000 phone calls, 40,000 confirmed reservations, and 20,000 ticket sales." As of 1990, there were "45 *million* fares in the database, with up to 40 million changes entered every month. During peak usage, SABRE handles nearly 2,000 messages per *second* and creates more than 500,000 passenger name records every day. ... During a fare war, [the] yield management system loads 1.5 million fares a day." This growth in transactions supports the discussion earlier in the paper that the automation of a task leads to greater complexity of the task by increasing the number of interrelationships between tasks.

SABRE has continued to evolve since its introduction in 1963. SABRE was later expanded with further innovations based on interfirm linkages to other travel-related firms, such as car rental companies and hotels. These interfirm linkages innovated AMRs product to its travel agents by offering them a service to facilitate travel planning and booking. SABRE also enabled AMR to create the Frequent Flier program as an attempt to lock in customers. More recently, AMR has created Travelocity by expanding SABRE and allowing customers direct access into the system (called "easySABRE") via the Internet and strengthening interfirm linkages to a wide range of travel service firms and publishers.

Although AMR led the way with the development of SABRE in the 1960s, many rivals have responded with similar innovations. United Airlines (Neo, 1988) developed the Apollo system that competed with SABRE. Southwest Airlines, TWA, and other airlines now offer direct customer access to their information of flights and allow customers to purchase tickets directly via the Internet. TWA, easySABRE and others are offering personalized services to customers by allowing them to enter profiles of their travel needs and receiving information regarding fares and special promotions targeted at their specific needs.

The Internet has created many opportunities for firm of all sizes to compete through their ability to use IT to support strategic activities (Applegate and Gogan, 1995). The Intenet began as a research network (Arpanet) in 1969 for universities and laboratories, and it began allowing commercial traffic on the network in 1991. The Internet is not one network; it is a global interconnection of public and private networks. Users gain access to the Internet through an Internet Service Provider.

The current competitive power and mass appeal of the Internet is due to the development of the World Wide Web and graphical user interfaces that enable any person with a PC to access the network. The World Wide Web (WWW) makes use of the Internet, and was started as a research project in 1989 intended to facilitate the exchange of information between different types of computer systems.

The tool that enables the masses to use the Internet and WWW are 'web browsers.' The first graphical web browser was Mosaic, released in 1993 (Maloff, 1995). Thereafter, the use of the WWW has skyrocketed. Web browsers enable a user to travel throughout the many interconnected networks by pointing a mouse and clicking on a highlighted name. Data can be accessed from around the world in a matter of minutes.

Multimedia applications are being developed as well, and the Internet is now carrying (albeit minimal) voice and video traffic, as well as large volumes of text and image traffic. The costs to access the Internet are minimal (Applegate and Gogan, 1995), and it has become the empowering telecommunications technology that creates a competitive tool which is accessible to small firms as well as large.

Internet Underground Music Archive (Rayport and Sviokla, 1995) is competing with traditional record companies, such as MCA's Geffen Records, by using the WWW to distribute the works of unknown artists in order to publicize their talents and attract an audience. The recordings are digitized and distributed via the WWW rather than through music stores. Geffen responded to the competitive challenge to its role by also using the WWW to distribute information about its artists, and it has expanded the information to include promotions for upcoming tours. Geffen also exploits the information made available by the individual artists posting their works on the WWW to search for new talent.

Silicon Graphics (Bloch, et al., 1996) has developed networked IT applications based on the Internet intended to innovate its sales, marketing, customer service, and technical support functions. It uses the Internet to establish direct linkages from customers to sales for product inquiries and information requests. Customers can order products on line. Technical support, including software patches and documentation, are distributed by the Internet.

Peapod (Bloch, et al., 1996) uses the Internet to create a new means of grocery shopping. Their innovative product is an online grocery service where a customers places an order with Peapod. Peapod employees shop in a variety of different grocery stores and deliver the customer's goods. The online grocery service even recommends promotional items or substitutions to assist the customer. This application is based largely on customer linkages to Peapod, as the grocery selection and delivery is not supported by information technology at this time.

Internet Shopping Network (ISN) uses networked IT to create a computer and electronics 'superstore' on the Internet. Customers search the online database for specific products, place items in their 'shopping basket,' and then finalize the order and select the mode of shipping desired. The database is integrated with the inventory management system so that customers know whether or not products are available or back-ordered. Order status can also be checked on line. Customers are notified by e-mail when orders are shipped. ISN's networked IT application creates direct linkages to customers as well as intrafirm linkages between sales, inventory and distribution.

Internet entrepreneurs are applying their ability to use networked IT to create a product, deliver the product, identify customers, and serve customers. Firms such as Netscape Communications and Open Market are creating new markets by offering products and services to create comprehensive solutions for 'doing business on the WWW' (Applegate and Gogan, 1995). Other firms are applying networked IT to create new markets as 'information brokers' offering information-based products that were never previously available.

2.7 Summary and conclusions

Although the descriptions of the networked IT applications are interesting accounts of individual strategic uses of the technology, the individual cases do not adequately describe the information demands of the competitive environment that create incentives to use the technology. In addition, while some cases describe rivalry that ensues after the application is deployed, there is no comprehensive analysis of how the characteristics of the applications affect the likelihood of responses from rivals. The result is a lack of knowledge of how networked IT can contribute to a firm's competitive advantage. These unresolved questions are addressed by the research framework proposed in Chapter 3.

To summarize this section, the relevant extant literature reveals that information technology is believed to play a significant role in the competitive behavior of firms, but there are few details that are known regarding the ways in which characteristics of particular applications of networked IT provoke competitive response or sustain a competitive advantage. Based on this literature, we now develop a framework to study the rivalry that is expected to ensue when firms compete based on their capabilities to use networked information technology.

CHAPTER 3: RESEARCH FRAMEWORK -- COMPETING WITH NETWORKED INFORMATION TECHNOLOGY

The background literature from the resource based view of the firm, information technology, diffusion of innovations, and rivalry forms the basis for the research framework defining how firms compete through their capabilities to use IT. The strategic uses of networked IT constitute both the competitive actions and the responses that are of interest in this research. Those factors that affect the rivals' incentive to respond and ease in formulating responses to the actions are the focal point of this inquiry.

3.1 Definition of strategic networked IT applications

The strategic use of networked IT is an important organizational capability that can alter the competitive dynamics of the industry (Rayport and Sviokla, 1995). Strategic uses of IT are those which focus on the firm's effectiveness rather than its efficiency (Barnard, 1938). Schendel (1985) points out that while a firm requires both efficiency and effectiveness to survive, its overall effectiveness is the source of its success in the industry, rather than mere survival. A firm's strategy encompasses both its entrepreneurial and integrating capabilities (Schendel, 1985). However, the entrepreneurial capabilities play the dominant role in determining its competitive scope, resource deployment, and means to achieve a competitive advantage.

In this research, *strategic networked IT applications result in product, service, or process innovations that affect the firm's core business processes.* This definition is consistent with the entrepreneurial emphasis of strategy, as well as the typology defined by Swanson (1994) for strategic IT innovations (Type III innovations). This definition is also supported by discussions in the MIS literature regarding the strategic use of IT (i.e. Cash and Konsynski, 1985; Clemons and McFarlan, 1986; Jarvenpaa and Ives, 1990;

Kambil and Short, 1994; Porter and Millar, 1985; Rayport and Sviokla, 1995; Wilson, 1993). Specifically, Jarvenpaa and Ives (1990: p. 352) define strategic applications of IT as those which "change the firm's product or the way it competes," and they suggest that strategic IT applications are those which target the customer, product, or distribution channel. Kettinger, Grover, Guha and Segars (1994) propose that strategic IT applications should be used by a firm to change products through differentiation, change the nature of the firm's industry, achieve cost efficiencies, and provide easier access to markets. Kambil and Short (1994) determined that the use of networked IT provides firms with new strategic options to differentiate products and services and to engage in new modes of competition through coordination that were not previously possible without the use of IT. The implication by all of these authors is that the strategic benefits gained from the use of networked IT are due to innovations in the firm's revenue generating activities or in the firm's processes that affect its core business functions.

Strategic applications of networked IT are a result of a firm's capability to use its IT resources to innovate its products and processes within its core tasks. All the applications consist of intrafirm linkages between business functions in the firm, and many applications also have interfirm linkages to customers, suppliers, distributors and partners. The strategic value of the networked IT application is derived from the configuration of linkages supported by the application to carry out the firm's activities within its competitive environment.

There is considerable evidence to suggest that firms are heterogeneous in their ability to use networked IT strategically (Jaikumar, 1986; Hayes and Jaikumar, 1988; Markus and Soh, 1993). This heterogeneity is immobile because it is based on a capability developed over time that involves extensive integration of knowledge across the firm (Grant, 1996a). The firm's ability to use networked IT is difficult for competitors to imitate (Ross, Beath, and Goodhue, 1996), and several examples were described previously regarding this inimitability.

The heterogeneity exists between firms because the capability to use networked IT cannot be easily transferred from one firm to another for several reasons. First, the capability is dependent on asset flows such as investments in up-to-date technology, training, and long-term experience building (Ross, Beath and Goodhue, 1996). Second, the asset flows lead to the accumulation of asset stocks of organizational technical know-how embedded in the firm's processes (Dierickx and Cool, 1989). King et al. (1989) and Neo (1988) found indications that cumulative experience with IT is an important contributor to further development of the organizational capabilities that are required to deploy future networked IT applications. Third, the networked IT application itself is an organizational capability that requires the integration of tacit knowledge throughout the organization. Such a capability cannot be encoded, so its only means of transfer to another firm is through observation (Grant, 1996b). However, imitation is thwarted because of the causal ambiguity and social complexity of the application embedded within the firm's value chain. As the networked IT application encompasses a broader degree of knowledge integration throughout the firm by linking several interrelated functions, the degree of inimitability is heightened.

Heterogeneity also exists between firms because of the characteristics of the diffusion of IT innovations (Swanson, 1994). Although the firm's strategic capabilities are not easily transferred, knowledge about the technologies eventually diffuses through the industry and limits the uniqueness of the application (Ross, Beath and Goodhue, 1996; Swanson, 1994). Such diffusion provides competitors with opportunities to learn about the technology and enables them to develop the organizational capabilities to use it in a strategic manner. The innovation diffuses as rivals develop the capability to respond to the initial strategic action with their own deployment of networked IT to support product or process innovation. Characteristics concerning the nature of the IT application and its degree of innovation affect the diffusion process (Swanson, 1994; Tushman and Nadler, 1986), and therefore they contribute to the likelihood of response from rivals.

The focus of this study is on networked IT applications used strategically by competitive organizations to innovate their products, services, or processes. IT applications that focus solely on creating strategic alliances through telecommunications, without specifying a business application, are excluded from this study. In addition, applications of networked IT by non-profit or governmental organizations are also excluded because they are not competing against rivals for a competitive advantage.

3.2 Development of the propositions: actions and responses

Based on the earlier discussion of the literature, we argue that: *a competitor is likely to respond to a firm's strategic use of networked IT with its own strategic application if it is aware of the action, if it has an incentive to respond based on the strategic value of the application, and if the characteristics of the application allow it to formulate a response easily.* This argument forms the basis of the proposed research framework.

3.2.1 Awareness of competitive actions

Rivals' awareness of a firm's strategic use of networked IT is dependent on the public disclosure of that information as well as on other boundary-spanning activities to gather such information. Public disclosures of such information are extensive, and they can be found in the firm's annual report, the CEO's letter to shareholders (Jarvenpaa and Ives, 1990) and in numerous business and technical publications (i.e. Brynjolfsson and Hitt, 1996a and 1996b; Kettinger, et al., 1994; Neo, 1988).

Rivals might become aware of a firm's strategic use of networked IT through a wide range of other information-gathering mechanisms, including conversations with suppliers, customers, consultants, attendance at trade-shows, workshops or training sessions, movement of employees within an industry, corporate competitive intelligence gathering techniques, and through intentional leaks of information proclaiming future intentions to use a specific technology. These announcements may take the form of a 'beta test' or 'trial' of a particular networking technology, and often times the trial does not result in any commercial service or product. This phenomenon accounts for the term 'vaporware' being commonly used, and the situation occurs for a wide range of products and services that are network based. Unless the product or service is actually available, the reliability of the information regarding a trial or test is suspect. While it is acknowledged that firms often attempt to position themselves to be able to use a given technology through trials, training, or other activities, the actual implementation of a full-scale application is a different matter. The trial of a technology still leaves unanswered the question as to whether the firm has the organizational capabilities to integrate the networked IT within its organizational structure to carry out tasks related to its core business functions.

Maier. Ranier and Snyder (1997) studied the environmental scanning behavior of 131firms in 12 major industry categories regarding their efforts directed at gathering information about IT. They cited the competitive motivations that firms had in scanning the environment to learn about uses of IT. especially given the rapidly changing nature of IT equipment. In their research. organizations were classified as exploiters or innovators. competitors or early adopters. and participants/effective efficient followers. The exploiters or innovators were the most aggressive users of IT. The competitors or early adopters were those firms that quickly followed the lead of innovators. The participants or effective/efficient followers are those who used IT out of necessity and not due to innovation. They found that. in terms of the relative sizes of the organizations. the three types of organizations expend very similar amounts of organizational resources and use very similar techniques in scanning.

Maier. Rainer and Snyder's research revealed that a variety of scanning techniques were use by firms. such as the following: human sources. including vendors: general documentary sources. including industry magazines. industry newspapers. and public newspapers: vendor sources such as demonstrations and product announcements: combination sources such as trade shows. conferences. seminars. and meetings; trade journals that focused on the computer, networking and telecommunications fields as well as general management trade journals; and academic journals published by MIS and management academic institutions and professional societies. The top environmental scanning sources of firms classified as innovators and exploiters include the *Wall Street Journal*. subordinates. friends. *Computerworld* magazine. *Communications Week* magazine. public newspapers. *Information Week* magazine. *Business Week* magazine. their software vendor. and their supervisor as the top-ranked sources of scanning information. with the firm's software vendors the most highly ranked. (The frequency rank ranged from 0 through 5. and these were the top sources with scores ranging from 4.0 through 4.5. Other sources were also used for scanning. but with lower frequency.)

Firms classified as competitor and early adopter also relied heavily on public newspapers, subordinates, *Wall Street Journal*, followed by *Computerworld* magazine for environmental scanning, with the highest importance being places on information from subordinates. Finally, the firm classified as the participant/effective efficient follower primarily used public newspapers, subordinates, and *Computerworld* magazine, as their sources for environmental scanning, with the subordinates the most highly ranked source.

The scanning mechanisms give rivals advance notice of innovative uses of networked IT, and therefore could facilitate their response in a shorter time frame to actions carried out with strategic networked IT. In some cases, the effect on the response of rivals could be systematic in that it occurs more readily in a given industry where competitors are likely to come into contact through trade shows and sharing of customers. Or, it may also create a systematic influence on rival response if it involves a particular vendor or consultant who specializes in a given type of IT applications within specific industries.

In addition to the possibility of advanced disclosure, it should also be acknowledged that some firms do not necessarily disclose their strategic applications of IT at all, as they believe that they are issues worthy of top corporate security. However, based on the case studies described in Chapter 2, there are many applications that that are revealed publicly.

3.2.2 Reporting of competitive responses

Related to the problem of public disclosure of actions, there are similar problems that surround the public disclosure of responses. Nondisclosure of responses would possibly be interpreted as reduced rivalry or slow speed of response. These effects could be systemic as well, occurring more often in one industry than another. It is possible that earlier responses are likely to be reported, but that later responses are not. It can also be argued that some responses that affect the firm's internal processes are not as likely to be reported since there is little evidence of their existence outside of the firm, unless their presence is made known. They may also be affected by the size of the initiating or responding firm. the concentration in the industry. and the type of technology or application that is the subject of the action-response dyad.

Some researchers have attempted to rely on the firm generating the action to disclose whether or not it perceives responses from its competitors (MacMillan. McCaffery and VanWijk. 1985). However. this technique can be equally criticized on similar grounds of lack of knowledge of the response. It only transfers the knowledge gathering task to the action-generating firm.

While acknowledging that rivals have many opportunities to lern about competitors' actions. this research relies on public disclosure of strategic networked IT applications that constitute both the rivalrous actions and responses. Earlier IT-related research relied on public disclosure of applications of IT. but did not track rival response (Kettinger. et al.. 1994). Other rivalry research relied on the public disclosure of rivalrous moves. with reasonable success (Chen. Smith and Grimm. 1992). Although the work by Chen. Smith and Grimm did not investigate organizational capabilities to apply networked IT. a similar technique is used in this research. However. the limitations of the technique must clearly be acknowledged and controlled to the extent possible. This research concentrates only on those applications of actual working implementations of networked IT that are announced publicly. and not trials or tests. Therefore. we focus our inquiry on the rivalrous behavior that ensues once we have clear evidence that firms are aware of a rival's organizational capabilities to apply networked IT strategically.

3.2.3 Proposition 1: Incentive for competitive response

The research framework is based on key strategy and rivalry relationships that have been developed thus far. The information intensity of the firm's outputs that are sold to customers provide opportunities to exploit the information-encoding and processing features of networked IT within the products and services. as well as within the processes that occur as part of the development of those outputs. Uncertainty requires that the firm gathers information from the environment and adapts rapidly to the changing demand conditions. The level of information complexity in the environment places demands on the firm to coordinate and control the interdependent information sources linked by the technology. The strategic value of the networked IT application is based largely on the linkages supported by the application and the extent to which they are suited to the characteristics of the firm's products, services, and demands of the environment. As the strategic value increases, the incentives for rivals to respond also increases. Consequently, Proposition 1 states:

The likelihood of a strategic networked IT application receiving a competitive response from rivals is positively associated with the incentives created by the strategic value of the that application.

Three hypotheses are developed in a following section that are derived from Proposition 1. These hypotheses (H1 through H3) are based on arguments surrounding the incentive of competitors to respond that are created by the strategic value of the networked IT application. These hypotheses take into account the strategic value of the networked IT application that create incentives for competitors to respond. The strategic value is driven by characteristics of the goods and services that are produced by the firm, as well as the information-related demands and opportunities of the competitive environment in which the firm operates. These hypotheses have to do with the information intensity of the outputs sold to customers, the degree of uncertainty in the environment, and the degree of information complexity in the environment. The development of the hypotheses, as well as the intended operationalization of the constructs, are discussed in detail in an upcoming section, following the presentation of Proposition 2.

3.2.4 Proposition 2: Ease of formulating competitive response

The likelihood of response is determined not only by the rivals' incentive to respond, but also by the application's characteristics that enable it to be easily imitated (Clemons and McFarlan, 1986; Chen and Miller, 1994; Keen, 1988). Ease of imitation is determined by the degree of innovation of the application and the extent of interconnections between business functions supported by the application. As an application is easier to respond to, there is a higher likelihood of response. Consequently, Proposition 2 states:

> *The likelihood of a strategic networked IT application receiving a competitive response from rivals is positively associated with the ease of responding to that application.*

Three hypotheses are also developed based on Proposition 2. These hypotheses (H4 through H6) have to do with characteristics of the networked IT application and the ways in which they may impede competitors from responding. One characteristic pertains to the degree of innovation of the application, a second pertains to the extent to which the application is compatible with existing networks, and the third is based on the extent to which the application integrates knowledge across multiple entities and business functions. The arguments supporting these hypotheses, and the intended operationalization of the constructs, are discussed in the following section of this chapter.

Figure 3.1 illustrates the general research framework in terms of the two propositions. The discussion of the hypotheses follows immediately after Figure 3.1.

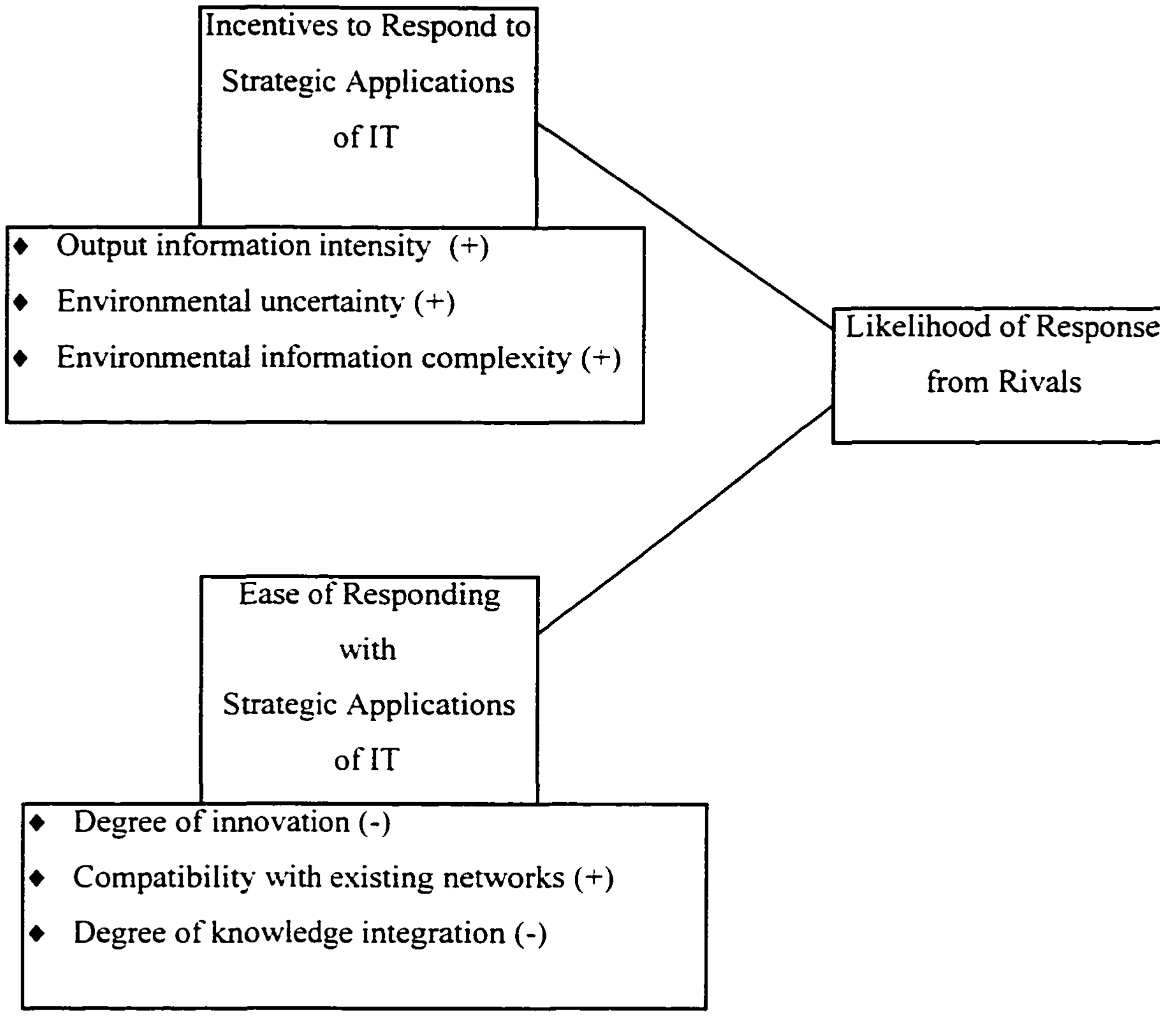

Figure 3.1. Research Framework of the Propositions

3.3 Hypotheses regarding the incentive of a competitor to respond

The first set of hypotheses describes the conditions of the networked IT application and the industry environment that are likely to create an incentive for a competitor to respond by means of a networked IT application. The focus is on the initiating firm's networked IT application and its industry. There is no analysis of the responding firm, other than the fact that it generates a strategic networked IT application that is provoked by an earlier IT application. *Both the initial action and the responses are strategic networked IT applications that result in product, service, or process innovations that affect the firm's core business processes.* Following the development of all of the hypotheses, an expanded view of the research framework is presented to illustrate the hypothesized effects.

3.3.1 The information content of the industry output

The incentive to respond to a competitor's use of networked IT is driven by the strategic value of the application in the competitive environment (Mata, Fuerst and Barney, 1995). The industry output characteristics, such as the products and services sold to customers, are one determinant of the value of IT applications (Jarvenpaa and Ives, 1990; National Research Council, 1994; Porter and Millar, 1985). Information-intensive products and services enable a firm to use IT strategically throughout the value chain to produce those goods. Porter and Millar (1985) suggested that the information intensity of a firm's output that is sold to customer would affect the use of IT in the firm's value chain. Some argue that these outputs have both a physical value chain and a virtual value chain (Rayport and Sviokla, 1995). The virtual value chain is made up of the information requirements within and between the processes associated with the physical value chain to produce the product or service, and they represent parallel activities which firms can exploit to create additional customer value. Within the virtual value chain, information is an explicit source of value and hence revenue to the firm, whereas in the traditional physical value chain, it was only a supporting element use largely for control and coordination.

According to the National Research Council, service industries, in particular, are often technically sophisticated and information-intensive industries. However, firms in industries where the outputs are not information intensive are still capable of using networked IT strategically (Monnoyer and Philippe, 1991). In fact, any automated process is based on the use of computers and communications, and the automated process creates information which can be used to enhance the 'information content' of the firm's output as an innovative and strategic use of the technology (Zuboff, 1988).

Zuboff (1988) defined the term 'informate' as the process of expanding the intellectual content of tasks and distributing knowledge throughout the organization. The information content of tasks, as well as products and services sold by the firm, is proposed by Zuboff to be a by-product of the automating processes. Applying computer and networking technology to automate a task generates additional information sources, and these courses can be exploited to create additional value. In terms of the value chain, the physical tasks are automated by substituting information technology for physical labor. Rayport and Sviokla (1995) suggest that through an appropriate integration of the physical and virtual value chain, firms can create new markets as they gather, organize, select, synthesize and distribute information along with their physical products and services in ways that are valuable to the customer. This requires more managerial involvement that merely automating a task, as it may require organizational transformations created by the new demands to share information across the organization (Wilson, 1993; Zuboff, 1988).

Networked IT applications provide the firm with more opportunities to differentiate their information-intensive products and services (Kambil and Short, 1994). The interfirm and intrafirm linkages created by the networked IT application can be used as distribution channels of information-based products; they can be used to control information-intensive processes; and they can be used in ways that create new business opportunities. Swanson (1994) suggested that there were many opportunities to develop innovative applications of IT when the firm produces information-intensive products and services. In industries such as banking, finance and insurance, the product itself is information, and the strategic value of IT is very high because it can perform many roles in production, coordinating, and distribution of the products. Service industries with information-intensive products have more experience in using networked IT in their operations than do other firms (National Research Council.1994). This is an example of how the underlying capabilities of firms in the industry are closely tied to. and possibly inseparable from. the use of networked IT when the product or service is information intensive. Jarvenpaa and Ives (1990) found that. indeed. the strategic use of IT correlated with the information content of the product. As the information content of the product or service increases. firms have more opportunities to use networked IT in ways that are directly related to their core business. and this should create incentives for rivals to respond. Therefore. Hypothesis H1 states that:

H1: The likelihood of a networked IT application receiving a competitive response is positively associated with the information-content of outputs of that industry.

3.3.2 Moderating effects of the competitive environment

The competitive environment moderates the strategic value of the firm's networked IT applications and therefore influences the incentives for responding to those applications. The degree of uncertainty and information complexity in the industry are conditions that require that a firm is able to be responsive and flexible to the demand changes and that it is able to process large amounts of information rapidly. The intrafirm and interfirm linkages created by the networked IT application allow it to exchange information within its own processes. with its customers. and with other enterprises in order to gather information about demand conditions. adapt processes rapidly. and coordinate interdependent business functions (Sanchez. 1993; Venkatraman. 1991). Therefore. the linkages created by the networked IT application should enhance its strategic value in the face of demand volatility and information complexity caused by automation. and therefore create incentives for rivals to respond. This is the premise for Hypotheses H2 and H3 that are now described in detail.

3.3.3 Uncertainty created by demand volatility

The firm's environment moderates the strategic value of IT applications, and the environmental conditions of interest in this research are those demand factors that most directly affect the use of networked IT. Although other factors in the competitive environment are important to a firm's overall strategy, this research only focuses on aspects of the firm's rivalrous behavior that pertain to its use of networked IT. Therefore, it is appropriate to narrow the consideration of the environment to those factors that are most likely to moderate the value of the firm's IT resources. The first dimension of the environment that is of interest in this research is *uncertainty created by demand volatility.*

Demand volatility in a product market creates uncertainty in the amount of output that should be produced. Therefore, output volatility is frequently used as an indicator of demand volatility (i.e. Downey, Hellriegel and Slocum, 1975; Mills and Schumann, 1985; Bourgeois, 1985; Fiegenbaum and Karnani, 1991). Common output measures include variation in predicted versus actual values, variance in the value of industry shipments, or variance in industry sales over a period of several years. Although aggregate output measures reflect the influences of national and industry factors (Kandil, 1997) as well as firm-level differences, these variance-related industry output measures are commonly used as valid indicators of the differences in demand uncertainty facing firms in one industry as compared to another. Consequently, *environmental uncertainty is represented by the degree of demand volatility in the industry, as suggested by the observed output volatility.*

Demand volatility requires that a firm gathers information from its environment and be flexible in its operations (Hambrick, 1982; Mills and Schumann, 1985; Sanchez, 1993; Tushman and Nadler, 1978). Networked IT can support linkages that can be used to gather and share information in order to respond quickly to demand changes. The linkages create a flexible resource that can minimize costs when the firm is faced with variable demand conditions.

Interfirm linkages supported by the networked IT application between the firm and its customers, suppliers, distributors and partners are a rich source of environmental information (Hambrick, 1982). They facilitate boundary-spanning activities by allowing the firm to gather information about demand conditions (Hambrick, 1982). Customer linkages established through public networks such as the Internet and the World Wide Web create an especially strong incentive for rival firms to respond with similar uses of IT because of the ability to reach "tens of millions of computers and their users" through a low cost communication and distribution network (Quinn, Baruch, and Zien, 1996: p. 20).

The interfirm IT linkages are also used as an attempt to lock-in customers through tight coordination of previously distinct value chains (Bakos, 1991; Clemons and McFarlan, 1986; Clemons and Row, 1993). When such coordination takes place, the firm is able to reduce its exposure to environmental uncertainty by stabilizing the demand volatility that it experiences as compared to other firms in the industry.

The firm's IT linkages also enhance its flexibility by enabling it to sense changes in customer demand and respond rapidly (Haeckel and Nolan, 1993; Pavitt, 1990; Sanchez, 1993). Demand volatility reduces the planning and lead times available to a firm, therefore requiring a greater need for centralized coordination (Nam, Rajagopalan, Rao, and Chaudhury, 1996). It can no longer plan its strategy in a static way, but instead it must sense the shifts in market demand and respond to those new demands. For instance, intrafirm linkages are valuable in such conditions because they enable the firm to disseminate and share information throughout its organization in a timely manner (Lee and Leifer, 1992; Wang and Siedmann, 1995). These information sharing requirements increase as the firm's tasks become less predictable.

When appropriate, the interfirm and intrafirm linkages enable the firm to provide customized products and services in response to demand changes. These linkages increase the value delivered to customers through the customized products, hopefully resulting in increased commitment to the firm and its products (Pine, 1993). Customer commitment, which can be viewed as a voluntary form of customer lock-in, can also serve to stabilize the impact of demand variations on a particular firm as compared to other firms in the industry.

Flexibility in operations requires a high degree of adaptability, and a combination of intrafirm linkages between business functions and interfirm linkages are essential to rapidly reconfiguring the value chain and deploying resources as needed (Sanchez, 1993). In times of demand stability, firms that rely on high-volume fixed production technology have an advantage. However, during periods of cyclical or random demand variation, firms with greater flexibility have an advantage by being more responsive (Mills and Schumann, 1985).

Flexibility requires that firms be able to get information into and through the organization very rapidly, which in turn requires timely access to information regardless of its location (Yates and Benjamin, 1991; Zaheer and Zaheer, 1995). Supplier linkages facilitate the rapid delivery of input materials and reduce inventories, and distributor linkages facilitate rapid delivery of the product to the customer (Lampel and Mintzberg, 1996; Levy, 1997). Through the linkages, production and processing capacity can be shifted rapidly. 'Quick-response' and 'just in time' manufacturing facilities are based on the flexibility provided through dynamic reconfiguration of the linkages in response to demand changes.

In conclusion, rivals have an incentive to respond when they compete in an environment with high demand volatility because of the increased strategic value of the interfirm and intrafirm linkages of the networked IT application. Therefore, Hypothesis H2 states that:

> *H2. The likelihood of a networked IT application receiving a competitive response is positively associated with the degree of demand volatility in the competitive environment.*

3.3.4 Information complexity created by the level of industry automation

The second environmental dimension of interest in this research is *information complexity created by the level of automation in the industry due to the use of networked IT.* Information complexity arises in the environment as firms are faced with many interdependent external sources of information which they must coordinate in order to conduct their core business processes (Haeckel and Nolan, 1993). This complexity is caused by the demands on the firm to coordinate the information associated with numerous interdependent relationships (Lawless and Fitch, 1989).

Traditional complexity measures have included the competitive concentration and the geographic concentration of firms in an industry, the heterogeneity of products in an industry, and the heterogeneity in the SIC codes within an industry group as indicators of the relationships and information sources that the firm faced (Dess and Beard, 1984; Sharfman and Dean, 1991). However, these measures are inadequate for several reasons due to their lack of specific focus on the information-related demands confronting the firm. In fact, their validity as proxies for complexity can be questioned because there is not necessarily a relationship these measures and the information sources that the firm must coordinate. Information complexity is driven by the interdependency of the relationships and the demands for exchanging information between the information sources. The number of products in an industry, as well as the number of SIC codes in an industry group, do not have any inherently systemic relationship and therefore do not imply any interdependencies that exist. Secondly, a highly concentrated competitive environment exists when a few large firms control the environment. These firms can operate somewhat autonomously with minimal regard for other firms in the environment. It can be argued that, under these circumstances, there are fewer interdependencies that firms must coordinate when operating in such environments, and therefore there is reduced information complexity. Furthermore, neither the number of products in the industry, the SIC codes, nor the market concentration assess the degree to which the firm's tasks require that it process information.

The information complexity of the environment is created by the demand for information that flows across the firm's boundaries, between it and its customers, suppliers, distributors, and other entities. While the information flow may be well defined, it can require processing large quantities of information very rapidly in order for the firm to survive (Mintzberg, 1979). Consequently, the measures used previously to represent complexity are not at all appropriate for our research because they do not specifically address the information complexity that results when information must be exchanged between interdependent information sources in the firm's competitive environment.

An appropriate indicator of information complexity is the degree of automation in the industry. Task automation is defined as resulting when human labor is replaced with computing and networking technology (Zuboff, 1988). The computer and networking technology is traded for human labor, and work is transformed to provide greater efficiencies through increased speed and machine control of the process (Scott Morton, 1991; Wilson, 1993; Zuboff, 1988). The U.S. Department of Labor associates the use of computers and networking technology with the concept of automation in both industrial and service industries (Freeman, 1996; Goodman, 1996; Hetrick, 1996; McConnell, 1996; Morisi, 1996; Warnke, 1996). While other physical resources in the firm may be used as well, it is the computers and communication equipment that form the basic defining elements of modern automation systems across all industries (Malone and Rockart, 1991). In manufacturing, for instance, earlier automation systems relied more heavily on specialized equipment for statistical process control or numerical control; however the modern computer integrated manufacturing systems rely on the versatility of computers and communication technology as fundamental elements of the system (Jaikumar, 1993).

The ability for networked IT to automate tasks extends beyond manufacturing industries and into the service industries as well. The National Research Council (1994) found that contrary to the general conception of service industries as 'low tech,' there were many technologically intensive firms in the transportation services, financial services, banking, insurance, retail trade, wholesale trade health care, professional services, personal services, and telecommunications. In the manufacturing industries, there are many information intensive activities as well, such as research, design, distribution, logistics planning, marketing, and order processing. Some of these information demands reflect industry-level differences in the interdependencies between information sources that are affected by industry structure, regulation, product availability, and the adaptability of networked IT to the processes and products of the specific industry. Several of these examples were described in Chapter 2.

Automated tasks rely heavily on networked IT because it is generally the only mechanism that is capable of processing information at the speed required to provide the necessary degree of control and coordination (Attewell, 1994; Haeckel and Nolan, 1993; Jonscher, 1994). Automation creates information complexity by intensifying the degree to which factors affecting the firm's processes are interdependent (Lawless and Finch, 1989; Levy, 1997) and by increasing the information sources that must be coordinated (Haeckel and Noan, 1993).

The extent to which one industry invests in computer and communications equipment as compared to another reflects the differences in information processing demands facing the firms which compete in these industries. These demands are a result of increasing complexity driven by the extent to which information must be coordinated between the interdependent information sources. Therefore, the investment in computer and communications equipment reflects significant differences in the information complexity of one competitive industry environment as compared to another.

Historically, firms have invested in computer and networking equipment in order to automate their tasks and meet the demands of information complexity. These demands include processing large volumes of information at high speed. The quantity of information required to be processed and coordinated in itself creates a complex situation, just through the information transmission, encoding, storage, and retrieval aspects alone. Furthermore the speed demanded of the processing, and the ability to access specific units of information, further increase the complexity demands imposed on the firm. These information transmission, encoding, storage, and retrieval tasks are performed by a combination of communications and computer-based equipment in order to meet the requirements for information throughput and quantity of processing required. Therefore, the level of computer and communications capital investments in an industry is an indicator of the degree of information complexity in the competitive environment of that industry.

The computer and communications capital investments support a variety of automated processes across multiple industries: with suppliers and buyers, within the distribution channels, and within internal operations to coordinate the information demands that exist due to these relationships. Within individual industries, there are likely to be additional types of equipment that are used in concert with the essential computer and communications equipment. However, in a cross-industry study, the computer and communication equipment investment per output of the industry represents a unit for comparing the information demands of the industry, given the broad versatility of the technology (McConnell, 1996). The National Research Council (1994) used the level of computer and communications capital investment to compare across industries the difference in information demands on firms based on the processing capabilities that are required. This further suggests that the degree of computer and communication capital is an indicator that is appropriate for cross-industry comparisons of their relative levels of information complexity. According to the National Research Council (1994), the investment in computer and communication technology suggests the minimum information processing requirements for firms competing in the industry by becoming the fundamental infrastructure for the organization to do business. Therefore, it represents a significant demand for a firm's organizational capabilities to employ this equipment within its processes in order to participate in the industry (Bradley, 1993; Mata, Fuerst and Barney, 1995).

While the computer and communications capital investment in an industry is an appropriate indicator of the information complexity of the competitive environment, it too is not a complete measure of this construct. It does not include software and computer-related services, such as electronic information services, data processing and network services, computer professional services, custom programming, systems integration, consulting, or training services (National Research Council, 1994). However, according to Stephen Roach of Morgan Stanley and Co., it is "the only systematic data available on IT expenditures" (National Research Council, 1994: p. 3), and it is these expenditures upon which automated tasks rely. Therefore, while this measure is used in this research, it is necessary to acknowledge that it is a conservative indicator of the information complexity faced by the firm in its competitive environment. In this research, *information complexity created by the degree of automation in the competitive environment is represented by the level of computer and communications capital investment in the industry.*

In such an environment, the firm's linkages supported by the networked IT application are valuable because of their ability to coordinate and control interdependent processes. These linkages form the vertical and horizontal integrating mechanisms that are necessary for efficient operation (Galbraith, 1977; Tushman and Nadler, 1978). Intrafirm linkages supported by networked IT can be used to coordinate information between interdependent functions, reduce slack between the functions, and exert a great deal of control over the interdependencies. This results in increased levels of complexity because of the intensified interdependency between the functions (Lawless and Finch, 1989). Cross-functional linkages, either intrafirm or interfirm, are required to optimize the performance of a tightly integrated system (Bierly and Spender, 1995). Without such linkages, individual functions in the system would be optimized, but the overall performance would suffer. Consequently, control and coordination are required to ensure that the system operates efficiently (Keen, 1988; Wang and Seidmann, 1995).

Dynamically reconfigurable configurations of linkages are valuable so that tasks can be coordinated according to changing demands. A public telecommunications network such as the WWW can be used to create intrafirm linkages that can be reconfigured on demand as the tasks demanded. For instance, cross-functional teams can be assembled on demand as required. Network linkages enable the firm to distribute and share information and personnel expertise between the interdependent functions in an efficient and complete manner that allows all member of the organization to have easy access to the information (Hameri and Nihtilä, 1997). Some prior investments in IT that were used to establish linkages for the firm's communications needs may not be as reconfigurable as newer technology. Consequently, some technological investments are better suited to the task of transforming the firm's communications linkages than others. However, overall the network of intrafirm linkages enables firms to improve the speed and lower the cost of coordinating work (Hameri and Nihtilä, 1997).

Interfirm linkages supported by IT are also valuable for controlling and coordinating interdependent relationships that extend beyond the firm's boundaries as it links its value chain with those of other firms (Willinger and Zuscovitch, 1988). The argument that began with intrafirm linkages extends to interfirm linkages: automated processes require extensive coordination and control due to the high degree of interdependencies between the entities of the system. Interfirm IT linkages can support horizontal coordination with partners or vertical linkages with suppliers and distributors.

Interfirm linkages supported by IT enable a firm to exploit the existing scope of automation in the industry by establishing linkages to buyers and suppliers and speeding the distribution of its products and services through channels and into the hands of customers. The interfirm linkages also provide firms with more opportunities to leverage their capabilities beyond their boundaries by coordinating tasks with outside firms (Kambil and Short; 1994). As a result, the linkages facilitate the transformation of the firm's products and processes.

When the operations expand globally, the use of interfirm linkages supported by IT is a necessity (Jonscher, 1994). The improved speed of global operations may be an operational requirement for participation in the industry, and the coordination supported by interfirm linkages may become a strategic necessity (Attewell, 1994).

In conclusion, rivals have an incentive to respond due to the increased strategic value of the linkages created by the networked IT application in the face of information complexity caused by the level of automation in the industry. Therefore, Hypothesis H3 states that:

H3. The likelihood of a networked IT application receiving a competitive response is positively associated with the level of automation in the industry.

3.4 Hypotheses regarding the ease of competitors formulating a response

Once competitors have incentives to respond to networked IT applications, the ease of response is determined by the inimitability of the original application. Applications which are highly innovative should be difficult for competitors to respond to. Closely associated with the degree of the innovation of the application is the extent to which it is compatible with existing networks, and therefore may exploit 'network externality' effects. These effects would cause the innovation to diffuse rapidly within the industry, therefore countering the expected inimitability of the innovation alone.

Competitors may also find it difficult to respond to networked IT applications that are socially complex, possibly created if the application integrates knowledge across multiple entities and business functions by means of the linkages created by the application. The hypotheses regarding these effects are now discussed in detail.

3.4.1 Degree of innovation of the application

The likelihood of a strategic networked IT application receiving a competitive response is influenced by the diffusion of the innovative uses of the technology. The applications are defined in this research as product, service, and/or process innovations. In each case, these innovations can be classified according to their degree of innovation, and the ability for rivals to respond should become less likely as the degree of innovation increases.

Swanson (1994) developed a typology of IT innovations that forms the basis for characterizing the degree of innovation of actions in this research. The strategic networked IT actions that are studied in this research can include three categories of innovation that Swanson described: Type IIIa innovations pertaining to the firm's core business processes, Type IIIb innovations pertaining to its products and services, and Type IIIc innovations pertaining to it horizontal and vertical linkages beyond the firm.

The degree of innovation is lowest when the networked IT application supports innovation in the firm's products and services because these can be readily observed by other firms (Damanpour and Evan, 1984). Process innovations have a higher degree of innovation because they are difficult to observe and because of the multiple effects caused by linkages to interdependent functions (Damanpour and Evan, 1984; Pennings, 1987). Innovations that cross firm boundaries have the highest degree of innovation (of these three categories) because they link the value chain of one firm to the value chain of another, and therefore require close coordination between multiple processes in more than one organization. Furthermore, innovations that cross the firm's boundaries also have an impact on its internal processes, and changes in internal processes have an impact on the firm's product and services. Therefore, there is a ripple effect of innovation through the firm's processes and outputs that further increases the magnitude of the innovation.

Within each of these three types of innovations, there are further degrees of innovation based on whether the product, process, or network spanning innovation was incremental, synthetic, or discontinuous (Tushman and Nadler, 1986). Incremental innovations involve small changes in the product, service, procedure, or network spanning function. Synthetic innovations recombine existing products or procedures in a new way, and thus require a higher degree of innovation. Discontinuous innovations involve radical changes to the procedures, products, or services.

The simpler the innovation, typically the faster it is adopted by other firms (Ali et al., 1995; Farrell and Saloner, 1985) An incremental innovation requires less learning on the part of the organization. This enables the firm to respond quickly, reducing its development cycle time. The reduced learning time, though, is shared by competitors and they can respond rapidly as well (Spatt and Sterbenz, 1985). The value of discontinuous innovations is difficult to assess because of the radical changes that they impose on the existing technology. Therefore, they involve significant investment risk and firms face many barriers to adopting the technology. Based on these arguments, Hypothesis H4 states that:

H4. The likelihood of a networked IT application receiving a competitive response is negatively associated with the degree of innovation of the application.

3.4.2 Compatibility of the innovation with existing networks

It is necessary to consider the network effects of an innovation that relies on IT in order to assess how these influence the inimitability of the application. Because of the network effects on innovations supported by IT, incremental innovations diffuse more rapidly than synthetic and discontinuous innovations because they are still able to exploit the existing network and take advantage of immediate scope advantages (Farrell and Saloner, 1985). They are easy for firms to adopt because they are compatible with the existing technology in the network. Therefore, they can be deployed rapidly and with minimal cost.

As the network grows in size, the likelihood of adoption increases because of the interest in beating competitors to the opportunities to exploit the network (Saloner and Shepard, 1995). This was demonstrated in the adoption of ATM technology (Hannan and McDowell, 1987). Innovations that snow-ball to this degree are likely to have a very high likelihood of provoking responses from competitors and increasing rivalry (Bakos and Kemerer, 1992). In fact, such applications are likely to become strategic necessities for firm competing in the industry; at best they provide only a temporary competitive advantage to firms that initially adopt the innovation (Bradley, 1993; Kettinger et al., 1994; Mata et al., 1995; Neo, 1988).

On the other hand, it is very difficult to coordinate a significant change to products and systems that rely on network effects (Farrell and Saloner, 1985). Discontinuous innovations are likely to be based on changes that render existing networks and automation technology obsolete. Discontinuous innovations must create a new network in order to match the scope advantages of the old technology. The switching costs to create such a network and adopt the new technology are very high and the benefits are unknown (Farrell and Saloner, 1986). Therefore, firms are expected to have greater difficulty in imitating discontinuous innovations. Based on these arguments, Hypothesis H5 states:

H5. The likelihood of a networked IT application receiving a competitive response is positively associated with the extent to which the innovation is compatible with existing networks.

3.4.3 Extent of business functions interconnected by the application

The extent to which a networked IT application interconnects business functions through its interfirm and intrafirm linkages is an important indicator of the ease rivals should have in responding to the application. Hypotheses H1 through H3 proposed that the intrafirm and interfirm linkages increase the strategic value of networked IT applications, which therefore increases the likelihood of competitors responding. In contrast, Hypotheses H6 proposes that the configuration of the linkages can increase the inimitability of the application and therefore reduce the likelihood of response. The linkages, therefore, have a counteracting effect on the application; they are largely responsible for the strategic value of the application, yet their configuration can be designed to impede rivals attempts to imitate the application.

When a firm uses networked IT to interconnect business functions, it is an indicator of how well the firm has appropriated the technology and thus created an inimitable organizational capability (Venkatraman, 1991). As the number of business functions that are interconnected increases, the causal ambiguity and social complexity of the application also increase. The interconnection of business functions indicates the extent to which the use of the technology is embedded in the organization's processes, which makes it less likely that competitors can respond to the application (Grant, 1996b; MacMillan, McCafferty and VanWijk, 1985). The extensive combination of linkages also make it difficult to understand precisely how the tasks are carried out and how the entities inter-relate (Bierly and Spender, 1995). The nature of linkages required by an innovation also plays a significant role in the diffusion of the innovation. An innovation that requires tight linkages within the firm's processes is less likely to diffuse because it requires strong intrafirm linkages between the appropriate functions and operating units (Pavitt, 1990).

The ability to interconnect business functions through the use of information technology is itself an organizational capability (Grant, 1996a) that enables the firm to appropriate the technology within its processes, customizing its processes to exploit the innovation (Robertson et al., 1996). Competitors may be able to observe that a particular technology is in use, but they cannot fully assimilate the arrangement of intrafirm linkages that are supported by the technology. For instance, manufacturing firms could observe competitors using the identical technology but could not match the benefits of the technology when they adopted the innovation in their firm (Hayes and Jaikumar, 1988; Jaikumar, 1986).

A competitor experiences greater difficulty in imitating a networked IT application as the number and configuration of the business functions interconnected by the application increases. An application which only has linkages within one business function in a firm is the simplest to observe and imitate. As the number of intrafirm linkages increases, the exact nature of the linkages is obscured from direct observation and the process is more difficult to imitate. Applications which have interfirm linkages are the most difficult to imitate because they require linking distinct value chains from more than one firm and their internal processes.

The interconnected business functions form the unique organizational configuration of the networked IT application in the firm. Information is exchanged within these connections in a way that cannot be duplicated by other firms because of the different organizational structures and flow of information from one firm to the next. Therefore, Hypothesis H6 states that:

H6. The likelihood of a networked IT application receiving a competitive response is negatively associated with the extent of business functions interconnected by the application.

3.5 Hypotheses summarized

In summary, the hypotheses state that the likelihood that rivals will respond to strategic applications of networked information technology depends on their incentive and ability to do so. The incentive is determined by the information content of the product and the strategic value of the networked information technology application in the context of uncertainty created by demand volatility and information complexity created by the level of automation in the industry. The ease of response is determined by the characteristics of the degree of innovation and the extent of the interconnections between business functions created by the interfirm and intrafirm linkages. As the degree of demand volatility increases, the strategic value of the firm's linkages supported by networked IT increases when those linkages are used to gather information and adapt rapidly to demand changes. As the degree of automation in the industry increases, the strategic value of the linkages increases because of their ability to coordinate and control interdependent factors. The increasing degree of innovation decreases the ease of rivals in formulating a response, but the compatibility that the innovation has with existing networks increases the ease of response. The increasing number of business functions that are interconnected by the application reduces the likelihood of response from competitors. By examining the hypotheses, it can be seen that the role of linkages supported by the networked IT application are vital to its ability to sustain a competitive advantage. Figure 3.2 presents the research framework expanded to illustrate the hypothesized effects.

Table 3.1 shows the expected signs of the coefficients for each proposition. The regression model shown below is used to test the main effects of the hypotheses as well as the interaction effects of the categorical variable, X_5, 'compatibility with exiting networks' with the remaining variables in the model.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6$$
$$+ \beta_{15} X_1 X_5 + \beta_{25} X_2 X_5 + \beta_{35} X_3 X_5 + \beta_{45} X_4 X_5 + \beta_{65} X_6 X_5 + \varepsilon$$

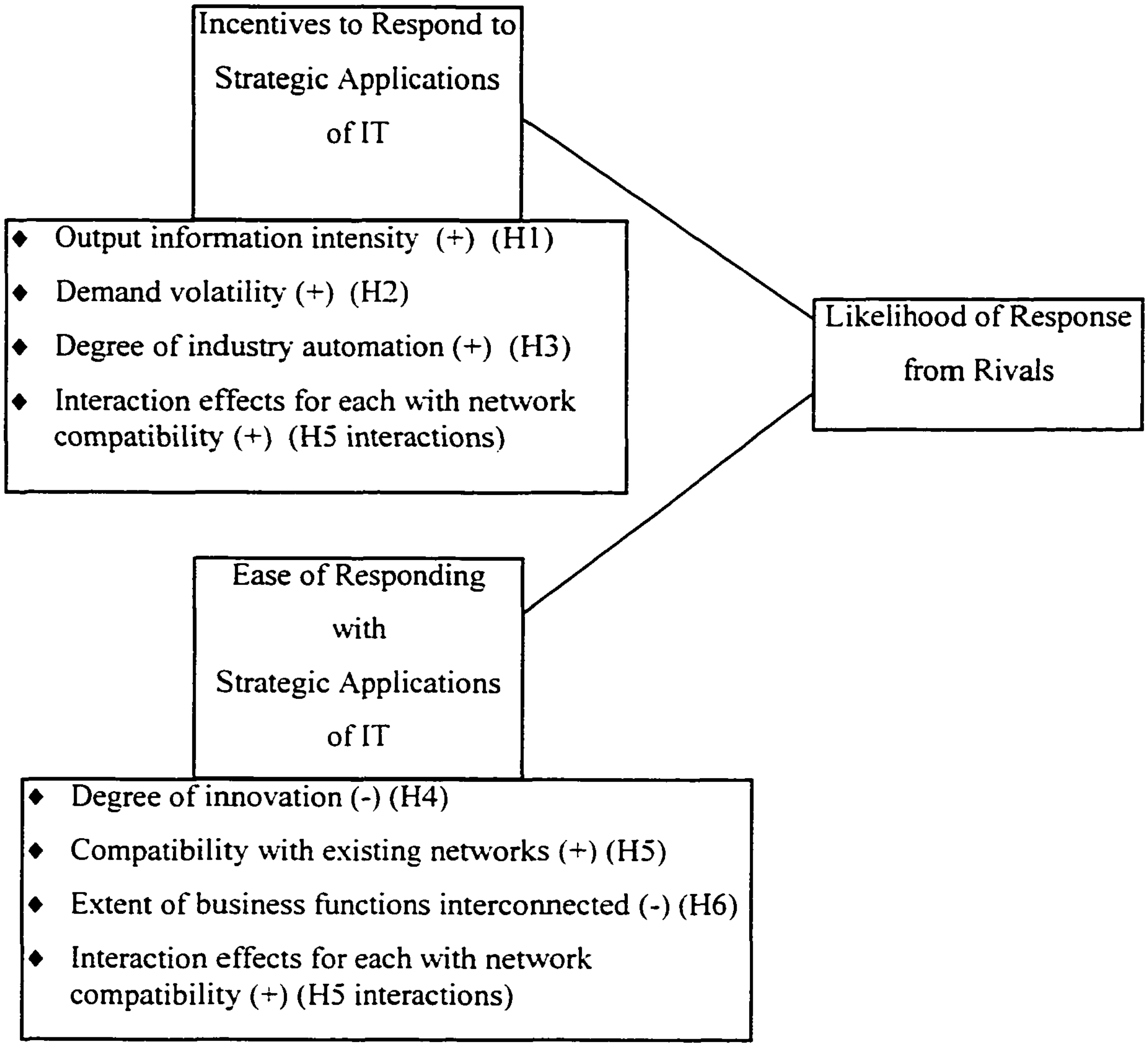

Figure 3.2. Research Framework – Expanded to Illustrate the Hypotheses

Table 3.1. Summary of Predicted Signs for the Likelihood of Competitive Response using Networked IT

Hypothesis and Expected Sign	Variables—Terms defined
	Y = dependent variable – indicating the competitive response from rivals
H1: β_1 +	X_1 = information content of the industry output
H2: β_2 +	X_2 = demand volatility
H3: β_3 -	X_3 = information complexity caused by the level of industry automation
H4: β_4 -	X_4 = degree of innovation
H5: β_5 +	X_5 = compatibility with existing networks
β_{15} +	Interaction effects: X_{15} X_{25} X_{35} X_{45} X_{65}
β_{25} +	
β_{35} +	
β_{45} +	
β_{65} +	
H6: β_6 -	X_6 = extent of business functions interconnected

3.6 Significance of the proposed research

This research is significant in several ways. First, it studies the strategic role of networked IT applications by examining how firms compete with these capabilities. Secondly, it examines the attributes of strategic capabilities carried out with networked IT in terms of the incentives they create and the ease of response that they provoke from rivals. The research provides an insight into whether such indicators are appropriate to assess the ability of these capabilities to sustain a competitive advantage, as suggested by the resource based view. Third, the effects of the competitive environment are considered in terms of how they create information demands on the firm and moderate the value of its resources and capabilities. We turn now to Chapter 4 to describe the specific operationalization of the constructs.

CHAPTER 4: OPERATIONALIZATION OF THE CONSTRUCTS

Strategic applications of networked IT are the focus of this research, and therefore the constructs are operationalized in a way that is relevant to the focus and level of analysis of this research. The reader should recall that strategic networked IT applications, first defined in Chapter 3, are *those which result in product, service, or process innovations that affect the firm's core business processes.* Let us now examine the operationalization of the independent and dependent variables that correspond to the research framework presented in Chapter 3.

4.1 Independent variables

There are several independent variables that must be operationalized in this research. The variables pertaining to the firm's environment include the industry output volatility as the indicator for demand volatility, and the level of automation in the industry as the indicator for information complexity. The variables pertaining to the networked IT application include the information content of the product, the degree of innovation of the application, whether or not the innovation is compatible with existing networks, and the extent of interconnections between business functions. In addition, it is appropriate to define dummy variables to identify the nature of the strategic networked IT application that constitutes the action. The definition for these actions allows for the possibility that they are used to support innovations within the firm's products, services, or processes, and that they may extend beyond the firm's boundaries. This section discusses how each variable is operationalized. The research methods are described in Chapter 5, which provides a more detailed explanation of the data sources, the content analysis methods for encoding the data, and the statistical techniques required to test the hypotheses.

4.1.1 Environmental constructs

The environmental constructs in this model is measured objectively using external indicators. This is preferable to subjective measures, since it has been shown that managers' perceptions of the environment vary dramatically among comparable firms operating within the same environment (Hambrick, 1982) and that perceptual measures are often times not well correlated with the true environmental conditions (Downey, Hellriegel, Slocum, 1975).

The firm's task environment defines its competitive environment; however the task environment does not match ideally with the objective industry environmental measures that are available. The firm's task environment is a theoretical depiction of the environment that has an impact on all of the firm's activities and where each firm is unique. The industry classifications, defined by the U.S. government, are based on aggregations of groups of firms that compete based on their ability to produce similar outputs defined as goods or services. There are multiple industry classifications, which aggregate the output markets in varying degrees. While the objective measures are available for the industry classifications, they are not ideal measures of the firm's specific task environment. A firm may operate in only a small area of the industry classification, or its task environment could fall across more than one of the industry classifications defined by the government. Consequently, any classification of industries introduces noise into the environmental data. With this fact acknowledged, we move on to define the environmental variables used in this study.

4.1.1.1 Demand volatility

Demand volatility is a source of environmental uncertainty, and it is operationalized in this research as the *output volatility of the industry*. The data on output volatility is reported as the *Gross Product Originating by Industry (GPO)*, published by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce. The GPO data is part of the National Income and Product Accounts (NIPA) series of data published by the BEA. The BEA compiles data collected from public, private and governmental sources and produces the statistics based on actual and forecasted information using appropriate economic models for estimation (Carson, 1993; Ehrlich, 1995; Fleming, 1996; Young, 1994).

GPO data indicates the contribution of individual industries to the national aggregate measure of economic output, Gross Domestic Product (GDP). The GPO is based on the gross output of the industry minus its intermediate inputs. The GPO data can be used to indicate the diversity of output movement from individual industries (National Research Council, 1994). The BEA publishes GPO data for the economic sectors and industries listed in Table 4.1. The National Research Council (1994) reports that real-dollar GPO data are the appropriate measure for annual comparisons of industry sector output.

Table 4.1. 61 Industries with available disaggregate BEA data

Economic Sector Category	Industry
Agriculture	Farms
	Agricultural services, forestries and fisheries
Mining	Metal mining
	Coal mining
	Oil and gas extraction
	Nonmetallic mineral mining
Construction	Construction
Manufacturing (Durable goods)	Lumber and wood
	Furniture and fixtures
	Stone, clay, and glass
	Primary metals
	Fabricated metals
	Non-electrical industrial machinery
	Electrical and electronic equipment
	Motor vehicles and parts
	Other transportation equipment
	Instruments and related products
	Miscellaneous durable goods
Manufacturing (Non-durable goods)	Food
	Tobacco
	Textiles
	Apparel
	Paper and allied products
	Printing and publishing
	Chemicals and allied products
	Petroleum and coal products
	Rubber and misc. plastics products
	Leather and leather products
Transportation	Rail transportation
	Local and interurban passenger transportation
	Trucking and warehousing
	Water transportation
	Air transportation
	Pipelines, except natural gas
	Transportation Services
Communications	Telephone and telegraph
	Radio and TV
Public Utilities	Electric services
	Gas services
	Sanitary services
Trade	Wholesale trade
	Retail trade
Trade (FIRE: Finance, insurance, and real estate)	Federal reserve banks
	Commercial and mutual banks
	Credit agencies

Table 4.1 (continued)

	Securities brokers
	Insurance carriers
	Insurance agents
	Real estate
	Investment holding companies
Services (Personal)	Hotels and lodging
	Personal services
Services (Business and repair)	Business services
	Auto repair, services, parking
	Miscellaneous repair services
Services (Entertainment)	Motion pictures
	Amusement and recreation
Services (Miscellaneous)	Health services
	Legal services
	Educational services
	Social and professional services

Additional data are also used in this research to assess the volatility faced by the firm, such as industry-level fluctuations in sales and pre-tax income, reported at the 4-digit Standard Industrial Classification (SIC) level of industry. (In contrast, the BEA industries for which data is reported generally correspond to a 2-digit SIC level.) The 4-digit SIC level of industry analysis provides the finest-grain level of analysis defined by the U.S. government for collecting economic data. However, the government does not typically publish industry statistics at the 4-digit SIC level. Consequently, the only statistics that are both collected and published by the government are those at the BEA industry level. Examples of 4-digit SIC codes are shown in Table 4.2. The 4-digit SIC level data provides an alternative assessment of the demand volatility at a level that is more fine grained than the GPO measures reported for economic sectors.

Table 4.2. Examples of SIC code classification

2-digit code level	3-digit code level	4-digit code level
35 - Industrial machinery and equipment	357 - Computer and office equipment	3571 - Electronic computers
		3572, 3577 - Computer storage devices, and peripherals not elsewhere classified (n.e.c.)
		3575, 3578, 3579 - Computer terminals, calculators, and office machines n.e.c.
36 - Electronic equipment	366 - Communications equipment	3661 - telephones and telephone apparatus
		3663 - radio and TV equipment
		3669 - communications equipment n.e.c.
	367 - Electronics component manufacturing	3672 - electronic circuit boards
		3674 - semiconductors and related devices
		3675 - electronic capacitors
		3676 - electronic resistors
54 - Retail trade - food stores		
56 - Apparel and accessories		
58 - Retail trade - eating and drinking places		
73 - Business services	737 - Computer programming, data processing, and other computer related services	7371 - Computer programming services
		7372 - Prepackaged software
		7373 - Computer integrated systems
		7374 - Computer processing and data preparation and processing services
		7375 - Information retrieval services

The data are used to compute measures for the demand volatility of the industry, consistent with prior research. Volatility measures used in prior research include variance measures and measures of deviation from the mean. The coefficient of variation of first differences is reported by Bourgeois (1985), and defined as the standard deviation of first differences divided by the mean of the first differences, from year to year for a five-year period. (The 'first differences' are calculated as the difference in the value of the variable of interest from year to year.) When the mean of the first differences is negative, the coefficient of variation of first differences can take on negative values Therefore, in this research it is appropriate to use the absolute value of the coefficient of variation of first differences. Price (1995) used the variance of economic output as indicated by GDP as the measure of aggregate demand uncertainty. Variance measures can also be converted into standard deviation measures. The model fit is frequently improved if the log of the standard deviation is used rather than the variance. Consequently, several forms of the GPO and the industry-level income data are tested as indicators for the demand volatility of the industry. *The measures used in this research to represent volatility in industry demand include the absolute value of the coefficient of variation of first differences, and the standard deviation of the following industry-level measures reported annually, over the five-year time period from 1990 through 1994: Real Gross Domestic Product by Industry (GPO), industry sales, industry pre-tax income.*

Multiple measures of a construct are useful for establishing the validity of the measures. They also measure slightly different aspects of the construct. For instance, the GPO data, reported for selected industries by the BEA, includes economic data for all firms in the U.S. economy. The data obtained at the 4-digit SIC code level is not published by the government, but rather it is compiled through Compustat reports and therefore only reflect the statistics for publicly-traded firms. Furthermore, the GPO data subtracts out intermediate inputs, but the industry sales and pre-tax income measures do not.

Similar industry output measures have been used by others as indicators of the competitive environment. For instance, Downey, Hellriegel and Slocum (1975) operationalized environmental uncertainty by calculating the coefficient of variation in the change in BEA industry output projections from year to year, over a 10-year period.

Mills and Schumann (1985) used the variability in industry output shipments to represent demand fluctuation. This was computed by "regressing the natural logarithms of industry product shipments onto a constant and a time trend with adjustments for serial correlation." (p. 763). The data on average industry product shipments (for appropriate 2, 3, and 4-digit SIC industries) were obtained from the *Annual Survey of Manufacturers*, published by the U.S. Census Bureau. Industry product shipments, however, do not accurately reflect output in service industries, and have limited usefulness in a broad cross-industry study.

Bourgeois (1985) operationalized environmental volatility by calculating the coefficient of variation of first differences (defined as the standard deviation of first differernces divided by the mean of the first differences) from year to year for a five-year period preceding data collection for several economic indicators. These indicators were factor analyzed and a two-factor solution that explained 63.2 percent of the total variance was used. The commercial volatility factor loaded primarily on industry sales, industry earnings, and Department of Commerce (BEA) projections of industry output.

Fiegenbaum and Karnani (1991) operationalized industry volatility as the standard deviation of total industry annual sales during a 9-year period. They elected to use standard deviation data rather than a time trend line, as Mills and Schumann (1985) did, due to the limitations of their data. Their data was collected at the firm level from the Compustat Business Segment and then pooled for firms in the same industry in order to obtain the industry-level measure.

4.1.1.2. Level of industry automation

The degree of automation in the industry is a source of information complexity in the environment, and it is operationalized as the *annual investment in computer and communications capital in the industry accumulated over 5 years, divided by annual industry output*. If the IT application in the sample is one implemented by a diversified firm, the industry of the application is determined by the market focus of the application. For instance, an application occurring at Pizza Hut, which was owned by PepsiCo during the time period of the research, is classified according to the degree of automation in the fast-food industry rather than in the soft-drink industry.

The annual investment data in computer and communications hardware accumulated over a five-year period provides an indication of the recent investments in modern computer and communications capital, and the time period is consistent with the time period for assessing demand volatility.

The complexity measure defined in this research is one that focuses on the information complexity caused by the degree of automation in the industry. Automation was defined as the application of computer and networking technology to tasks, but it also created information demands that could only be met with increasing uses of such technology (Hayes and Jaikumar, 1988; Jonscher, 1994; Venkatraman, 1991). The complexity measure used in this research is an industry-level measure that is appropriate to use in order to contrast the different degrees of information complexity across a broad range of industries. (Bradley, 1993; Mata, Fuerst and Barney, 1995; McConnell, 1996; National Research Council, 1994).

The reader is reminded that there was considerable discussion of this measure in Chapter 3, as an indicator of the degree of information complexity in the firm's environment. As stated in Chapter 3, this measure is useful in that it provides some indication of the information demands facing the firm, in terms of demands presented by tasks automated with computer and communication networks. It is also acknowledged that this is an incomplete measure which significantly underestimates the industry-level investments in software, maintenance, training, and other necessary expenditures. Hardware costs may only represent eight to ten percent of the total investment in IT.

Another drawback of this measure is that it does not distinguish between the different types of computer and communications capital investments that were made and how they were configured. Consequently, it is not possible to know what firms did with these investments; they can only suggest the relative differences in the capital investments from one industry to the next. It also does not explicitly identify the interdependent tasks that are connected together in the system created through the use of the computer and communications hardware. Related to the notion of the use of the technology, some may argue that the measure may overstate the degree of automation in the firm's environment, based on the argument that firms may invest in computer and communication equipment and not in fact use it properly or effectively.

The benefit of using this measure is that it is based on very reliable data collected on an industry level by the U.S. Bureau of Economic Analysis. Furthermore, it enables comparisons to be made in a cross-industry analysis by focusing on the basic components of computer and communications hardware that form the essential building blocks of the information systems. Unfortunately, an alternative and more complete measure is not available, and therefore this measure is used while acknowledging its limitations.

This measure is affected by the overall size of one industry as compared to another, and by the size of firms in the industry. The investment in computer and communication hardware is scaled by the annual industry output so that comparisons can be made between industries of different sizes. In this way, the value reflects the relative differences in information-complexity facing firms in one industry as compared to another. The measure is not scaled, however, to adjust for the relative differences in the size of firms in one industry as compared to another. Larger firms have been described as having more complex information relationships with their environments (Hagström, 1991), and as driving the complexity of the environment that is experienced by all firms in the industry (Rockart and Short, 1991). Therefore, the proposed measure has the face validity to serve as an indicator of the information complexity demands facing firms in an industry, and it has the broad applicability to allow comparisons to be made regarding the relative differences in such demands between industries.

4.1.2 Information content of the industry output

At face value, the information content of a product or service output by an industry appears to be a simple construct. Financial and insurance products, for instance, are considered to be 'information intensive.' However, retail services are also considered 'information intensive' (Jarvenpaa and Ives, 1990). Therefore, the measure of the industry's output information content must take into account the information intensity of producing the product or service as well as the information intensity of the final goods and services.

Operationalization of the output information content is based on industry profiles regarding the 'information intensity' of leading firms in specified industries. This is known as the *output information industry score*. The firms, while large in size, are considered to be leaders in their use of information technology as compared to all firms. While many of the firms are also the largest firms in the industry, the firm's size was not the determining factor in calculating the scores. Consequently, the scores represent how firms used the technology, and the firms with the best use of the technology were ranked the highest. Therefore, the measure is an indication of 'best practice' in using IT in the industry, rather than a measure of the industry average. The measure is representative of how firms can best use IT to support their processes that are vital to producing their outputs sold to customers, based on the experiences of those in the industry with the most exemplary uses of the technology.

The measure for the output information content is derived from firm-level profiles regarding the use of networked IT by leading-edge users. The data are published annually by Information Week in their *Information Week '500'* classification of the 500 leading users of networked IT in the U.S.(Brynjolfsson and Hitt, 1996b). Data are gathered by a consulting firm, and the firm-level scores are developed in conjunction with MIT to determine the 'top 500' productive users of IT. The scores for each firm are based on the variety and level of investment in IT hardware and software resources, the extent to which the firm uses 'leading edge' technology, its number of employees and sites, the ways in which employees use of IT, workflow information, and financial performance information. Information Week then assigns a rank order to the score to identify the 'top 500 productive users' of networking and information technology. It also groups the top 500 firms into 20 selected manufacturing and service industries to summarize industry applications of the technology. The industries are shown in Table 4.3. (The weighting of the sub-categories that are used to calculate the scores are not available.) Although the profiles are weighted toward large firms, these firms are believed to be the 'best practice' examples of the use of information technology in a particular industry group. In the context of Rayport and Sviokla's virtual value chain, these firms have successfully exploited the virtual value chain of the product or service of their industry.

Table 4.3. Industries in the Information Week '500' ranking of firms

Industry Classification
Aerospace/Engineering
Banking
Chemicals
Computers
Consumer Goods/Services
Electronics
Energy
Financial Services
Food Processing
Health Care
Insurance
Manufacturing
Media
Metals/Natural Resources
Pharmaceuticals
Professional Services
Retail
Telecommunications
Transportation
Utilities

The output information content measure in this research begins with scores of 500 firms published by Information Week and segmented into 20 industries. The 'output information content' score is obtained by calculating the average score for the firms in each of the 20 industries. The scores suggest differences in the use of networked IT when assessing top users of the technology across all industries. Since the industry scores include much more than just hardware investments, the score is believed to reflect the extent to which the products, services, and processes within a selected industry are ripe for exploiting through the use of information technology. In other words, the scores reflect the general product-information content of the industry. The industry rankings suggest the degree to which firms that are most advanced in the use of IT in the given industry integrate the technology in their numerous organizational capabilities. These are the organizational capabilities that the firms rely on for competing successfully to in their selected market. However, the scores do not assess competitive behavior aspects of the firm. These rankings, therefore, focus on the information aspects of the products and services that are the outputs of a particular industry.

By including a measure of the 'information intensity' of the industry output in the model, there is an opportunity to test an additional, or possibly alternative, plausible explanation of the findings (Dess, Ireland and Hitt, 1990). The finding could reveal, for instance, that competitors are motivated to respond to strategic IT applications based on the information intensity of the products in the industry rather than on the effects of the environment on the firm's IT capabilities. This would be demonstrated by comparing the results of H1, assessing the information-content of the industry output, versus H2 and H3, assessing the competitive environmental demands upon the firm.

4.1.3 Degree of innovation

The degree of innovation of the networked IT application is based on Swanson's (1994) typology of Type III innovations using IT as well as the three degrees of innovation defined by Tushman and Nadler (1986). The discussion of increasing innovation appeared earlier in the paper, so just the results are shown here. An *innovation score* is determined for each application. This innovation score combines the effects of the degree of innovation within each category along with the comparative degrees of innovation associated with the distinct categories. The definitions that form the basis of this classification were discussed earlier. The resulting innovation score is shown below, in Table 4.4.

One may argue that the proposed innovation score should first rank the incremental innovations as levels 1 through 3, followed by the synthetic innovations taking on the values of 4 through 6, and finally the discontinuous innovations being assigned the values of 7 through 9. In other words, the classifications of incremental, synthetic, and discontinuous are given precedence over the IT applications that Swanson proposed demonstrated increasing degrees of innovation. This alternative scoring is shown in Table 4.5.

Table 4.4. Innovation Score: Increasing degrees of innovation in IT applications

IT Innovation Category - by increasing innovation in the IT application (Based on Swanson's typology)	Increasing degree of innovation - within the category (Based on Tushman and Nadler's classification.)	Innovation Score
Product or service innovation	incremental	1
	synthetic	2
	discontinuous	3
Process innovation	incremental	4
	synthetic	5
	discontinuous	6
Innovation extending beyond the firm's boundaries	incremental	7
	synthetic	8
	discontinuous	9

Table 4.5. Alternative Innovation Score: Increasing degrees of innovation

Innovation Category - by increasing innovation (Based on Tushman and Nadler's classification.)	Increasing degree of IT Innovation - within the category (Based on Swanson's typology)	Alternative Innovation Score
Incremental innovation	Product or service innovation	1
	Process innovation	2
	Innovation extending beyond the firm's boundaries	3
Synthetic innovation	Product or service innovation	4
	Process innovation	5
	Innovation extending beyond the firm's boundaries	6
Discontinuous innovation	Product or service innovation	7
	Process innovation	8
	Innovation extending beyond the firm's boundaries	9

The innovation score depicted in Table 4.4 gives priority to Swanson's typology of IT innovation by first sorting or classifying the IT applications based on their intended use, and then classifying them in terms of incremental, synthetic, and discontinuous innovations. The alternative innovation score in Table 4.5 gives priority to Tushman and

Nadler's classification of innovations by first sorting the applications as incremental, synthetic or discontinuous innovations, and then classifying them according to the type of IT application. As can be seen by comparing Table 4.4 and 4.5, the innovation scores of 1, 5, and 9 are identical with both methods. The alternative scale, presented in Table 4.5, is tested to determine the sensitivity of the regression results to the specific scoring method of the degree of innovation of the IT application. The results of this sensitivity analysis are discussed in Chapter 6.

One drawback to either innovation scale is that an equal increment in the degree of innovation is assumed from one category to the next. This speculated relationship is unavoidable, because to our knowledge no other scaled measure exists to reflect the increasing degree of IT innovation that would be appropriate in this research. Another drawback is that the innovation score requires subjective judgment of the innovations. Therefore, it is appropriate to assess the reliability of the classification by having other individuals classify a sample of the innovations and compare the results.

The reliability of the innovation classification is assessed by randomly selecting articles from the data sample to be encoded by multiple people. The encoders must be competent to determine whether the application is being implemented as a product innovation, service innovation, process innovation, or an innovation extending beyond the firm's boundaries, and they must be able to evaluate the degree of innovativeness of the technology used in the application in order to classify it as an incremental, synthetic, or discontinuous innovation. The results of the multiple-encoding efforts are analyzed to assess the reliability of the encoding. This is done by calculating the following measures that suggest the extent to which the encoding is reliable: the frequency of agreement in the classifications and Cohen's Kappa for the categorical classifications (Maier, Rainer and Snyder, 1997).

The frequency of agreement is calculated as the number of classifications that agreed with the original classification, divided by the total number of times the item was classified. Clearly, the frequency ranges from zero to one. The frequency of agreement for each category is calculated, as well as an average frequency of agreement.

Cohen's Kappa indicates the proportion of classifications that are in agreement after removing the effects caused by the proportion for which agreement is expected by chance (Cohen, 1960). Kappa is calculated as the proportion of agreement minus the proportion of chance, divided by 1 minus the proportion of chance. Kappa ranges from plus or minus one. A Kappa score of greater than 0.65 is considered acceptable (Moore and Benbasat, 1991; Maier, Ranier and Snyder, 1997). The Kappa score is calculated for each classification category, and an average Kappa is calculated to assess overall agreement.

The procedure described above is used to assess the reliability of the other measures in the study that also require subjective judgment for encoding, and the results are discussed in Chapter 6. The remaining measures are discussed in the following sections of this chapter.

4.1.4 Compatibility with existing networks

A binary categorical variable (1, 0) is used to indicate whether or not the applications of networked IT are *compatible with existing public networks*. The application is considered to be 'compatible' (coded 1) if it uses an existing public network as a key component of the application. An application is not compatible (coded 0) if it does not make use of public networks. (An alternative indicator variable is used to assess if the application relied on private networks as a key component.) This coding allows for a very straight-forward testing of the main effects and interaction effects of this variable on the other variables in the model. Main effects of this categorical variable create a change in the intercept of the estimated model, whereas interaction effects alter the slope of the model. This measure is also assessed for reliability using the same method described above for the innovation score.

4.1.5 Extent of business functions interconnected

The extent of business functions interconnected by the networked IT application is operationalized as a score based on the number of the intrafirm and interfirm functions supported by the IT application and the entities that are interconnected by the application.

This is referred to as an *integration score*. The integration score is calculated as the product of the two values: the number of firms involved in the application times the number of business functions or customer groups interconnected by the application. For instance, for an application that resides solely within one firm and interconnects two business functions, perhaps marketing and customer service, the score would be 2. If an application interconnects 10 firms and five different business functions within those firms, the score would be 50. In terms of customer groups, retail customers would be distinct from commercial or industrial customers, for example, and each would constitute a different group interconnected by the application.

Alternative calculations may also be considered. For instance, one might choose to calculate the interconnections between the number of firms, such as $[n(n-1)/2]$, where n is equal to the number of firms. Another alternative is a calculation of the interconnections between the number of business functions, $[f(f-1)/2]$, where f is equal to the number of business functions interconnected by the application. In the first case, the extent to which the interconnections support a variety of business functions is ignored. In the second case, the extent to which the business functions are distributed across several firms or entities is similarly ignored.

Another serious flaw in this possible approach is the implied topology of the network of firms, or business functions, respectively. The calculations assumes that there is a mesh configuration of the linkages, where each entity in the network, or in this case the firms or the business functions, is connected directly to all other entities in the network. This requires $n(n-1)/2$ linkages in order to connect together n nodes in a mesh configuration (Bellamy, 1991). While the precise information topology of the linkage is not known, it is highly likely that it is not a mesh configuration where every firm in the network connects via linkages to every other firm in the network. The level of analysis of this research is focused on the application, which originates with one firm. With the application as the focal point, a more likely scenario of the information exchange is that of a star configuration, where the initiating firm is the central point which communicates in specific ways with entities of its choosing. There is no implication that those entities have similar linkages to the other entities in the network configuration. The application is based on the information interdependencies of the central firm with the other entities, and says nothing about the information relationships between the other entities. Consequently, the mesh calculation is inappropriate for this research. Similarly, the mesh calculation based on the functions performed is also inappropriate because there is no reason to expect that every business function would require linkages with all other business functions in the network.

The straight-forward multiplication of the number of entities times the number of business functions is recommended because of the multiple potential purposes for exchanging information between firms and business functions, with an implied star configuration between the firm initiating the application and the entities to which it has chosen to include in the application. Furthermore, it is more appropriate to multiply the number of firms times the number of functions, since the linkages between the firms can be used simultaneously to support multiple functions, as is commonly the case in advanced information networks due to the versatility of the technology and the design of the networks. In many cases the exchange is two-way where either party can initiate the shared communication, even though one party is likely to originate different types of information. Finally, it is frequently reported that while communications are established initially for well-defined purposes, once the link is in place many other types of information are also shared over the same link (Malone and Rockart, 1991; Sproull and Kiesler, 1991). Therefore, it appears to be inappropriate to reduce the interconnection score through another multiplication factor, therefore indicating a lesser degree of information integration. It can be argued that a higher degree of integration should be considered, but the proposed integration score, based on the product of the number of firms times the number of functions, offers a conservative estimate of the extent to which information is shared.

The business functions used in this calculation are pre-defined in order to achieve a more consistent coding of this variable as firm's label their functions differently. The business function encoding categories are shown in Table 4.6, based on likely uses of IT in organizations to support innovation (Davenport, 1993).

Table 4.6. Encoding categories for business functions integrated by the strategic networked IT application

I. Product/service development an delivery functions
a) market or product research
b) engineering, design, development, or testing
c) manufacturing, production, or service creation
d) logistics (supply chain, tracking, inventory)
II. Customer-facing functions
a) marketing
b) sales and order processing
c) case management, order segmentation, customer service
d) customer participation, customized requests
III. General management processes
a) strategy formulation
b) financial control, planning, and budgeting
c) performance monitoring and measurement
d) resource allocation
e) human resource management
f) communication infrastructure development
g) stakeholder communication
(Note: Given the definition of the strategic applications in this research, most application are expected to interconnect functions in categories I and II.)

The index has the face validity of increasing rapidly as the number of firms and number of business functions interconnected increases, just as the level of integration increases rapidly as business functions are interconnected by the networked IT application. Unfortunately it suffers that a degree of subjective classification is required. Therefore, it is appropriate to assess the reliability of the classification in the same manner that was described above for the innovation score and the classification regarding the use of public networks.

4.1.6 Dummy variables classifying the type of networked IT application

The definition of strategic networked IT applications encompasses applications that result in product, service, or process innovations that affect the firm's core business processes. These applications may be contained within the firm, or they may extend beyond the boundaries of the firm. Therefore, the cases actually encompass four types of strategic networked IT applications: *product innovations, service innovation, process innovations, and innovations that extend beyond the firm's boundaries*. A strategic networked IT application could be classified as at least one of these four categories.

Swanson (1994) included four types of strategic applications in his typology of IT innovations. They represent specific examples of the firm's organizational capability to use networked IT. Product and service innovations have an impact on the firm's market domain because they alter the firm's products or services and possibly create new ones. Process innovations result in new methods, procedures, means of controlling or coordinating functions, and means of collaboration within internal processes. Process innovation may alter the communications linkages in the firm by creating new linkages or by improving the capabilities of those in place. The innovations that extend beyond the firm's boundaries affect its horizontal and vertical integration with other firms.

It was not known in advance of this research whether or not the four different types of applications would influence the responses of competitors, and if so, what the effects of the influence would be. Therefore, it is appropriate to test for these effects. This is done through the use of dummy variables in the regression models to control for any main and interaction effects between these four types of innovative applications and the other terms of the model that are associated with the hypothesized relationships. The dummy variables are created using a binary (1,0) encoding scheme. The main effects are determined by the dummy variables themselves. The interaction terms are formed by the product of each dummy variable times the measure for each of the hypothesized constructs in the research framework that was shown in Figure 3.1. Therefore, the models include tests for the significance of the main-effect of each dummy variable, as well as the interaction effect of each dummy variable with the six hypothesized relationships. Significant main effects of these dummy variables would influence the intercept of the model, and significant interaction effects would influence the slope of the model associated with the appropriate hypothesized factor.

The dummy variables classifying the type of strategic networked IT application are distinct from the degree of innovation scale discussed earlier, and should not be confused with this other explanatory variable. The four dummy variables are used to identify attributes of the action, but they are not ranked in any way. On the other hand, Swanson's typology of IT innovation was based on arguments that implied a ranking in the degree of innovation of one IT system as compared to another. This typology formed the basis for the innovation scale, which was a nine-level scale used to quantitatively rank the degree of innovation of one application as compared to another.

The hypotheses described in Chapter 3 do not distinguish between the four types of applications: applications to support product innovations, service innovations, process innovations, or innovations that extend beyond the firm's boundaries. Therefore the use of dummy variables is exploratory in the sense that it may provide additional insight about the likelihood of competitive responses for a specific type of application. This information could aid managers in seeing how some types of strategic networked applications may generate competitive responses, and how an application that consists of a combination of categories may have trade-off effects in competitive response. By exploring these relationships, we are able to provide mangers with a greater understanding of how they can use networked IT in a variety of circumstances that maximize the advantage that they gain over competitors.

The reliability of the dummy variable classification as product innovations, service innovations, process innovations, or innovations that extend beyond the firm's boundaries is assessed in the same manner described for the other judgment-based variables described above.

4.2 Dependent variable: responses from competitors

This research makes use of two dependent variables in order to assess the competitive responses from rivals. One variable is based on a *count of the responses* from rivals, and another is based on the *response per key competitor*. These variables are described in detail in the next two sections.

The response variable is essentially a categorical variable that is used to provide a count of the number of responses that a particular action received. All individual responses are counted as being equal to each other; there is no indication regarding the range of response. In reality, there is likely to be a varying degree of response from competitors. Some competitors who respond may generate an IT application that merely meets the performance of the action, while others may generate an IT application that exceeds the performance of the original action. There may also be differing geographic deployment issues that are relevant to the response. One firm may deploy an application globally, while another will only have a regional deployment. Similarly, a firm may implement an application that has a greater degree of knowledge integration within its firm than the response generated by another competitor.

These are legitimate concerns regarding the response variable, because varying degrees of response could influence the competitor's ease and speed in generating the response. Since this research is the first to assess competitive response using IT, the research relies solely on a categorical representation for each response. However, further research that is an extension of this work should examine more closely the range of responses generated by competitors.

As discussed extensively in Chapter 3, an important concern regarding both forms of the dependent variable pertains to systematic differences in reporting responses that affect which firms capture the attention of the press in the specified research time period. For instance, there may be differences in responses reported for firms due to the distinct uses of networked IT applications across different industries, differences in the types of technology used in the response, differences in reporting later responses as compared to earlier responses to an innovation, and the differences that can be caused by varying levels of industry concentration. First, it should be acknowledged that the public announcement of both applications and responses is a conservative number that falls below the actual number of strategic networked IT applications. In particular, actions or responses that are not highly innovative may not be considered noteworthy by the press. Secondly, a firm may be in the process of developing a response, but its responses may not be made known publicly. This could occur, for instance, if the firm had not completed the response to the point of deployment, which is a likely scenario when the response itself is highly innovative or involves a high degree of knowledge integration within the firm or beyond the firm's boundaries. The response may not be publicly reported if it did not come to the attention of the journalists, as might be the case for a less innovative response. There is also the possibility that late responses are not reported as diligently by the press as earlier responses.

These problems can be addressed in part by testing the significance of control variables that indicate systematic industry level differences according to the originating firm's industry, the industry concentration, and the technology used. Controls can also be tested that assess journalistic biases. These control variables are described in detail in Chapter 5.

Another important element of the reliability of the response data, however, comes from the source itself. The publications selected for this research as the source of the action as well as response data are considered to be reliable and high-quality by firms seeking information about innovative uses of networked IT. Maier, Rainer, and Snyder (1997) studied the techniques used by firms when they scan their environment for information on uses of IT. Key industry technical and professional trade journals, including those that are used in this research, were found to be important sources of information by firms engaged in environmental scanning for on information technology to assess how their competitors are using IT. The trade journals are written with the specific intent of conveying factual information regarding the use of IT across a wide variety of industries. Therefore, the information reported is highly credible and reliable, as they report on important activities undertaken by firms in a timely manner. These data sources have been used in similar research studies, and therefore they are believed to be appropriate sources for this research (i.e. Brynjolfsson and Hitt, 1996a; Kettinger, Grover, Guha and Segars, 1994; Neo, 1988).

4.2.1 Number of responses from competitors

The most basic form of the dependent variable is the count of the number of responses received from competitors. This variable does not take into account differences in the number of competitors faced by the firm initiating the action. *Responses* are defined as *those applications of networked IT that are provoked by the prior action of a competitor*. It should be emphasized that both the actions and the responses are based on strategic applications of networked IT that are publicly described in published articles. An application may be encoded as a response: a) if it states in the description of the application that it is a response; or b) if an application is found which attempts to duplicate or leap-frog the benefit that a competitor originally sought to achieve by an earlier application of networked IT. The source of the information may or may not state explicitly that it is a 'response,' but the description should indicate the purpose of the application sufficiently to make this determination. The *Response* variable is first operationalized as a binary categorical variable. Then the total number of responses generated by an application are summed together.

4.2.2 Likelihood of Response

The second form of the dependent variable in this research is the *Likelihood of Response* from a rival. This is operationalized to reflect the occurrence of responses per competitor. This is defined as the *number of competitive responses provoked by an application, divided by the number of key competitors.* This measure takes into account the firm's most direct and important competitors. It is not appropriate, for instance, to just count the number for firms that share the same 4-digit SIC code. For one, this excludes private firms that may be formidable competitors. Secondly, SIC codes define economic sectors, but industry boundaries are frequently blurry and firms that are actually direct competitors, may appear in different 4-digit SIC codes. Information regarding competitors is self-reported by public firms, and publicly available in their 10-K filings with the Securities and Exchange Commission (SEC). However, while some firms list competitors by name, other merely describe their industry as being 'highly competitive.' In addition, privately owned firms do not file such reports with the SEC and therefore there is no publicly available self-reported information. Rather than to rely on the firms themselves to identify competitors, an alternative is to rely on an independent organization who responsible for financial and strategic research on specific firms. Such an agency is Hoovers, who publishes information on key competitors for a wide range of selected public and private firms. Similar methods of identifying a firm's key competitors were used by Kettinger, Grover, Guha and Segars (1994).

The reason for defining one form of the dependent variable as the sum of responses per key competitor is to enable valid comparisons to be made between responses that occur in different competitive contexts. If a firm has few competitors, one could expect fewer responses as compared to a firm with many competitors. The dependent variable has the ability to indicate when responses exceed the number of key competitors. Such a situation suggests that responses were provoked from other firms that were not originally considered as 'key competitors,' suggesting the possibility of inter-industry rivalry and possible industry transformation as new competitors emerge.

4.2.3 Limited dependent variable

The dependent variable defined in this research is a left-censored variable that can potentially have a high number of zero values. The censoring is caused by four conditions. First, competitors observe an action, but choose not to respond. Second, competitors observe the action and want to respond, but they are not able to do so. Third, competitors observe the action and are in the process of formulating a response, but they have not implemented the response within the time period of data collection. Fourth, competitors observe an action, and choose to respond in a different way other than using IT. (In temporal studies which measure the time elapsed prior to a response, these conditions cause the data to be right-censored. However, this research does not measure time; it measures responses, and the zero responses cause the data to be left-censored.) These conditions result in the zero responses being provoked by the application.

This type of variable, first defined by Tobin (1958), requires special attention during statistical analysis in order to account for the left censored distribution. The appropriate statistical techniques for handling such a dependent variable are described in detail in Chapter 5.

4.3 Summary

The constructs of the research framework are operationalized through a combination of published measures and encoded measures derived from articles describing the IT application. Independent variables consist of measures assessing industry-level characteristics, such as the information intensity of the firm's product, the demand volatility in the environment, and the information complexity in the environment due to the level of automation in the industry. The independent variables also include measures pertaining to the characteristics of the networked IT 'action' application, such as its degree of innovation, the extent of the business functions integrated by the network, and the use of public networks, thus suggesting indicating network compatibility. The independent variables are only collected for the firm initiating the 'action' application.

The dependent variable is derived in two forms. One is the basic count of the number of individual responses an action receives from competitors. The other is the count of the individual responses divided by the number of key competitors the firm faces. This form of the dependent variables enables one to assess the likelihood of response from competitors. Chapter 5 further examines the data sources and describes the research methods in detail that are used to analyze the models and test the hypotheses.

CHAPTER 5: RESEARCH METHODS -- DATA COLLECTION AND ANALYSIS

5.1 Sample Selection

This research requires a multi-industry sample of networked information technology applications implemented by U.S. firms. The sample includes public and private firms of a wide range of sizes. Noncompetitive organizations and governmental organizations are excluded from the study. The applications may be global in scope, although the firms have their headquarters in the U.S. to simplify data collection requirements. From a theoretical standpoint, by limiting the sample to U.S. based firms, the noise in the measures is reduced for several reasons. First, the U.S. telecommunications regulatory environment is uniform across the sample of firms. Secondly, the relative access to telecommunications and computing technologies of comparable technological performance, at relatively the same cost, is ensured. This eliminates the effect of trade barriers which severely limit the availability and price of telecommunications and computing technologies in some foreign countries. Third, the measures for the environmental variables and the industry output information intensity would not be available on a consistent basis, if at all.

By collecting data at the level of the application, a response is observed that is closely attributed to an earlier action carried out with networked IT. Similarly, Kelley (1994) studied the application of IT at the process level in order to examine innovations specifically related to those processes. The application-level focus is necessary in order to learn more about the nature of strategic uses of IT (National Research Council, 1994). The action-response approach to this research establishes a high degree of face validity that there is, in fact, a relationship between the characteristics of the networked IT application and the resulting rivalrous behavior.

5.2 Networked IT application data: actions and responses

The nature of this research requires detailed information about innovative applications of networked information technology in a competitive context. These networked IT applications constitute both the actions and responses; the responses are applications which are provoked by the prior action of a competitor. In addition, these applications must be public knowledge to satisfy the condition that rivals are likely to be aware of them. The source of data must describe the applications in sufficient technical and business detail to enable each to be coded for the variables defined earlier.

Articles published in journals targeted toward the information technology industry are the sources used in this research because they are readily available and they accurately depict strategic applications of networked information technology across a wide variety of industries. These articles are written by technically astute journalists who present an explanation of the business and technical aspects of the application in sufficient detail so that the applications can be coded. The articles frequently cite the firm's senior-level information managers who are involved in the application, so the information is obtained from a knowledgeable person in the company and has a high degree of validity and reliability. In addition, some articles specifically refer to applications being "in response to" a competitor's earlier actions, which clearly identifies the application as a response.

Many of the articles were obtained from electronic databases accessible via the Internet. These include the CMP-TechWeb database of articles published in Information Week and Communications Week, the Ziff-Davis Publications database of articles from numerous publications, and the McGraw Hill database of articles from Data Communications Magazine. These data sources have also been used previously in other IT research that pertains to the strategic application of information technology (i.e. Brynjolfsson and Hitt, 1996a; Kettinger, Grover, Guha and Segars, 1994; Neo, 1988). These same data sources have been shown to be used by firms for environmental scanning on IT (Maier, Rainer and Snyder, 1997). On-line databases of articles are useful in that they reduce the time and cost of first-hand case-based research and they are publicly accessible. The articles are retrieved using key-word search terms, thus ensuring a greater degree of uniformity in the types of cases used in this sample. The full text of each article is downloaded and stored on disk for later encoding by computer-assisted content analysis techniques.

Data are collected pertaining to the dependent variable and the application-specific independent variables from articles that describe strategic networked IT applications. This requires encoding the articles as to whether or not the IT application is a response to a prior action, its degree of innovation, whether or not the application is compatible with existing networks, and the nature of the business functions interconnected by the application. The dependent variable can take on two closely related forms: the number of responses per competitor, and the count of the number of responses. While the responses are collected over a two-year window, both forms of the dependent variable are assessed within a 1-year window as well as a 2-year window in which competitors can respond.

The competitive action data is collected over the period spanning 1993 through 1994, while the response data is collected over a two-year sliding window from the time of the action. Therefore, the responses fall within the time period of 1993 through 1996. With this time period selected for the action data, it is likely that all competitors have a reasonably likely opportunity to use and access the Internet and WWW. The time period for the response data is sufficient to allow competitors the opportunity to respond to a networked IT application. At the same time, the data collection focuses on a sufficiently narrow time frame where the price-performance capabilities of the equipment, and its availability to rivals, should not require additional control variables to account for inherent technological differences. By examining a time period with relative uniformity in the technology available to the firms, we can assume that the applications and responses are largely an indicator of the firm's ability to use the technology rather than differences in the processing capabilities and capacity of the technology.

There are also financial implications that deserve to be commented on. The technological push of IT, described in Chapter 2, has resulted in a dramatic reduction in the effective cost of processing and transmission capability of the technology. Therefore, over a period of many years it would be necessary to scale for the effective information processing power purchased for a given dollar amount. By limiting the window as defined, the processing capabilities of the technology are relatively uniform.

Another issue regarding the financial implication of the time period of the study is that a firm's general financial position may influence its ability to respond. The degree of slack that a firm has is one possible explanation for why it has the capability to develop competitive responses using information technology. However, the literature shows many examples where firms with considerably lower financial positions use information technology to 'level the playing field' against larger competitors. This is possible because a wide variety of technology can be deployed to achieve a similar benefit for different firms. Secondly, while there are large IT projects, the majority are smaller-scale endeavors designed to reap near-term benefits (National Research Council, 1994). Third, many managers in professional firms consider the cost of IT to be vital for preventing future losses to the firm if it did not invest in the technology. In fact, according to the National Research Council, managers "may consider the cost of over-investment in IT as insignificant against (the potentially much larger) losses the firm might incur if it fails to attract top talent, sustain its competitive edge, or hold market share because its IT systems are inadequate" (National Research Council, 1994: p. 99). Therefore, firms frequently give a very high priority to IT investments. Fourth, the focus of this research is to provide information about actions the initiating firm can take when it uses information technology to prolong the advantage of the technology, regardless of who the competitor can be. The underlying assumption is that the initiating firm cannot select its competitors, and therefore this research does not control for differences in competitors' financial position.

Content analysis techniques are used to encode the articles. Content analysis is an empirical technique to systematically and objectively make inferences based on qualitative data by encoding the message in the data so that it can be analyzed. It is a classification technique that produces repeatable results and allows the researcher to focus on the desired information within a written text (Carney, 1972; Holsti, 1969; Lindkvist, 1981; Weber, 1990). Consequently, content analysis is an appropriate technique to use in this research to code each networked IT application according to the variables required for the research model.

Content analysis procedures are as follows: a) define the text unit to be analyzed; b) define categories for classification; c) develop the coding rules for each category; d) test the coding of sample text; e) assess the validity and reliability of the coding rules; f) revise the coding rules to achieve the appropriate level of validity and reliability; and f) apply the coding rules to all text. Common content analysis techniques include word frequency counts or key word in context (KWIC) concordances which can also be extended to phrases.

The variables in this research that require content analysis encoding include: a) whether or not the article describes a response; b) the dummy variables that indicate whether or not the application resulted in a product, service, or process innovation, and if the innovation extended beyond the firm's boundaries; c) the degree of innovation of the IT application; d) its compatibility with existing networks; e) the nature of the interconnections between business functions; and f) the time of implementation of the application. These variables were defined in Chapter 4, and the content analysis coding rules are based on these definitions.

This research classifies networked IT applications based on key word and key phrase concordances. This method relies on the existence of specific words or phrases in the article describing the application in order to encode it with the appropriate dimension. The word frequency count method is not to be used because of the high likelihood of coding bias caused not by the intended message of the article but instead by different journalists' writing styles. The unit of analysis is the published article describing the strategic networked IT application.

Computer-aided word search techniques were used in the analysis of the articles. Computer-based content analysis has increased reliability, stability, and objectivity over techniques that are performed without such a tool by an individual researcher (Kabanoff, Waldersee, and Cohen, 1995; Morris, 1994.) The computer-aided searching was performed using the "find" feature of the software application used to display the text of the article. While text management software packages exist for content analysis for general social science research, technology-related content analysis software tools do not exist. Consequently, in the absence of such a tool, the built in text searching mechanisms in standard word processors and database software packages proved to be very useful in analyzing the applications.

Content analysis techniques have been used previously in strategic IT-related research. Jarvenpaa and Ives (1990) used content to code references made by CEOs regarding IT in their letters to shareholders. Jarvenpaa and Ives' unit of analysis was an IT-related phrase, defined as one that "Discusses the management, application, investment, organization of computer, communications, or office technology for improving or modifying operations, establishing linkages with customers, suppliers, competitors, channel partners, or the development of new products." (p. 357-358). Two readers encoded the letters and achieved nearly a 97 percent agreement in coding a trial, and thus the actual encoding was carried out by only one reader. The encoding scheme used to encode each IT-related phrase was empirically derived from annual reports from firms in the banking and retailing industries in the U.K. Based on Jarvenpaa and Ives' use of content analysis to encode the strategic context of IT, we feel it is a suitable technique for encoding the strategic IT applications required in this research.

The data collection requires a two-step process in reviewing articles. The first phase of the search focuses on finding articles that describe applications that are the strategic actions in this study. The second phase involves searching for articles that describe responses to those applications. This technique is distinct from the method used by Chen and MacMillan (1992) and Chen, Smith and Grimm (1992), who searched first for responses and then identified actions described in published articles. In their sample, all responses had a prior action attributed to them, and many actions received more than one response. Consequently, their dependent variable was not censored and they appropriately used OLS regression. However, by limiting their sample in this way, the results underestimate the responses of the more general population of rivalrous actions (Singer and Willett, 1991). In the data sample in our research, not all actions have a response within the defined time period, and these are the ones that are more likely to sustain a competitive advantage. The responses create a limited dependent variable that requires an appropriate model other than OLS regression.

Let us now examine the data collection methods required for the remainder of the variables required in this research.

5.3 Environmental data

The environmental data in this research is collected at the industry level. As described in Chapter 4, data collected by the U.S. government, Department of Commerce's Bureau of Economic Analysis (BEA), and are published for industries listed in Table 4.1. The industries correspond roughly to the 2-digit level of SIC codes. The BEA industry categories define the level of the GPO data on output volatility, as well as the data on computer and communications capital investments that is described shortly. In the case of output volatility, there are additional measures proposed to provide insight into this construct at the 4-digit level of the SIC code. However, there is no such alternative for providing data on the information complexity caused by the level of automation that can be measured at the 4-digit level of the SIC code.

As defined earlier, one measure used in this research to represent volatility in industry demand is based on *Real Gross Domestic Product by Industry (GPO) from year to year, over the five-year time period from 1990 through 1994*. The latest available GPO data is 1994 (Yuskavage, 1996), and this corresponds well to the period immediately preceding the data collection period identified for the strategic networked IT articles. This data is published in the Survey of Current Business and it is also available electronically via an account with Stat-USA, available at Purdue University.

The Morgan Stanley Capital Stock and Investment Data Base is the source of data on the *computer and communications capital investments*. These investments represent the information complexity in the industry environment as caused by the degree of automation. The original data is collected annually by the BEA as part of the NIPA data, but it is only published in an aggregate form at the level of the economic sector. The data used in this research are stored in a proprietary database maintained by Morgan Stanley to track the capital stock and annual investment in computing and communication hardware for the BEA-defined industries. These industries were listed in Table 4.1. Therefore, the industry level of analysis is the same as the GPO data that is used to calculate demand volatility. The data are highly reliable, and were used by the National Research Council as part of its study of service industries. Thanks to the cooperation and generosity of Stephen Roach, Chief Economist at Morgan Stanley, the data are available for use in this research as well.

The data available represent accumulated wealth and annual investment in computers and communications capital in real 1987 dollars in each of the 61 industries listed in Table 4.1. The database has information on investments made from 1947 through 1994. For consistency with the output volatility measures, the level of the industry automation is based on computer and communications equipment investments over the same five-year time period, from 1990 to 1994.

The industry-level computer and communications investments is scaled to industry size by dividing by the Gross Product Output by industry. In scaling for differences in industry size, alternatives to GPO are industry sales or value added. The Gross Product Output by industry was selected for two reasons. First, it is an appropriate measure of industry size because it is defined as industry output minus intermediate inputs for a given industry. It therefore provides a better ratio of the extent of the automation required per output in the industry. Secondly, the BEA collects both the computer and communications capital investment data as well as the gross product output data. This results in very highly reliable data at consistent industry classifications, as listed in Table 4.1. Furthermore, GPO is very closely related to value added: value added is calculated as the gross product output minus capital consumption, property, and sales tax (National Research Council, 1994). However, value added data are not published at the level of the BEA industry classification needed to match that of the computer and communications capital investments. The product market breadth of industries is not scaled for, other than testing the significance of industry dummy variables as control variables. The market distinctions established by the BEA are considered to be acceptable units for comparing environmental differences across a multi-industry sample.

Additional industry-level data on the demand volatility of the environment is collected at the 4-digit SIC level in order to supplement the data collected at the level of industries defined by the BEA. Sales and pre-tax income data is available through the Compustat Business Segment industry-level income statements that are compiled and published by Standard and Poor's. The Compustat market segment reports provide industry-level financial data for many, but not all, 4-digit SIC codes. These reports are based on data reported to the Securities and Exchange Commission (SEC) and therefore only reflect the activity of publicly traded firms.

It is appropriate at this point to acknowledge both the benefits and limitations of using the data proposed for the environmental constructs in the research framework. The first benefit is the objectivity of the data, as compared to perceptual or subjective measures. The second benefit is that the data are collected by the U.S. Bureau of Economic Analysis, and therefore are deemed to be highly reliable. Third, the data are accessible to other researchers. The tradeoff to these benefits also stems from the fact that the BEA collects the data for purposes of assessing the U.S. economy, and not firm-level strategy research. Consequently, the degree of granularity of the data may be less than what is desired for an optimal analysis. There is a trade-off required between the availability, reliability, objectivity and granularity of the data. For this reason, the governmentally published data were only considered if they were available at the industry level defined by the BEA as opposed to the economic sector, both of which are listed in Table 4.1.

The question still remains as to whether or not the specificity of the BEA-collected data, or the 4-digit SIC level data compiled from SEC filings, is sufficient for this research activity. Stepping back from the question of granularity, it is appropriate to recall that the purpose for trying to gather this data is to assess the differences in the competitive environment that answer the question regarding why would a firm even want to use information technology. The firm's competitive environment contains many degrees of specificity, including the health of national and global economies, factors that influence its industrial sector, as well as factors that influence its industry. These factors can be assessed to a local geographic level, and the definition of a firm's industry can be subdivided ad infinitum along product lines. However, this degree of specificity does not necessarily provide a better indication of the information-demands and opportunities that exist in the firm's competitive environment. The boundaries between industries are not rigid, and applications of information technology can diffuse across industry boundaries, especially given the versatile nature of computer and communications technologies. Therefore, the use of the environmental industry-level data in this research is accepted based on the plausible assumption that within an industry defined by the BEA, data on output volatility and level of investment in computer and communications capital generally reflect the information demands and opportunities for firms operating in that industry. When comparable measures are available for a more specifically defined industry, such as the case for the volatility data at the 4-digit SIC level, then it is appropriate to use such data. The alternative to not using the data would be to drop the implications of the competitive environment out of the model entirely. However, this then avoids a fundamental question that was critical for the development of this research by probing why should firms use networked IT.

5.4 Industry-level output information content data

The degree to which an industry's products and services are information-intensive is used as an indicator of the information content of the products. As discussed in Chapter 4, this construct provides an alternative explanation for why a firm may use networked IT that is different from the environmental constructs pertaining to uncertainty and information complexity. Consequently, this measure requires data that is not derived from the same sources of information so as to avoid multicollinearity problems that would result.

Chapter 4 described the derivation of the industry information-intensity score from the published firm-level scores in Information Week. This measure is intended to provide an alternative assessment of the use of information technology in an industry, beyond that which is obtained using the capital investment data that assesses the extent to which the industry relies on automation as assessed through its hardware investments in computer and communication equipment. The measure published by Information Week takes into account factors which are not included in the capital stock data, for instance, investments in software, consulting, and training required. It is estimated that firms' investments in information technology require "roughly equal doses of consulting, programming and systems development time, i.e., labor, and hardware and software purchases." (Fleming, 1996: p. 62) However, the IT capital investment data only account for hardware investments. Therefore, this measure should capture an additional dimension of the information intensity of the product.

Unfortunately the industry groups selected by Information Week do not align identically with the BEA industry categories, but the data are collected and reported at the firm level, and include measures that are not evaluated by any other means. While the data are not collected by the U.S. government, they are believed to be very credible due to the professional and systematic manner in which they are collected, and due to the collaborative assistance provided by of Brynjolfsson and Hitt of MIT in analyzing and scoring the data for each firm (Brynjolfsson and Hitt, 1996b).

5.5 Firm-level data on key competitors

The firm's key competitors are published in Hoover's financial reports. Hoover's is an outstanding resource for this data because it reports on a wide number of public and private firms. They claim to be a leading provider of high-quality and reliable company and financial data on more than 12,000 public and private firms. For 3,000 of the largest or fastest-growing firms, they provide additional information regarding the firm's history, product information, officers, and key competitors. The data on each company is updated annually. Data on public firms is based on their Form 10-K filings with the SEC. Private companies are contacted to obtain the information directly. In addition, researchers compile the remaining information from information obtained from the companies themselves, from business publications, news releases, and other sources of information.

5.6 Control variables

Control variables are used to determine any influences that are not already included in the model which might affect the reported responses from competitors. For instance, such influences could be due to industry concentration, firm size, and publication source of the data. The degree of industry concentration may impact the nature of responses within an industry and the diffusion of innovations (Mansfield et al., 1977; Mansfield Schwartz and Wagner, 1981). An appropriate measure for industry concentration is the Herfindahl-Hirschman Index (HHI) (Barron and Lynch, 1989; Rhoades, 1993). The HHI is calculated by summing the squares of the market shares of the firms in the market. The maximum value of the HHI is 10,000, and the minimum value can be a very small positive number. The HHI was calculated at the level of the 4-digit SIC code by using market share data obtained from the Compustat market segment reports. The segment report was obtained for the specified 4-digit SIC, which includes market share data on the firms in that segment. The HHI for each 4-digit SIC was calculated by summing the squares of the market shares of the firms in the report. It should be noted that the Compustat data is based on the reports of publicly-traded firms.

Firm size is another factor which may affect responses and diffusion of innovation, and therefore its influence should be tested through a control variable (Mansfield, 1968, 1993; Mansfield et al., 1977). Firm-level data on firm size is available for many publicly traded companies through a variety of sources. The data is derived from the firm's 10-K forms that are filed with the Securities and Exchange Commission (SEC) and therefore are considered to be very reliable. The firm-level data regarding the number of employees and annual sales was used as an indicator of size.

Finally, categorical control variables identifying the source of the articles used in the study are used to test if the results are biased according to their source. This could potentially occur due to biases caused by the interests of the journalists, as well as technical biases that result in certain publications focusing on particular industries or firms that use specific IT technologies.

The role of vendors is one element that may bear upon the results, but which cannot be controlled for in this research. The vendors may have an impact on the IT applications that a firm implements. For instance, vendors may specialize in specific applications or on specific industries. They may promote one type of technology over another. They may cause information to be leaked in advance to rivals. However, the information regarding the vendors involved in each firm's IT applications is seldom ever reported in the articles describing the cases. This information would require gathering data directly from the firms deploying the strategic IT applications.

5.7 Method of analysis

5.7.1 Tobit analysis: left censored dependent variable

The dependent variable in this research is limited, and thus requires special consideration to select an appropriate model for the statistical analysis. The dependent variable, defined as the number of responses per key competitor, is censored at zero. One type of technique for analyzing a censored dependent variable is classified as *survival analysis* because it focuses on an event that should occur during the period of analysis. Survival analysis techniques primarily focus on temporal studies, such as event history, failure analysis, hazard rates, and other forms of longitudinal research (i.e. Blossfeld, Hamerle and Mayer, 1989; Cox and Oakes, 1984; Singer and Willett, 1991). Although our research is not longitudinal, it shares important characteristics that are commonly associated with survival analysis data and therefore makes use of similar statistical techniques: a) the sample is collected over a period of time; b) the dependent variable is based on the occurrence of an event during a data collection period of the study; and c) the value of the dependent variable is greater than or equal to zero. In the case of our research, the dependent variable is based on the sum of strategic responses that are provoked by an earlier strategic action, divided by the number of key competitors. The exact timing of the responses is not under investigation, so long as they occur within the data collection period of the study.

Tobin (1958) defined the analysis of a limited dependent variable that is a combination of probit analysis and multiple regression. This analysis, which is referred to as "tobit analysis," takes into account the left censoring of a variable as well as its range of values that are dependent on a set of explanatory variables. Specifically, the tobit model is a loglinear relationship that is appropriate when the dependent variable has a high probability of assuming its lower bound value, and then it is continuously distributed for values above this lower bound for the remaining probabilities. The model coefficients are Maximum Likelihood Estimates (Tobin, 1958).

Ordinary Least Squares (OLS) regression is not appropriate when the dependent variable exhibits the characteristics of a tobit model because the resulting residuals do not adhere to the assumed normal distribution with a mean of zero and a constant variance, due to the left-censoring of the dependent variable (Long, 1997). Stata Statistical Software, Release 5.0, is used to analyze the data, and it has a function for tobit regression model analysis (StataCorp, 1997).

The hypothesis testing is based on the likelihood-ratio method. The likelihood-ratio, lnL, is calculated as the maximum value of the log-likelihood of the model restricted by the null hypothesis, minus the maximum value of the log-likelihood of the unrestricted model with up to $m+1$ estimated coefficients. The statistic, $-2lnL$, has a chi-squared distribution of up to m degrees of freedom for large samples; the null hypothesis is rejected according to the significance of the statistic. The likelihood ratio method is sensitive to the number of observations used to determine the log-likelihood of each of the models. Therefore, care must be taken to ensure that when dropping variables out of the models to test full versus restricted models, that the number of observations does not change. The only way to accomplish this with certainty throughout all tests is to ensure that any observations with missing variables are dropped from the sample.

5.7.2 Negative binomial regression

A second form of the dependent variable is analyzed in order to provide additional insight into the response characteristics. This variable is the count of the number of responses from competitors, and it is appropriate to analyze this form of the dependent variable with the negative binomial regression model (Long, 1997). The negative binomial regression model is derived from the poisson distribution, but it relaxes the requirement that the mean and the variance are equal. When the variance exceeds the mean, the negative binomial regression model is the more appropriate model to use. Ideally, a zero-inflated negative binomial regression model would be the preferred form. However, in its absence, the standard form of the model can be used.

The negative binomial regression models use the same method of hypothesis testing as is used for the tobit models, based on the likelihood-ratio. The method is repeated here. The likelihood-ratio, *lnL*, is calculated as the maximum value of the log-likelihood of the model restricted by the null hypothesis, minus the maximum value of the log-likelihood of the unrestricted model with up to $m+1$ estimated coefficients. The statistic, $-2lnL$, has a chi-squared distribution of up to m degrees of freedom for large samples; the null hypothesis is rejected according to the significance of the statistic. Any observations with missing variables are dropped from the sample in order to ensure that all models tested with the likelihood ratio method have the same number of observations. The negative binomial regression model is also tested against the null hypothesis that the Poisson regression model would be a better fit.

5.8 Sample validity

The validity of the sample is based on an evaluation of the "measurement instrument in relation to the purpose for which it is being used." (Carmines & Zeller, 1979). This evaluation encompasses criterion validity, content validity, and construct validity.

Criterion validity refer to the correspondence between the criterion and the actual purpose of the measure. In this research, the criterion is responses from competitors to specific strategic uses of IT, and the purpose of the measure is the extent to which IT applications can contribute to a firm's competitive advantage. The scope of the research applies specifically to competitive behavior that stems from the use of IT; it is not intended to be generalized to other forms of competitive behavior. The technique applied in this research establishes a very close relationship between the use of IT and the reported action by competitors, and therefore it appears to achieve a high degree of criterion validity.

Content validity refers to the correspondence between the empirical measures and the content domain. In this research, content validity refers to the extent to which the measure spans the domain of strategic uses of networked IT applications. The definition of the strategic network IT applications is closely adhered to throughout the data collection and encoding process, and therefore the sample should have a high degree of content validity.

Measures of specific independent variables were described in detail in their respective section, and weaknesses were discussed regarding the limiting aspects of a measure selected as compared to the theoretical construct, and therefore the discussion is not be repeated here. If additional data sources were available, there is room for improvement in the measures. However, in the absence of other objective data sources, the measures were selected carefully with the objective of maximizing content validity to the extent possible.

Construct validity refers to the correspondence between measures that theoretically represent similar concepts. Some of the measures used in this research closely follow those recommended as having the appropriate construct validity. Others, however, have not been tested and therefore are subject to scrutiny regarding their validity. Construct validation requires establishing logical relationships between multiple factors and assessing the fit of measures against known factors. Such relationships are not available for strict testing for this research. Therefore, this is an open question that requires further research to refine the measures.

5.9 Sample reliability

Reliability refers to the extent to which the research results are repeatable, based on well defined and systematic collection and analysis of the data. Sample reliability is demonstrated through the analysis of multiple forms of the dependent variable, over multiple time periods. The two forms of the dependent variable are tested with two different statistical models, over a one-year response window and a two-year response variable. This method, while not fully replicating the study, provides additional insight into the findings as the relationships are tested in multiple ways. The extent to which the results are consistent between these various models indicates the degree of reliability of the sample.

5.10 Summary

The research methods employed for this work are based on the collection of secondary data regarding applications of networked IT. The data is based on articles written in technically and professionally reputable magazines, and therefore should be a rich source of reliable and unbiased information on the strategic networked IT applications. The articles are encoded using computer-assisted content analysis techniques to ensure consistency throughout the encoding process.

Industry and firm-level data are collected from governmental and professional organizations, and are also of high quality. No data is collected from the firms themselves, so self-reporting biases and perceptual influences have not occurred. To the extent possible, control variables have been included for industry and firm-level factors relevant to the dependent variable in order to test for their potential influence on the results.

The limited dependent variables are analyzed using maximum likelihood techniques to estimate the tobit regression model for the number of responses per competitor, and to estimate the negative binomial regression model for the count of the number of responses. The hypotheses are tested by means of the likelihood ratio test. The statistical analysis of the data begins in Chapter 7, with the discussion continuing in Chapter 7.

CHAPTER 6: ANALYSIS OF RESULTS

The data collected for this study were stored in a database using Microsoft Access (Version 7.00) and analyzed with Stata Statistical Software (Release 5.0). The use of the database to organize the data contributed to the integrity of the sample. The database consisted of several tables pertaining to the networked IT application, the firm, and the industry. Information from the published articles about each IT application was encoded and entered into the *case application table*. Information from various sources on the firm, such as its industry classification, primary SIC code, and number of key competitors, was entered into the *company table*. Industry data pertaining to the specific BEA industry classifications and 4-digit SIC codes were entered into tables as well. Relationships were then defined between the tables, and the database combined the relevant information from each table to create a record containing all variables for each application. This technique ensured that each application in the data sample had the appropriate industry-level measures in its record to be analyzed. There were a total of 124 applications with sufficient data for analysis.

After the database was used to organize the data that corresponded to each application, the data were exported to an Excel spreadsheet, and from there they were imported into the Stata Statistical Analysis Software. The applications in the database become the observations in the statistical data file analyzed by Stata. Each observation includes the dependent variables, independent variables, and control variables associated with each application in the data sample. Throughout the data collection and transfer processes, the integrity of the data was maintained through careful attention to the fields assigned to each variable to ensure that the data were not truncated as they were organized in the database and transferred to the statistical software.

6.1 Profile of sample networked IT applications and their sources

The data collected consist of 124 networked IT applications that are considered *actions*, spanning the time period from 1993 through 1994. They are a result of reviewing approximately 1200 articles, searching for those that met the definition for strategic networked IT application as well as having sufficient information in the article that enabled the application to be coded according to the independent variables in the mode. One source was a textbook that was recently published by John Wiley with cases in the appropriate time frame. All other sources were professional or technical magazines, with the exception of *Business Week*, targeted at professionals who are interested in reading about information technology and applications using networked IT. The magazines feature articles that are of primary concern to managers of information technology, IT network designers, and other IT networking professionals. Some of the sources are published weekly, and others monthly. Typical articles found in these publications includes company profiles on their use of information technology and their IT investments, technical analyses of IT equipment, performance results of benchmark tests of IT equipment, announcements of new IT products and services, announcements of new network infrastructure developments, announcements of events affecting the IT industry such as mergers, changes in executive officers, and some include stock market performance information regarding the vendors of telecommunications and IT equipment, software and services. The publications that were the source of the articles encoded for this data set are listed in Table 6.1.

Table 6.1. Publication sources of the articles on networked IT applications

Publisher Name	Title
CIO	CIO
CMP	Open Systems Today
CMP	Network Computing
CMP	Information Week
CMP	Communications Week
CMP	High Performance Computing
CMP	Value Added Reseller
John Wiley and Sons	Information Technology for Management: Improving Quality and Productivity
McGraw Hill	Business Week
McGraw Hill	Data Communications
NW World	Network World
Ziff Davis	PC Week Online
Ziff Davis	Interactive Week

The summary statistics of the independent variables reveal information regarding the characteristics of the networked IT applications that constitute the actions. (Only the actions required encoding for the model to be tested. The responses were not encoded. other than referencing them to an appropriate action.) Table 6.2.a. shows the summary statistics of key independent variables in the sample. and Table 6.2.b. shows the summary statistics for the dependent variables.

Chapter 4 described in detail the four categories of applications that were identified through dummy variables. In terms of these four categories of applications, approximately 20 percent were product innovations. 37 percent were service innovations. 82 percent were process innovations. and 34 percent were innovations that extended beyond the firm's boundaries. As stated earlier, a single application can satisfy the definition for more than one of these categories given the versatility of the networked IT. This explains why the sum of these percentages exceeds 100 percent.

A single application could include the use of more than one network. Approximately 41 percent of the applications relied on public telecommunications networks as a key component of the application, and approximately 69 percent relied on the firm's own private networks. Fewer than 1 percent of the applications attempted to create a new network. Only 21 percent of the applications in the 1993 to 1994 time frame made use of the Internet or the World Wide Web.

The degree of innovation of the applications varied considerably. The innovation score of the applications ranged from 1 through 9, with an average value of 5.6 Similarly, the extent to which business functions were integrated by means of the application varied as well. The integration score of the applications ranged from 1 through 40, with an average score of 7.7.

The summary statistics reveal that there is considerable variation in the industry-related measures, as would be expected in a multi-industry sample. The industry output information intensity score of cases in the sample varies from approximately 4109 to 13,389. The level of demand volatility of the industries represented in the sample, as indicated by the absolute value of the coefficient of variation of first differences of the gross product output, ranges from approximately 0.25 to 9.36. There is also a great variation in the extent to which the industries invest in computer and communications hardware. The investment over five years in computer and communications hardware, per gross product output, ranged from approximately 0.01 to 0.67. Further information regarding the mean and standard deviation of the summary statistics for key independent variables are indicated in Table 6.2.a.

The dependent variable in this study is based on the number of competitive responses that were reported. The sample contained a total of 513 networked IT application responses which corresponded to the 124 actions. These responses were found after reviewing approximately 10,000 articles. These 513 responses occurred in a two-year sliding window from the data of the action. Of the 513 responses, 239 were found to have occurred within the first year of the initial action. The publication sources for the responses are the same as the sources for the actions, which were listed in Table 6.1.

The summary statistics of the dependent variables, shown in Table 6.2.b., show that the number of single responses that an action received from competitors in the two-year sliding window ranged from 0 to 50, with 4 being the average number of total responses. The number of single responses from competitors that occurred within one year ranged from 0 to 19, with 2 being the average. In terms of the likelihood of response per competitor, the average number of single responses per competitor in a two-year period is 0.32, and 0.12 in the one-year period. In other words, based on the published information, approximately 12 percent of the competitors respond on average within one year and 32 percent within two years. These responses only count the first published response from a specific competitor during the time frame of the study. Many applications had responses that extended past the study time frame, and therefore it appears that the sample did not suffer from lack of later responses as was discussed earlier as a possible source of truncation of the dependent variable. However, the data are not complete for all applications to extend the analysis beyond the first two years, and therefore no such statistics are reported formally. Following the tables of the summary statistics, the discussion resumes regarding the responses from competitors.

Table 6.2.a. Summary Statistics of Key Independent Variables

Variable description	Mean	Standard deviation	Minimum value	Maximum value	Std. Dev. / Mean
Number of key competitors	21.0	9.7	2.0	64.0	0.46
Product information score	6842	2329	4110	13389	0.34
Industry information ranking score	252	62	155	377	0.24
Standard Deviation of Industry Gross Product Output (GPO) (in millions of dollars)	12803	11152	281	34302	0.87
Absolute Value of the Coefficient of First Differences of Industry Gross Product Output (GPO)	1.47	1.87	0.25	9.36	1.27
Standard Deviation of Industry Pretax Income (in millions of dollars)	1233	2080	3	9284	1.69
Industry IT Capital Investments in 5 years per GPO (to scale for industry size)	0.161	0.131	0.009	0.605	0.81
IT Application Innovation Score	5.6	1.9	1	9	0.33
IT Application Integration score	7.7	6.9	1	40	0.90
Use of Public Networks in the application	0.41	0.49	0	1	1.20
Use of Private Networks in the application	0.69	0.46	0	1	0.67
Use of the Internet or WWW in the application	0.21	0.41	0	1	1.95
Applications that are Product Innovations	0.20	0.40	0	1	2.0
Applications that are Service Innovations	0.37	0.49	0	1	1.32
Applications that are Process Innovations	0.82	0.38	0	1	0.46
Applications that involve Innovations that Extend beyond the Firm's Boundaries	0.34	0.48	0	1	1.41

Table 6.2.b. Summary Statistics of Dependent Variables

Variable description	Mean	Standard deviation	Minimum value	Maximum value	Std. Dev./ Mean
Number of single responses in the 2-year window	4.01	6.91	0	50	1.72
Number of single responses in the 1-year window	1.90	3.16	0	19	1.66
Number of single responses per competitor in the 2-year window	0.32	1.33	0	14.5	4.16
Number of single responses per competitor in the 1-year window	0.12	0.37	0	3.5	3.08

The advantage gained through the use of networked IT is limited by the responses of competitors in using networked IT to duplicate or improve upon those benefits. If one assumes that the application is valuable, then the longer the time period before competitors respond, the more advantageous the application becomes. Chapter 2 discussed the theoretical arguments about rivalry that can ensue in the action and response cases of using networked IT. Chen and Miller (1994) found that competitors responded quickly to highly visible applications for which they could easily formulate a response. Spatt and Sterbenz (1985) indicated that the speed of response increased as more competitors responded, because firms were acquiring more information about the value of the innovation. Additionally, as more firms respond, the knowledge of how to respond diffuses through the industry which makes it easier for additional firms to respond.

Various problems regarding public announcement of actions and responses were discussed in Chapter 3. These ranged from the secrecy surrounding the actual event, the diffusion of knowledge facilitated by vendors and consultants, and other factors that affect whether or not a firm's innovations are announced publicly in a timely manner. The cases for both actions and responses are based on articles that describe working implementations of networked IT that were found in the publications identified earlier.

The selection of the two-year sliding window from the time of the application was discussed in Chapter 5. While this research does not model the actual speed of response, it explores differences in competitive responses within one year of the action. as compared to the full two-year window. If two actions had the same total response in the second year. but one had less of a response in the first year. that action would provide a greater advantage than the other based on the lower likelihood of receiving responses from competitors within the first year. By conducting the analysis for the one-year and two-year window time periods. we learn more about the likelihood of response and therefore we can provide managers with greater insight regarding which applications may convey a greater advantage.

Under certain circumstances. it is reasonable to expect that there could be differences in responses within the one-year and two-year window of study. Some networked IT applications may be more readily visible or understood by competitors. in which case there could be responses within the first year. Others. such as process and complex service innovations. may be less visible or understood by competitors. and therefore the response may be delayed into the second year. Other applications. such as those which are intended to innovate products. may require re-tooling. modification of product lines. and other alterations to existing firm operations and resources that are used along with the networked IT to formulate a response. The result in these situations could be to delay the competitive response into the second year. In general. responses are expected in the first year when the technology is readily available. when its use in implementing the application is clearly understood. and when the impact on the firm's other resources and personnel is relatively modest. Responses are expected to be delayed if the firm encounters some difficulty in implementing the response. in spite of the fact that it may be motivated to develop a response with its own organizational capabilities to use networked IT. This could occur if there is a shortage in the necessary technology. when additional changes are required to the firm's existing processes are required in order to deploy the responses. when the response has a significant impact on the firm's other resources or personnel. when there is a significant cost associated with the response which might create undue financial burden on the firm. and if the response may require a shift in strategy which the firm perceives to be essential for its survival.

It should be kept in mind that when comparing models between the one-year and two-year response windows, one can also expect that the model fit for the two-year response window would be somewhat less than the fit for the one-year response window. For instance, over a two year time span, additional factors that are not in the model of hypothesized relationships are more likely to have a significant effect on the results because their cumulative time span has doubled in the two-year period as compared to the one-year period. The goal of the model is to assess first-order relationships between the constructs. Within the second year, second and third order effects begin to enter the picture as the technology evolves, as societal relationships with the technology evolves, as firms modify their strategy, as competitive relationships evolve, as industries are created or as industry borders change, and as other factors in the environment accumulate over time. These factors contribute to increased noise in the measures, which translates to increased error variance in the statistical model. Therefore, while we still expect to see the competitive responses within the second year, the overall fit of the model is expected to diminish.

6.2 Profile of sample firms and industries

The 124 action cases of the networked IT applications were distributed across 109 different firms. The applications in the data sample are representative of the organizational capabilities of these firms to use networked IT to support product, service, or process innovations. The number of key competitors of these firms ranged from 2 through 64, with the average being 21. The names of these firms are listed in Table 6.3, as well as the number of key competitors that each firm faces.

The firms in the sample that generated the IT actions operate in 65 different 4-digit SIC codes and 32 industries recognized by the Bureau of Economic Analysis, as shown in Table 6.4. As expected, there is a wide variation in the characteristics of the industries as assessed by several measures of size, environmental variables indicating uncertainty and information complexity, and industry output information intensity. Recall that the summary statistics for these measures appeared in Table 6.2.a.

Table 6.3. Firms with Networked IT Applications Actions

Company	Primary 4-digit SIC Code	Number of Key Competitors
AAA	4731	27
Aetna Life and Casualty Co.	6321	16
Airborne Freight Corp.	4513	20
All Ways Courier	4210	13
AlliedSignal	3724	36
American National Can Co.	3411	13
Amoco Corporation	2911	38
Arco Products Co. -- Arco Chemical	2860	35
Autodesk Inc.	7372	22
Avis Rent a Car Inc.	7510	8
Bank IV	6021	18
Bear Stearns and Co.	6211	25
Bell Atlantic	4813	19
Bernard Hodes Advertising Co. -- Omnicon Group	7311	16
Blockbuster, div. of Viacom	7841	14
Boeing Inc.	3721	19
Boston Chicken Inc.	5812	25
Boston Edison	4911	59
Burger King	5812	11
Caesar's World (Caesar's Palace) -- subsidiary of ITT	7990	12
Caliber Systems Inc. (Roadway Services Inc.)	4213	26
California Pizza Kitchen Inc. – partially owned by Pepsi	5812	30
Carlson Wagonlit Travel	4731	26
Carmike Peachtree Cineplex	7830	7
Caterpillar Inc. (CAT)	3531	29
Charles Schwab and Co.	6211	20
Chase Manhattan Bank N.A.	6021	31
Chevron Corp.	2911	38
Chrysler Corp.	3711	29
Cisco Systems	3577	20
Citibank -- owned by Citicorp	6021	30
ClubCorp International Inc.	7990	4
Cole & Weber	7311	20
CS First Boston (Credit Suisse First Boston)	6189	26
CSX Transportation	4011	17
CUC International, Inc.	7389	29
Del Monte Corp.	2033	33
Digital Equipment Corp.	3571	26
Du Pont Merck Pharmaceutical Co.	2834	23
Electronic Newsstand	2721	11
Eli Lilly and Co.	2834	27
Farmland Foods, Inc.	2013	28
Federal Express (FedEx)	4513	13
Fidelity Investments	6211	30

Table 6.3 (continued)

Fingerhut	5961	21
First Commerce Corp.	6021	18
First National Bank of Chicago	6021	17
Goodwin's Market	5411	13
Greenville Hospital System	8062	7
Harley-Davidson	3751	9
Hartford Financial Services Group (ITT Hartford Insurance)	6331	25
Hertz	7510	10
Holiday Inn Worldwide -- owned by Amerihost	7011	12
Holland America (Westours Inc.) -- owned by Carnival	4400	10
HomeView Realty	6531	13
Howe Barnes Investments	6211	21
Hyatt Hotels	7011	27
Inland Steel Corp.	3312	64
Internet Shopping Network – owned by HSN	5734	23
J. B. Hunt	4213	21
J.P. Morgan Securities Inc.	6022	19
KPMG Peat Marwick	8742	19
Mark III	7510	3
Marriott (Host Marriott)	7011	14
Marshall Industries	5065	20
McKesson Water -- subsidiary of McKesson Drug Company	2080	29
MGM Grand -- owned by MGM Corp.	7990	16
Minnesota Mutual Insurance	6311	29
Mobil Oil Corp.	2911	36
Motorcycle Online	2721	11
MTC Inc.	4813	20
Nets Inc. -- Industry.net	7374	2
New York Times Co.	2711	26
Nike	3021	18
Non-Stop Logistics Corp.	4210	17
Nordstrom Department Stores	5311	29
Online Bookstore	5940	20
Panhandle Eastern Corp. -- owned by PanEnergy	4922	22
Peapod LP	7374	11
Pick Systems	7371	14
Pitney Bowes	3579	20
Pizza Hut – owned by Tricon (div. of Pepsi)	5812	22
Pratt and Whitney -- owned by United Technologies	3724	19
Quote.com	7374	13
R.P. Scherer Corp.	2834	11
Reebok International	3021	28
Reno Air	4512	6
Rockwell International Corp.	3823	23
Santa Fe Pacific Corp. (Santa Fe Railway)	4011	13
Sears, Roebuck and Co.	5311	34

Table 6.3 (continued)

Silicon Graphics	3571	28
Solectron Corp.	3672	19
Sports Illustrated. Time Inc. – owned by Time Warner	2721	28
Storage Dimensions Inc.	3572	11
Sundance Catalog Inc.	5961	33
Texas Instruments (TI)	3674	33
The Great Atlantic and Pacific Tea Company (A&P)	5411	17
Toro Corp.	3524	10
Trane Co. -- American Standard Inc.	3585	22
United Airlines	4512	22
United Parcel Service (UPS)	4210	26
United Stationers Supply Corp.	5110	16
US West	4813	27
VeriFone Inc.	3578	12
Vons Companies Inc.	5411	18
Warner-Lambert Co.; Parke-Davis Research	2834	28
Westinghouse Electric	3510	16
Yellow Corp. -- Yellow Freight Systems Inc.	4213	23
Zeneca Group -- Zeneca Pharmaceuticals	2834	30

Table 6.4. Industries Represented by the Networked IT Application Actions

Number of firms	Industry 4-digit SIC code	BEA Industry (BEA classification number)
1	2013	MN-food and food products (19)
1	2033	MN-food and food products (19)
1	2080	MN-food and food products (19)
1	2711	MN-printing and publishing (24)
3	2721	MN-printing and publishing (24)
5	2834	MN-chemicals and allied products (25)
1	2860	MN-chemicals and allied products (25)
3	2911	MN-petroleum and coal products (26)
2	3021	MN-rubber and plastic products (27)
1	3312	MD-primary metal industries (11)
1	3411	MD-fabricated metals (12)
1	3510	MD-nonelectrical ind machinery, equip (13)
1	3524	MD-nonelectrical ind machinery, equip (13)
1	3531	MD-nonelectrical ind machinery, equip (13)
2	3571	MD-electrical machinery, equip (14)
1	3572	MD-electrical machinery, equip (14)
1	3577	MD-electrical machinery, equip (14)
1	3578	MD-electrical machinery, equip (14)
1	3579	MD-electrical machinery, equip (14)
1	3585	MD-nonelectrical ind machinery, equip (13)
1	3672	MD-electrical machinery, equip (14)
1	3674	MD-electrical machinery, equip (14)
1	3711	MD-motor vehicles, parts, equip (15)
1	3721	MD-other transportation equip (16)
2	3724	MD-other transportation equip (16)
1	3751	MD-motor vehicles, parts, equip (15)
1	3823	MD-instruments and related products (17)
2	4011	TR-rail trans (29)
3	4210	TR-trucking and warehousing (31)
3	4213	TR-trucking and warehousing (31)
1	4400	TR-water trans (32)
2	4512	TR-air trans (33)
2	4513	TR-air trans (33)
2	4731	TR-trans services (35)
3	4813	COMM-telephone and telegraph (36)
1	4911	PU-electric public utilities (38)
1	4922	PU-gas services (39)
1	5065	WT-wholesale trade (41)
1	5110	WT-wholesale trade (41)
2	5311	RT-retail trade (42)
3	5411	RT-retail trade (42)
1	5734	RT-retail trade (42)
4	5812	RT-retail trade (42)
1	5940	RT-retail trade (42)
2	5961	RT-retail trade (42)

Table 6.4 (continued)

5	6021	FIN-commercial and mutual banks (44)
1	6022	FIN-commercial and mutual banks (44)
1	6189	FIN-security and commodity brokers (46)
4	6211	FIN-security and commodity brokers (46)
1	6311	INS-insurance carriers (47)
1	6321	INS-insurance carriers (47)
1	6331	INS-insurance carriers (47)
1	6531	RE-real estate (49)
3	7011	PER-hotels and lodging (51)
2	7311	BUS-business services (53)
1	7371	BUS-business services (53)
1	7372	BUS-business services (53)
3	7374	BUS-business services (53)
1	7389	BUS-business services (53)
3	7510	BUS-auto repair. services. and parking (54)
1	7830	ENT-motion pictures (56)
1	7841	ENT-motion pictures (56)
3	7990	ENT -amusement and recreation (57)
1	8062	MISC-health services (58)
1	8742	BUS-business services (53)

6.3 Correlation Analysis

The variable names defined in the study are shown in Table 6.5.a., and the results of the two-way correlation matrix are shown in Table 6.5.b. Significant correlations with a p-value less than or equal to 0.10 are indicated with a star. The correlation matrix confirms that the four forms of the dependent variable are highly correlated. The Number of Single Responses in the one-year window (*nsr1yr*) and the two-year window (*nsr2yr*) have a correlation of 0.6838 (p=0.0000). The Number of Single Responses per Competitor in the one-year window (*ys1yr*) and the two-year window (*ys2yr*) have a correlation of 0.9393 (p=0.0000). The strong correlation found between the dependent variables is fully expected, as they were derived from the count of the number of responses and the number of key competitors.

The correlation matrix also reveals the correlation between the dummy variables used to classify the types of innovative networked IT applications that constitute the actions in this research: product innovations (*inprod*), service innovations (*inserv*), process innovations (*inproc*), and innovations that extended beyond the firm's boundaries (*inbound*). Recall that the networked IT applications were classified as one or more of these categories according to the information published in the article. Specifically, the applications could result in product, service, or process innovations, and they could extend beyond the firm's boundaries. The two-way correlation relationship of these dummy variables reveals the combination of categories within categories.

Innovations which extended beyond firm boundaries (*inbound*) always appeared in combination with the other categories of innovations (*inprod, inserv, inproc*). The two-way correlations confirm the significant relationship between *inbound* and each of the other variables. There is a positive correlation of 0.235 (p=0.0086) between applications resulting in product innovations (*inprod*) and those that extended beyond the firm's boundaries (*inbound*). There is also a positive correlation of 0.3675 (p=0.0000) between applications resulting in service innovations (*inserv*) and those that extended beyond the firm's boundaries (*inbound*). There is a negative correlation of -0.3813 (p=0.0000) between applications resulting in process innovations (*inproc*) and those that extended beyond the firm's boundaries (*inbound*). These relationships suggest that product and service innovations are also likely to be accompanied by IT applications that extend beyond the firm's boundaries.

The relationship between innovative processes (*inproc*) and each of the other variables is negative. In addition to the negative correlation between *inproc* and *inbound* that was presented above, there is a negative correlation of -0.3454 (p=0.0001) between applications resulting in process innovations (*inproc*) and those that result in product innovations (*inprod*). There is also a negative correlation of -0.2989 (p=0.0007) between applications resulting in process innovations (*inproc*) and those that result in service innovations (*inserv*). These correlation coefficients suggest that networked IT applications used to innovate the firm's internal processes do not simultaneously innovate the products or services that it sells to its customers.

These correlation results regarding network applications to support process innovations appear to contradict assumptions about information technology systems. They are many commonly held assumptions about information technology, but the purpose of this research is to test those assumptions with quantitative analysis rather than to presume them away. There are two possible explanations for the negative correlation findings between IT innovations to support processes and those which support the other forms of innovation. First, it is likely that in many cases, separate systems are in fact used to support internal firm processes as compared to applications to support service, or product innovations, or innovations extending beyond the firm's boundaries. While all of these systems may use very simillar technology, for instance client-server systems, the specific configuration and access to the systems may be very distinct as determined by the application. Security and network management is one reason for having separate network.. Networks extending beyond the firm's boundaries require different levels of security and access than internal process networks. The configuration of the network, in terms of its end-points and linkages between entities, must make sense for the application. The IT systems to support processes may in fact be very different than those which support service activities, and are not used in general to support the same types of applications simultaneously, which would explain the negative correlation. For instance, a firm's network to support an internal process innovation may have linkages between various business functions and individual corporate users. A network intended to support a service innovation may be configured very differently, with linkages to databases contining information specifically for consumers, isolated from the firm's operating systems. Similarly,a network intended to support product innovations is likely to be configured with the firm's product value chain, its designers, or other product-development business functions. This configuration of the network technology is distinct from the configuration required when the network is intended to support a service or process innovation.

A second reason for the finding of the negative correlation within this data may have to do with the encoding being limited to only the information about the network that was published in the article. Recall that the applications were encoded as product, service, or process innovations, or innovations extending beyond the firm's boundaries, according to the decription in the article. Perhaps the process systems described by the articles were also used for other purposes, even though the other applications were not discussed in the article. The encoding was based only on attributes of the system that were known with a high degree of certainty based on the published description of the system.

While there are numerous other correlations identified in the matrix, it must be kept in mind that these only represent relationships between two variables at a time. The multivariate analysis of the hypotheses reveals more insight into the combination of relationships that have an effect on competitive responses. Therefore, further discussion of the relationships is reserved for the analysis and discussion of the hypotheses.

Table 6.5.a. Variable names defined

Variable Name	Definition
nsr2yr	Number of single responses from competitors within a 2-year window
nsr1yr	Number of single responses from competitors within a 1-year window
ys2yr	Number of single responses per key competitor within a 2-year window
ys1yr	Number of single responses per key competitor within a 2-year window
numcomp	Number of key competitors
hhi	Herfindahl-Hirschman Index for industry concentration
fnetinc	Firm's net income
fnumemp	Firm's number of employees
indscore	Industry score for information intensity
indr500	Industry IW500 ranking
avuncpti	Absolute value of the coefficient of first differences of industry pre-tax income (industry level = 4-digit SIC code)
avuncgpo	Absolute value of the coefficient of first differences of industry gross product output (industry level = BEA industry classification)
lsdsal	Natural log of the standard deviation of industry sales (industry level = 4-digit SIC code)
lsdgpo	Natural log of the coefficient of first differences of industry gross product output (industry level = BEA industry classification)
itinv5	5-year investment in Computer and Communications capital per Gross Product Output by industry (GPO) (industry level = BEA industry classification)
itcapcum	Total cumulated capital investment in Computer and Communications capital per Gross Product Output by industry (GPO) (industry level = BEA industry classification)
innov	Innovation score
integr	Integration score
netpub	Public network used as a key component in the application (dummy variable)
netpriv	Private network used as a key component in the application (dummy variable)
wwwinet	World Wide Web or Internet used as a key component in the application (dummy variable)
inprod	Networked IT Application is a product innovation (dummy variable)
inserv	Networked IT Application is a service innovation (dummy variable)
inproc	Networked IT Application is a process innovation (dummy variable)
inbound	Networked IT Application is an innovation that extends beyond the firm boundaries (dummy variable)

Table 6.5.5. Two-way correlation matrix (* $p \leq 0.1$ level of significance)

	nsr2yr	nsr1yr	ys2yr	ys1yr	numcomp	hhi	fnetinc
nsr2yr	1.0000						
nsr1yr	0.6838* 0.0000	1.0000					
ys2yr	0.5110* 0.0000	0.2742* 0.0021	1.0000				
ys1yr	0.5434* 0.0000	0.5166* 0.0000	0.9393* 0.0000	1.0000			
numcomp	0.0449 0.6201	0.0834 0.3571	-0.2123* 0.0179	-0.1940* 0.0308	1.0000		
hhi	-0.0386 0.6905	-0.0734 0.4484	0.0669 0.4892	0.0629 0.5159	-0.2801* 0.0032	1.0000	
fnetinc	0.0467 0.6696	-0.0717 0.5115	-0.0768 0.4823	-0.1334 0.2208	0.3219* 0.0025	-0.1011 0.3818	1.0000
fnumemp	0.2558* 0.0155	0.1690 0.1134	0.1569 0.1419	0.1005 0.3485	0.1156 0.2806	-0.0909 0.4225	0.5068* 0.0000
indscore	-0.0884 0.3287	-0.1598* 0.0763	0.0116 0.8982	-0.0428 0.6372	0.0534 0.5560	0.2173* 0.0232	0.0587 0.5915
indr500	-0.0821 0.3649	-0.1555* 0.0845	-0.0047 0.9583	-0.0643 0.4778	0.0819 0.3658	0.1998* 0.0372	0.0921 0.3989
avuncpti	0.2101* 0.0284	0.0661 0.4949	0.4866* 0.0000	0.4357* 0.0000	-0.3456* 0.0002	0.1780* 0.0721	-0.0404 0.7269
avuncgpo	-0.1160 0.1995	-0.1322 0.1432	-0.0438 0.6289	-0.0647 0.4756	-0.3105* 0.0004	-0.0110 0.9095	-0.0647 0.5541
lsdsal	-0.0362 0.6946	-0.0061 0.9476	-0.0588 0.5232	-0.0486 0.5984	0.3523* 0.0001	-0.3924* 0.0000	0.3066* 0.0051
lsdgpo	0.2028* 0.0239	0.1732* 0.0544	0.1061 0.2410	0.1238 0.1709	0.0714 0.4304	0.1059 0.2731	-0.0239 0.8270
itinv5	-0.1151 0.2031	-0.1388 0.1243	-0.0566 0.5326	-0.0752 0.4067	-0.1450 0.1081	-0.0220 0.8200	0.0424 0.6980

Table 6.5.b. (continued)

	nsr2yr	nsr1yr	ys2yr	ys1yr	numcomp	hhi	fnetinc
itcapcum	-0.0947	-0.1173	-0.0587	-0.0738	-0.1331	-0.0870	0.0244
	0.2957	0.1945	0.5170	0.4152	0.1405	0.3682	0.8238
innov	0.1764*	0.2741*	0.1211	0.1638*	-0.0838	0.1212	-0.1247
	0.0501	0.0021	0.1802	0.0691	0.3548	0.2093	0.2526
integr	0.1928*	0.1656*	0.0161	0.0297	0.0787	0.0515	-0.0652
	0.0319	0.0661	0.8589	0.7431	0.3852	0.5951	0.5506
netpub	0.2896*	0.2362*	0.1732*	0.1870*	-0.1046	-0.0041	0.1133
	0.0011	0.0083	0.0543	0.0376	0.2475	0.9664	0.2989
netpriv	-0.2890*	-0.1945*	-0.2042*	-0.2036*	0.1391	-0.0443	-0.0799
	0.0011	0.0304	0.0229	0.0233	0.1234	0.6477	0.4648
wwwinet	0.2729*	0.2564*	0.2267*	0.2525*	-0.0550	0.0430	0.0854
	0.0022	0.0040	0.0114	0.0047	0.5439	0.6572	0.4341
inprod	0.1776*	0.0679	0.2450*	0.2210*	-0.2871*	0.0653	0.0227
	0.0485	0.4540	0.0061	0.0137	0.0012	0.5002	0.8354
inserv	0.2684*	0.2962*	-0.0268	0.0328	0.0128	-0.0584	-0.1483
	0.0026	0.0008	0.7678	0.7178	0.8882	0.5466	0.1731
inproc	-0.2479*	-0.2100*	-0.0164	-0.0484	0.0609	-0.0540	-0.1578
	0.0055	0.0192	0.8566	0.5936	0.5017	0.5768	0.1469
inbound	0.2839*	0.3271*	0.1961*	0.2334*	-0.1389	0.1568	-0.0664
	0.0014	0.0002	0.0291	0.0091	0.1238	0.1034	0.5437

	fnumemp	indscore	indr500	avuncpti	avuncgpo	lsdsal	lsdgpo
fnumemp	1.0000						
indscore	-0.0069	1.0000					
	0.9491						
indr500	-0.0096	0.9478*	1.0000				
	0.9286	0.0000					
avuncpti	-0.0425	-0.0455	-0.0614	1.0000			
	0.7083	0.6385	0.5256				

Table 6.5.b. (continued)

	fnumemp	indscore	indr500	avuncpti	avuncgpo	lsdsal	lsdgpo
avuncgpo	-0.1270	-0.2079*	-0.1634*	0.2328*	1.0000		
	0.2355	0.0205	0.0697	0.0148			
lsdsal	0.1050	0.1677*	0.0859	-0.1931*	-0.3126*	1.0000	
	0.3388	0.0670	0.3509	0.0442	0.0005		
lsdgpo	0.1272	0.3813*	0.3376*	0.0373	-0.5361*	0.2826*	1.0000
	0.2348	0.0000	0.0001	0.7003	0.0000	0.0018	
itinv5	-0.1435	0.1821*	0.1554*	-0.0056	0.2652*	0.1575*	-0.0155
	0.1796	0.0429	0.0847	0.9543	0.0029	0.0858	0.8643
itcapcum	-0.0869	0.2560*	0.1868*	-0.0349	0.2116*	0.2281*	-0.0698
	0.4180	0.0041	0.0378	0.7188	0.0183	0.0122	0.4413
innov	-0.0649	-0.0824	-0.0855	0.2395*	-0.0306	-0.1118	0.1692*
	0.5457	0.3629	0.3450	0.0121	0.7360	0.2242	0.0604
integr	0.0484	-0.1132	-0.1159	0.0318	-0.0834	-0.0336	0.0422
	0.6527	0.2107	0.1998	0.7430	0.3574	0.7154	0.6415
netpub	0.2078*	0.0269	-0.0666	0.2604*	0.0675	-0.0002	0.0954
	0.0507	0.7669	0.4620	0.0062	0.4561	0.9985	0.2917
netpriv	-0.1784*	-0.0515	0.0369	-0.3515*	-0.1061	0.0120	-0.0877
	0.0943	0.5699	0.6839	0.0002	0.2407	0.8968	0.3326
wwwinet	0.0058	0.2253*	0.1165	0.1513	-0.1468	0.0375	0.2565*
	0.9570	0.0119	0.1975	0.1163	0.1037	0.6844	0.0040
inprod	-0.0821	-0.0975	-0.0756	0.4273*	0.1778*	-0.1507	-0.0161
	0.4441	0.2815	0.4039	0.0000	0.0482	0.1004	0.8591
inserv	0.0997	-0.1207	-0.1829*	-0.1185	-0.0481	0.1161	0.0662
	0.3524	0.1819	0.0420	0.2197	0.5958	0.2068	0.4651
inproc	-0.0167	0.1264	0.1349	-0.1800*	-0.1965*	0.2241*	0.0652
	0.8764	0.1618	0.1352	0.0611	0.0287	0.0139	0.4718
inbound	-0.0151	-0.1323	-0.1492*	0.3294*	0.0548	-0.1453	0.1351
	0.8880	0.1429	0.0982	0.0005	0.5454	0.1133	0.1346

Table 6.5.b. (continued)

	itinv5	itcapcum	innov	integr	netpub	netpriv	wwwinet
itinv5	1.0000						
itcapcum	0.9260* 0.0000	1.0000					
innov	-0.0533 0.5568	-0.0723 0.4246	1.0000				
integr	0.0055 0.9518	0.0231 0.7991	0.4808* 0.0000	1.0000			
netpub	0.0432 0.6338	0.0589 0.5157	0.1029 0.2553	0.1065 0.2391	1.0000		
netpriv	-0.1169 0.1961	-0.1454 0.1071	-0.1096 0.2258	-0.0147 0.8716	-0.7953* 0.0000	1.0000	
wwwinet	0.0348 0.7012	0.0750 0.4080	0.2232* 0.0127	0.1199 0.1848	0.4955* 0.0000	-0.5600* 0.0000	0.0000
inprod	0.0938 0.3001	0.0491 0.5879	0.1686* 0.0613	0.1502* 0.0958	0.1519* 0.0922	-0.2328* 0.0093	0.2843* 0.0014
inserv	0.0861 0.3417	0.1846* 0.0401	0.2126* 0.0178	0.1881* 0.0364	0.1724* 0.0556	-0.1776* 0.0485	0.1376 0.1276
inproc	0.0034 0.9699	0.0226 0.8031	-0.1526* 0.0906	-0.0223 0.8060	-0.2124* 0.0179	0.3323* 0.0002	-0.1756* 0.0510
inbound	0.0035 0.9689	-0.0238 0.7932	0.8864* 0.0000	0.4736* 0.0000	0.2675* 0.0027	-0.3005* 0.0007	0.3011* 0.0007

	inprod	inserv	inproc	inbound
inprod	1.0000			
inserv	0.0718 0.4280	1.0000		
inproc	-0.3454* 0.0001	-0.2989* 0.0007	1.0000	
inbound	0.2350* 0.0086	0.3675* 0.0000	-0.3813* 0.0000	1.0000

6.4 Reliability of subjectively encoded variables

Chapter 4 described in detail the subjectively encoded measures that would require a reliability assessment. The measures include the dummy variables indicating the type of innovative networked IT application, as well as the variables for the degree of innovation, network compatibility, and the extent of knowledge integration. To assess the reliability of the encoding, a sample consisting of 16 randomly selected articles was encoded by 12 other individuals who are knowledgeable about applications of networked IT. In order to make the work more manageable for the encoders, each article was encoded by six individuals, rather than all 12.

The reliability analysis was discussed in detail in Chapter 4. The reliability of these measures is determined by two values: the frequency of agreement in the classifications and Cohen's Kappa. Recall that Cohen's Kappa indicates the proportion of classifications that are in agreement after removing the effects caused by the proportion for which agreement is expected by chance (Cohen, 1960). Any results for Kappa above 0.65 are considered acceptable. The reliability results are reported in Table 6.6.

Table 6.6. Reliability assessment of the encoding of subjective measures

Encoded Measure	Average frequency of agreement	Average Cohen's Kappa
Type of innovative networked IT application	92%	0.84
Degree of innovation	89%	0.77
Use of public networks as a key component of the application	99 %	0.98
Extent of knowledge integration	88%	0.76
Overall encoding of the categories	89%	0.77

6.5 Hypothesis testing

The hypotheses proposed in this research are tested using models that require maximum likelihood analysis and likelihood ratio tests because of the limited dependent variables in this research. The issue of sample size was investigated, in light of the fact that the data sets being analyzed are not terribly large and that maximum likelihood analysis is based on asymptotic assumptions as the sample size approaches infinity. Unfortunately, there is no strict rule of thumb regarding sample size. One reference suggests that the coefficients estimated with this method were consistent so long as the number of observations exceeds nine (Shenton and Bowman, 1977), while another suggests that the results are reliable when the number of observations exceeded 100 (Long, 1997). The conclusion is this: while the maximum likelihood techniques work well with large samples, we do not know that they work poorly with small samples. Consequently, the analysis proceeded with maximum likelihood techniques since they are the only ones available for the necessary hypothesis testing. However, care was taken during the analysis to ensure that the sample size was not reduced unnecessarily.

6.5.1 Data sets

Two data sets were derived from the original sample of 124 observations in order to conduct both an industry-level analysis as well as a firm-level analysis. These data sets contained fewer than 124 observations due to missing data for some of the independent variables and control variables. One data set (N=103) is used to analyze the models with industry-level control variables, and the other data set (N=85) is used to conduct a firm-level analysis by including controls for the firm size. Recall that the industry-level and firm-level control variables were described in Chapter 4. The industry-level controls include the HHI index of concentration for the industry, and the data set includes both publicly-traded and private firms. The firm-level controls included the number of employees and the net sales of publicly-traded firms. By considering the results of both of these groups, we have a better sense of the reliability of the findings if consistent relationships across the two data sets.

In the interest of maximizing the sample size, the two data sets analyzed in the research descend directly from the original sample of 124 observations. The industry-level analysis was limited to 103 observations due to missing control variables for industry concentration ratios and industry sales volatility measures. The firm-level analysis was limited to 85 observations due to missing control variables for firm sales and number of employees as indicators of firm size. For this same reason, the firm-level analysis does not include cases from privately-held firms since the data on firm sales and number of employees were only available for publicly-held firms. In contrast, the data set with the industry-level control variables includes cases from privately held firms as well. The number of cases in each data set would have been reduced even further if the firm-level analysis data set was derived as a sub-set of the industry-level analysis data set. For this reason, the firm-level analysis data set does not contain the industry control variables of industry concentration ratio and industry sales volatility.

The theoretical rationale for creating dummy variables to control for differences in competitive responses for the four possible types of innovations carried within the networked IT application was described in Chapter 4. The statistical rationale is also important. The method of using the dummy variables to categorize the four types of networked IT applications enables the analysis to be conducted with the larger data set while still revealing relationships within subgroups of the data set based on the type of application. Both the industry-level analysis and the firm-level analysis of the data included these dummy variables.

6.5.2 Regression diagnostic issues

Several regression diagnostic issues were addressed, as described in this section. The detailed numerical results are not included because remedial measures were not needed.

6.5.2.1 Multicollinearity, bias, and sensitivity concerns

The industry-level and firm-level models were tested for multicollinearity prior to testing the hypotheses, by analyzing their variance inflation factor (VIF), and multicollinearity was not found to be a problem. (The reader is reminded that multicollinearity cannot be assessed by inspecting the two-way correlation matrix, as it only depicts two-dimensional relationships between the variables.) The models were also analyzed for sensitivity to outliers and bias through robust regression analysis. The coefficients resulting from the robust regression were very similar to those resulting from the models reported later in this chapter. Therefore, it was concluded that the results were not being unduly influenced by a few outlying cases, nor were the coefficients biased. Other attempts to analyze the data segmented into industry categories, were not successful due to the extremely small sample size once the cases were segmented by industry, the lack of variance of the measures within an industry segment, and consequently the multicollinearity that resulted in the industry variables when the cases were segmented by industry.

6.5.2.2 Sensitivity to the innovation score

The discussion in Chapter 4 raised the possibility that a second approach to the proposed innovation score should be considered, where the incremental, synthetic, and discontinuous classification of the application suggested by Tushman and Nadler (1986) took precedence over the IT innovation ranking proposed by Swanson (1994). A sensitivity analysis was conducted to test the results of using the innovation score listed in Table 4.4 versus the alternative approach listed in Table 4.5. Two separate innovation variables were created and tested, based on these two scales. The two variables were significantly correlated, with a two-way correlation of 0.67, and a p-value of 0.0000. The summary statistics of the two innovation scores were very similar. The innovation score in Table 4.4 had a mean of 5.6 and a standard deviation of 1.9, while the alternative score had a mean of 4.6 and a standard deviation of 2.1. Both were 9-level scales. The resulting models were re-tested with the second score, and in no case did the second scoring technique improve the results. The signs of all the coefficients remained the same, therefore having no impact on the acceptance or rejection of the hypothesis. Additionally, the model fit in each case using the alternative score was at best not significantly different from the result found using the original score, or in some cases worse than the fit obtained with the originally proposed innovation score. Given the results that the hypotheses tests were identical, it was concluded that the results were not overly sensitive to the innovation encoding used, and that the originally proposed innovation scale produced better results than an alternative methods for this specific sample of data.

6.5.3 Models tested

Two forms of the dependent variable were tested for responses after both a one-year and a two-year response window. The dependent variable defined as the number of responses per competitor was analyzed with the tobit model. The dependent variable defined as the count of the number of responses was analyzed with the negative binomial regression model. Recall that these models were described in detail in Chapter 5. The tobit model is better suited to the data since it is intended for censored data. Consequently, the tobit models exhibit a better fit than the comparable negative binomial regression models for the same window of response.

The benefit of considering both the tobit and the negative binomial regression models is that we are again able to assess the reliability of the relationships that appear to have statistical significance. The tobit model assesses responses per key competitor, and thus indicates to what extent responses might increase if the firm is faced with a larger group of key competitors. This situation would occur, for example, as industry boundaries blur and firms modify their strategy to compete in new areas. The negative binomial regression model is purely a count model. It provides an indication of the number of responses without regard for the number of competitors. The number of competitors, however, can be tested in the negative binomial regression model to determine if it produces a significant effect or not.

The coefficients for both the tobit and the negative binomial regression models are determined using maximum likelihood estimation calculated by Stata Statistical Software. The significance of the coefficients is tested using the likelihood-ratio test that compares the log-likelihood of the restricted (null) model to that of the unrestricted model, as described in Chapter 5. The *likelihood-ratio, lnL,* is calculated as the log-likelihood of the restricted model minus the log-likelihood of the unrestricted model. From this the statistic *-2lnL* is formed . which has a chi-squared distribution. Therefore. the significance of the statistic is compared to the value of a chi-squared distribution. and the null model is rejected if the probability of the statistic is greater than the chi-squared distribution at the specified level of significance.

The models were initially tested with all main effects of the hypothesized terms. plus all main effects of the dummy variables. plus first-order interaction terms of the four application category dummy variables with the hypothesis interaction terms. plus the interaction terms of the hypothesized main effects and the effect of using public networks. plus all control variables. The models were tested using the likelihood ratio test. and insignificant variables were removed from the model since it could not be rejected that their coefficient was equal to zero. This process was repeated until the resulting models were found with the significant coefficients shown in Tables 6.9 through 6.12.

The order of the likelihood ratio tests proceeded as follows: 1) compare the null model to the full model; 2) compare the full model without both the main and interaction effects of the dummy variables for the four types of applications to the full model; 3) compare the model without the interaction effects of the dummy variables for the four types of applications to the full model; 4) compare the model without the interaction effects associated with use of the public network to the full model; 5) compare appropriate models to assess the significance of groups of variables. such as all interaction dummy variables pertaining to one type of an application; 6) compare appropriate models to assess the significance of individual variables. The resulting models were deemed to be the best-fit models. based on the pseudo-R^2 value and the significance of the coefficients remaining.

The resulting models were found to have the best fit with the remaining variables. after testing them against restricted models with the likelihood ratio statistic. Table 6.8 summarizes these models. and it also lists the significance level of the chi-squared statistic testing each model to the null model. All resulting models were significant over the null model with a p-value of 0.0000. Tables 6.9 through 6.12 list the details of the coefficients in each model, including the significance of the overall model, and the significance level of the individual coefficients.

In the vast majority of the cases, the p-value of the coefficient is 0.1 or below, but in some cases the model coefficient p-values are greater than 0.1. However, these coefficients were retained because the fit of their respective model degraded considerably if they were dropped, as compared to the unrestricted model that contained the variables in question. The specific coefficients were tested using the likelihood ratio test, and in these situations the significance of the test statistic that compared the restricted and unrestricted models fell between a p-value of 0.1 and 0.2, indicating weak to marginal rejection of the restricted (null) hypothesis. (The significance level of each likelihood ratio statistic is not reported.) Therefore, since in these cases the likelihood ratio test did not provide strong support for dropping the variable, it was kept in the model due to the overall results of the model fit. The higher p-value in the likelihood ratio test for a these coefficients accounts for them having a comparatively higher t-value or z-value in the models.

In the majority of the cases, the coefficients were tested and dropped in order to produce the resulting best-fit models. In these situations the restricted and unrestricted models were tested, and the likelihood ratio test had a significance level of alpha between 0.0 to 0.1 for rejecting the restricted (null) hypothesis.

The pseudo-R^2 values reported for each model provide an indication of the degree of model fit. They are calculated as one minus the ratio of the log-likelihood of the full model to the log-likelihood of the constant-only model. The pseudo-R^2 derives from precisely the same values that were used to form the likelihood ratio statistic that tests the significance of coefficients in the full-model to the constant-only model. Therefore, the chi-square value of the log-likelihood statistic for the full model also provides an indication of which models fit better than others.

When comparing the pseudo R^2 values that assess overall fit, it was found that, as expected, the tobit models had a better fit than the negative binomial regression models. This is accounted for by the fact that the tobit models are designed for censored dependent variables. Furthermore, the models for the responses within a one-year window had a better fit than those for responses in the two-year window, suggesting that the relationships described by the research framework listed in Figure 3.1. do indeed diminish with time. The rationale for this effect was discussed earlier in this chapter.

6.5.4 Results of testing the models

Several tables are included in this section to document the results for both data sets: the one with the industry-level control variables and the other with the firm level controls. Table 6.7 restates the hypotheses, for the convenience of the reader, that were originally shown in Chapter 3. Tables 6.8.a and 6.8.b summarize the results of the regression model analysis, listing the measures for model fit and results of the hypotheses tests. Table 6.8.a summarizes the results of the industry-level analysis for the tobit regression models and the negative binomial regression models. Table 6.8.b summarizes the results of the firm-level analysis for the tobit regression models and the negative binomial regression models.

The summarized information that is presented in Tables 6.8.a and 6.8.b is based on the regression model results that are shown in Tables 6.9 through 6.12. Tables 6.9.a and 6.9.b show the resulting models for the Tobit Analysis of the Number of Responses per Competitor within a 1-year window, for the industry- and firm-level analysis, respectively. Tables 6.10.a and 6.10.b show the resulting models for the Tobit Analysis of the Number of Responses per Competitor within a 2-year window, for the industry and firm-level analysis, respectively. Tables 6.11.a and 6.11.b show the resulting models for the Negative Binomial Regression Analysis for the Total Number of Responses within a 1-year window, for the industry- and firm-level analysis, respectively. Finally, Tables 6.12.a. and 6.12.b. show the resulting models for the Negative Binomial Regression Analysis for the Total Number of Responses within a 2-year window, for the industry- and the firm-level analysis, respectively.

It is apparent from Tables 6.8 through 6.12 that there are several interaction terms which are statistically significant in the regression models. When interpreting the results of the models, it is vital to recall that statistically significant interaction effects cannot be discarded in order to evaluate the main effects terms alone (Neter, Wasserman and Kutner, 1990). Chapter 4 discussed the appropriateness to test whether or not the four types of network IT applications would have differing effects on the relationships proposed in the hypotheses. In order to test whether or not there were such effects, dummy variables were created to account for the main effects of these applications, and interaction terms were formed with these dummy variables and each of the variables representing the hypothesized constructs. Therefore, the marginal contribution of a particular main effect variable, associated with Hypotheses 1 through 6, must also include the effects present under the conditions specified by any significant interaction effects that occur with the respective variable. Evaluation of a single term alone assumes that the value of the other terms in the regression model is held constant, which is clearly not the case when the term under investigation is also present in interaction terms in the model.

The significance of the main effect of the four dummy variables representing the different types of networked IT applications is also noted in Tables 6.8 through 6.12. These coefficients will have an impact on the constant of the model. Since these terms also appear in interaction terms in the regression model, analysis of the effect caused by specific types of network IT applications must also take into account the value of the interaction terms for the respective application.

Following Tables 6.7 through 6.12, found on the next several pages, the discussion of the effects indicated in these models will resume.

Table 6.7. Summary of Predicted Signs for the Likelihood of Competitive Response using Networked IT

Hypothesis and Expected Sign	Variables—Terms defined
	Y = dependent variable – indicating the competitive response from rivals
	Factors that create incentives for rivals to respond
H1: β_1 +	X_1 = information content of the industry output *This is an assessment of the information-intensity of the industry output, evaluated on an industry-basis and compared across multiple industries.*
H2: β_2 +	X_2 = demand volatility *This is an assessment of the degree of uncertainty in the environment, evaluated on an industry-basis and compared across multiple industries.*
H3: β_3 +	X_3 = information complexity caused by the level of industry automation *This is an assessment of the degree of information complexity in the environment, evaluated on an industry-basis and compared across multiple industries.*
	Factors that affect the ease of response of rivals
H4: β_4 -	X_4 = degree of innovation *This is an assessment of the innovativeness of the networked IT application that constitutes the action to which competitors are responding.*
H5: β_5 + β_{15} + β_{25} + β_{35} + β_{45} + β_{65} +	X_5 = compatibility with existing networks Interaction effects with X_{15} X_{25} X_{35} X_{45} X_{65} *This is an assessment of the compatibility of the networked IT application with current networks, as indicated by the use of public networks as a key component in the application. The application constitutes the action to which competitors are responding.*
H6: β_6 -	X_6 = extent of business functions interconnected *This is an assessment of the degree to which the networked IT application integrates knowledge across business functions and multiple entities such as suppliers, distributors, and customers. The application constitutes the action to which competitors are responding.*

Table 6.8.a. Summary of the Regression Model Analysis: Model Fit and Hypotheses Testing. (Industry-level analysis; N=103)

	NUMBER of RESPONSES PER COMPETITOR		TOTAL NUMBER of RESPONSES	
	Tobit Regression		Negative Binomial Regression	
Window of response	1 year	2 year	1 year	2 year
Regression model results	Table 6.9.a.	Table 6.10.a.	Table 6.11.a.	Table 6.12.a.
Controls that were significant	HHI concentration ratio: - influence	Insignificant	Number of competitors: - marginal influence	Number of competitors: - influence
H1 (+) main effects	Wrong sign	Insignificant	Wrong sign	Wrong sign
H1 (+) interaction effects	Supports the hypothesis -- *product or process innovation*	Supports the hypothesis -- *product innovation*	Wrong sign -- *service innovation*	Insignificant
H2 (+) main effects	Insignificant	Supports the hypothesis	Supports the hypothesis	Supports the hypothesis
H2 (+) interaction effects	Wrong sign when the application is a product innovation.	Insignificant	Insignificant	Insignificant
H3 (+) main effects	Supports the hypothesis	Supports the hypothesis.	Insignificant	Wrong sign
H3 (+) interaction effects	Supports the hypothesis – *innovation extending beyond the firm's boundaries* Wrong sign -- *product, service, or process innovation*	Wrong sign -- *process innovation*	Wrong sign -- *product or service innovation*	Insignificant
H4 (-) main effects	Wrong sign	Wrong sign	Wrong sign (marginal)	Wrong sign
H4 (-) interaction effects	Supports the hypothesis -- *process innovation, or innovation extending beyond the firm's boundaries.* Wrong sign -- *service innovation*	Supports the hypothesis -- *product or process innovation*	Supports the hypothesis -- *process innovation or innovation extending beyond the firm's boundaries* Wrong sign -- *product or service innovation*	Supports the hypothesis -- *process innovation*

Table 6.8.a. (continued)

	Tobit Regression		Negative Binomial Regression	
Window of response	1 year	2 year	1 year	2 year
H5 (+) main effects	Insignificant	Wrong sign	Insignificant	Insignificant
H5 (+) interaction effects	Supports the hypotheses -- *product innovation*	Supports the hypotheses -- *product or process innovation*	Supports the hypothesis – *innovation extending beyond the firm's boundaries* Wrong sign -- *product innovation*	Supports the hypothesis -- *innovation extending beyond the firm's boundaries*
H5 (+) Interaction effects	Insignificant	Insignificant	Insignificant	Insignificant
H6 (-) main effects	Insignificant	Wrong sign	Insignificant	Insignificant
H6 (-) interaction terms	Supports the hypotheses -- *product or service innovation* Wrong sign – *innovation extending beyond the firm's boundaries*	Supports the hypotheses -- *process innovation* Wrong sign -- *product innovation*	Supports the hypotheses -- *product or service innovation* Wrong sign -- *innovation extending beyond the firm's boundaries*	Wrong sign -- *service innovation*
Dummy variables				
Innovative product	Insignificant	Significant: (+) influence	Significant: (-) influence	Insignificant
Innovative service	Significant: (-) influence	Insignificant	Significant: (-) influence	Insignificant
Innovative process	Significant: (+) influence	Significant: (+) influence	Significant: (+) influence	Significant: (+) influence
Innovation extending beyond firm's boundaries	Significant: (+) influence	Significant: (+) influence	Significant: (+) influence	
Model Chi2 and P-value significance over null model of all coefficients = 0	Chi2(21) = 68.34 Prob > chi2 = .0000	Chi2(16) = 57.32 Prob > chi2 = .0000	Chi2(20) = 55.12 Prob > chi2 = .0000	Chi2(9) = 48.08 Prob > chi2 = .0000
Pseudo R^2 value	.4531	.1789	.1553	.1002

Table 6.8.b. Summary of the Regression Model Analysis: Model Fit and Hypotheses Testing. (Firm-level analysis; N=85)

	NUMBER of RESPONSES PER COMPETITOR		TOTAL NUMBER of RESPONSES	
	Tobit Regression		Negative Binomial Regression	
Window of response	1 year	2 year	1 year	2 year
Regression model results	Table 6.9.b.	Table 6.10.b.	Table 6.11.b.	Table 6.12.b.
Controls that were significant	Number of employees: (+) influence	Number of employees: (+) influence Net sales: (-) marginal influence	Number of employees: (+) influence	Number of employees: (+) influence
H1 (+) main effects	Wrong sign	Wrong sign	Wrong sign	Wrong sign
H1 (+) interaction effects	Supports the hypothesis -- *product or process innovation*	Supports the hypothesis -- *product innovation*	Supports the hypothesis -- *process innovation*	Insignificant
H2 (+) main effects	Supports the hypothesis	Supports the hypothesis	Supports the hypothesis	Supports the hypothesis
H2 (+) interaction effects	Supports the hypothesis -- *innovation extending beyond the firm's boundaries* Wrong sign -- *process innovation*	Insignificant	Supports the hypothesis -- *innovation extending beyond the firm boundaries* Wrong sign -- *process innovation*	Wrong sign -- *process innovation*
H3 (+) main effects	Insignificant	Wrong sign (marginal influence)	Wrong sign	Wrong sign
H3 (+) interaction effects	Insignificant	Wrong sign -- *process innovation*	Supports the hypothesis -- *process innovation*	Supports the hypothesis -- *process innovation*
H4 (-) main effects	Wrong sign	Supports the hypothesis	Insignificant	Supports the hypothesis
H4 (-) interaction effects	Wrong sign -- *service innovation*	Supports the hypothesis -- *product or process innovation*	Wrong sign -- *service innovation or innovation extending beyond the firm's boundaries*	Wrong sign -- *process innovation, or innovation extending beyond the firm's boundaries*

Table 6.8.b. (continued)

	Tobit Regression		Negative Binomial Regression	
Window of response	1 year	2 year	1 year	2 year
H5 (-) main effects	Insignificant	Wrong sign	Insignificant	Wrong sign
H5 (-) interaction effects	Supports the hypothesis – *innovation extending beyond the firm's boundaries* Wrong sign -- *service innovation*	Supports the hypotheses -- *product or process innovation*	Supports the hypothesis -- *innovation extending beyond the firm's boundaries* Wrong sign -- *service innovation*	Supports the hypothesis -- *process innovation, or innovation extending beyond the firm's boundaries*
H5 (-) Interaction terms	Insignificant	Insignificant	Insignificant	Insignificant
H6 (-) main effects	Insignificant	Wrong sign (marginal)	Insignificant	Wrong sign (marginal)
H6 (-) interaction effects	Insignificant	Supports the hypothesis -- *process innovation* Wrong sign -- *product innovation*	Insignificant	Supports the hypothesis -- *process innovation* Wrong sign -- *service innovation*
Dummy variables				
Innovative product	Insignificant	Significant: (+) influence	Insignificant	Insignificant
Innovative service	Insignificant	Significant: (-) influence	Insignificant	Insignificant
Innovative process	Significant: (-) influence	Significant: (+) influence	Insignificant	Significant: (+) influence
Innovation extending beyond firm's boundaries	Significant: (-) influence	Significant: (-) influence	Significant: (-) influence	Significant: (-) influence
Model Chi2 and P-value significance over null model of all coefficients = 0	Chi2(12) = 57.28 Prob > chi2 = .0000	Chi2(22) = 80.08 Prob > chi2 = .0000	Chi2(13) = 53.00 Prob > chi2 = .0000	Chi2(17) = 69.52 Prob > chi2 = .0000
Pseudo R^2 value	1.1196 (Stata recommends reporting the Chi2 value, shown above.)	.9019	.1830	.1821

Table 6.9.a. Tobit Analysis: Resulting Model for Number of Responses per Competitor within a 1-year window. (Industry-level analysis: N=103)

Dependent variable: ys1yr
Number of obs = 103 (51 left-censored observations at ys1yr<=0: 52 uncensored observations)
chi2(21) = 68.34
Prob > chi2 = 0.0000
Log Likelihood = -41.247134
Pseudo R2 = 0.4531

ys1yr	Coef.	Std. Err.	t	P>|t|	[95 %	Conf. Interval]
hhi	-0.0000785	0.0000485	-1.619	0.109	-0.0001749	0.0000179
indscore	-0.0002487	0.0000943	-2.637	0.010	-0.0004364	-0.0000611
itinv5	15.1638500	3.2618080	4.649	0.000	8.6750770	21.6526300
innov	2.3347620	0.5442926	4.290	0.000	1.2519910	3.4175330
inserv	-2.0835560	0.6582962	-3.165	0.002	-3.3931170	-0.7739949
inproc	19.1397100	4.2031220	4.554	0.000	10.7783600	27.5010600
inbound	10.6568500	2.0172190	5.283	0.000	6.6439590	14.6697400
iprodx1	0.0001819	0.0000541	3.360	0.001	0.0000742	0.0002896
iprodx2	-0.4570656	0.1687121	-2.709	0.008	-0.7926876	-0.1214435
iprodx3	-4.7272350	2.2480450	-2.103	0.039	-9.1993130	-0.2551569
iprodx5	1.5856360	0.3770343	4.206	0.000	0.8355947	2.3356770
iprodx6	-0.0344611	0.0185757	-1.855	0.067	-0.0714141	0.0024919
iservx3	-10.0447900	2.1288450	-4.718	0.000	-14.2797400	-5.8098440
iservx4	0.6966904	0.1711791	4.070	0.000	0.3561607	1.0372200
iservx6	-0.0959457	0.0375334	-2.556	0.012	-0.1706115	-0.0212799
iprocx1	0.0002327	0.0000954	2.439	0.017	0.0000429	0.0004224
iprocx3	-15.6948800	3.2100700	-4.889	0.000	-22.0807300	-9.3090250
iprocx4	-2.3327260	0.5406269	-4.315	0.000	-3.4082050	-1.2572470
ibounx3	2.6419620	1.0961390	2.410	0.018	0.4613922	4.8225320
ibounx4	-1.5682150	0.3048577	-5.144	0.000	-2.1746750	-0.9617562
ibounx6	0.0883645	0.0342828	2.578	0.012	0.0201651	0.1565638
_cons	-18.9595400	4.2131670	-4.500	0.000	-27.3408700	-10.5782100
_se (Ancillary parameter)	0.3618249	0.0368967				

Table 6.9.b. Tobit Analysis: Resulting Model for Number of Responses per Competitor within a 1-year window. (Firm-level analysis; N=85)

Dependent variable: ys1yr
Number of obs = 85 (42 left-censored observations at ys1yr<=0; 43 uncensored observations)
chi2(12) = 57.28
Prob > chi2 = 0.0000
Log Likelihood = 3.0600879
Pseudo R2 = 1.1196

ys1yr	Coef.	Std. Err.	t	P>|t|	[95 %	Conf. Interval]
fnumemp	0.00000059	0.00000021	2.842	0.006	0.0000002	0.0000010
indscore	-0.00033170	0.00009050	-3.667	0.000	-0.0005120	-0.0001514
lsdgpo	0.50763170	0.15509920	3.273	0.002	0.1985195	0.8167440
innov	0.05207330	0.02898870	1.796	0.077	-0.0057011	0.1098477
inproc	2.56288500	0.98639850	2.598	0.011	0.5969954	4.5287740
inbound	-1.13653000	0.41795280	-2.719	0.008	-1.9695090	-0.3035515
iservx4	0.02552990	0.00850270	3.003	0.004	0.0085841	0.0424757
iservx5	-0.30039190	0.09699910	-3.097	0.003	-0.4937109	-0.1070730
iprocx1	0.00029790	0.00009010	3.306	0.001	0.0001183	0.0004775
iprocx2	-0.49941820	0.15455620	-3.231	0.002	-0.8074483	-0.1913880
ibounx2	0.10187000	0.04597840	2.216	0.030	0.0102352	0.1935048
ibounx5	0.28517290	0.09753840	2.924	0.005	0.0907792	0.4795665
_cons	-2.71562700	1.02270500	-2.655	0.010	-4.7538750	-0.6773800
_se (Ancillary parameter)	0.1422325	0.0162203				

Table 6.10.a. Tobit Analysis: Resulting Model for Number of Responses per Competitor within a 2-year window. (Industry-level analysis; N=103)

Dependent variable: ys2yr
Number of obs = 103 (36 left-censored observations at ys2yr<=0; 67 uncensored observations)
chi2(16) = 57.32
Prob > chi2 = 0.0000
Log Likelihood = -131.5655
Pseudo R2 = 0.1789

ys1yr	Coef.	Std. Err.	t	P>|t|	[95 %	Conf. Interval]
avuncpti	0.0189913	0.0061326	3.097	0.003	0.0068021	0.0311806
itinv5	12.1271500	6.2488180	1.941	0.056	-0.2930477	24.5473600
innov	3.6098790	0.9625197	3.750	0.000	1.6967670	5.5229910
integr	0.2430930	0.0864024	2.813	0.006	0.0713589	0.4148272
netpub	-2.1156140	1.0459020	-2.023	0.046	-4.1944570	-0.0367712
inprod	11.9828300	3.7865840	3.165	0.002	4.4565860	19.5090800
inproc	34.1418700	7.8843180	4.330	0.000	18.4709400	49.8128100
inbound	2.0427350	0.9495124	2.151	0.034	0.1554766	3.9299940
iprodx1	0.0007652	0.0002407	3.179	0.002	0.0002868	0.0012437
iprodx4	-3.4361840	0.8728102	-3.937	0.000	-5.1709890	-1.7013800
iprodx5	8.4779200	2.0949430	4.047	0.000	4.3139940	12.6418500
iprodx6	0.2161897	0.0839866	2.574	0.012	0.0492572	0.3831222
iprocx3	-13.8998800	6.3174720	-2.200	0.030	-26.4565400	-1.3432160
iprocx4	-4.0754790	0.9451830	-4.312	0.000	-5.9541330	-2.1968250
iprocx5	2.0509940	1.0741410	1.909	0.060	-0.0839764	4.1859650
iprocx6	-0.2424375	0.0874611	-2.772	0.007	-0.4162758	-0.0685991
_cons	-32.1823400	7.9047220	-4.071	0.000	-47.8938300	-16.4708500
_se (Ancillary Parameter)	1.3076280	0.1149333				

Table 6.10.b. Tobit Analysis: Resulting Model for Number of Responses per Competitor within a 2-year window. (Firm-level analysis; N=85)

Dependent variable = ys2yr
Number of obs = 85 (32 left-censored observations at ys2yr<=0; 53 uncensored observations)
chi2(22) = 80.08
Prob > chi2 = 0.0000
Log Likelihood = -4.3563733
Pseudo R2 = 0.9019

ys2yr	Coef.	Std. Err.	t	P>|t|	[95 %	Conf. Interval]
fnetsal	0.0000000	0.0000000	-1.464	0.148	0.0000000	0.0000000
fnumemp	0.0000012	0.0000004	2.876	0.005	0.0000004	0.0000021
indscore	-0.0000624	0.0000149	-4.186	0.000	-0.0000922	-0.0000326
lsdgpo	0.9462306	0.3881778	2.438	0.018	0.1705193	1.7219420
itinv5	-16.8465100	11.7058600	-1.439	0.155	-40.2388100	6.5457810
innov	-0.3850779	0.1074044	-3.585	0.001	-0.5997084	-0.1704473
integr	0.2510446	0.1766764	1.421	0.160	-0.1020149	0.6041042
netpub	-1.1465340	0.4065334	-2.820	0.006	-1.9589260	-0.3341415
inprod	0.1471334	0.0944579	1.558	0.124	-0.0416256	0.3358925
inserv	-0.1463377	0.1049613	-1.394	0.168	-0.3560861	0.0634108
inproc	5.2893540	2.7963620	1.892	0.063	-0.2987296	10.8774400
inbound	-3.0357040	0.8515426	-3.565	0.001	-4.7373760	-1.3340320
iservx5	-0.2043165	0.1472117	-1.388	0.170	-0.4984956	0.0898625
iservx6	0.0288693	0.0095465	3.024	0.004	0.0097921	0.0479464
iprocx2	-0.9417039	0.3890647	-2.420	0.018	-1.7191880	-0.1642201
iprocx3	16.8192500	11.6973600	1.438	0.155	-6.5560500	40.1945500
iprocx4	0.3617135	0.1063347	3.402	0.001	0.1492205	0.5742065
iprocx5	0.9535137	0.4026868	2.368	0.021	0.1488084	1.7582190
iprocx6	-0.2666149	0.1763298	-1.512	0.136	-0.6189819	0.0857521
ibounx2	0.1033709	0.0600113	1.723	0.090	-0.0165522	0.2232940
ibounx4	0.2785206	0.0994963	2.799	0.007	0.0796931	0.4773482
ibounx5	0.5246794	0.1695590	3.094	0.003	0.1858428	0.8635160
_cons	-4.6411350	2.7835600	-1.667	0.100	-10.2036300	0.9213651
_se (Ancillary Parameter)	0.190649	0.0193886				

Table 6.11.a. Negative Binomial Regression Analysis: Resulting Model for Total Number of Responses within a 1-year window. (Industry-level analysis; N=103)

Dependent variable: nsr1yr
Number of obs = 103
Model chi2(20) = 55.12
Prob > chi2 = 0.0000
Log Likelihood = -149.8513596
Pseudo R2 = 0.1553

nsr1yr	Coef.	Std. Err.	z	P>|z|	[95 % Conf.	Interval]
_lnmean						
numcomp	-0.0201439	0.0171866	-1.172	0.241	-0.0538291	0.0135412
indscore	-0.0001970	0.0000940	-2.096	0.036	-0.0003812	-0.0000128
lsdgpo	0.4401708	0.1707263	2.578	0.010	0.1055534	0.7747883
innov	1.8488870	1.1967500	1.545	0.122	-0.4966998	4.1944740
inprod	-10.0567000	4.1871620	-2.402	0.016	-18.2633900	-1.8500100
inserv	-3.2812890	1.8718070	-1.753	0.080	-6.9499630	0.3873843
inproc	14.3591700	8.9417440	1.606	0.108	-3.1663230	31.8846700
inbound	12.6396600	5.7914500	2.182	0.029	1.2886310	23.9907000
iprodx3	-16.5944400	7.4634130	-2.223	0.026	-31.2224600	-1.9664230
iprodx4	2.5535600	0.9026748	2.829	0.005	0.7843500	4.3227700
iprodx5	-3.7328800	1.5834140	-2.357	0.018	-6.8363150	-0.6294461
iprodx6	-0.3104493	0.0981366	-3.163	0.002	-0.5027935	-0.1181050
iservx1	-0.0002956	0.0001883	-1.570	0.116	-0.0006647	0.0000735
iservx3	-9.8890090	4.0598560	-2.436	0.015	-17.8461800	-1.9318380
iservx4	1.3344160	0.4431926	3.011	0.003	0.4657740	2.2030570
iservx6	-0.1499024	0.1047325	-1.431	0.152	-0.3551743	0.0553696
iprocx4	-1.7767410	1.1584670	-1.534	0.125	-4.0472940	0.4938133
ibounx4	-2.1111110	0.8810978	-2.396	0.017	-3.8380310	-0.3841913
ibounx5	0.9587217	0.5920854	1.619	0.105	-0.2017444	2.1191880
ibounx6	0.2205620	0.1048222	2.104	0.035	0.0151143	0.4260096
_cons	-16.7939600	9.3186990	-1.802	0.072	-35.0582700	1.4703590
_lnalpha						
_cons	-0.3363374	0.3429061	-0.981	0.327	-1.0084210	0.3357462

alpha .714382 [_lnalpha]_cons = ln(alpha)
(LR test against Poisson, chi2(1) = 28.70516 p = 0.0000)

Table 6.11.b. Negative Binomial Regression Analysis: Resulting Model for Total Number of Responses within a 1-year window. (Firm-level analysis; N=85)

Dependent variable = nsr1yr
Number of obs = 85
Model chi2(13) = 53.00
Prob > chi2 = 0.0000
Log Likelihood = -118.2858503
Pseudo R2 = 0.1830

nsr1yr	Coef.	Std. Err.	z	P>|z|	[95 %	Conf. Interval]
_lnmean						
fnumemp	0.0000039	0.0000014	2.736	0.006	0.0000011	0.0000067
indscore	-0.0018686	0.0006955	-2.687	0.007	-0.0032318	-0.0005054
lsdgpo	1.6479310	0.6003156	2.745	0.006	0.4713337	2.8245280
itinv5	-12.2243600	6.2289630	-1.963	0.050	-24.4329000	-0.0158177
inbound	-11.8811200	4.2907430	-2.769	0.006	-20.2908300	-3.4714210
iservx4	0.1395834	0.0628419	2.221	0.026	0.0164156	0.2627512
iservx5	-1.1485130	0.5663259	-2.028	0.043	-2.2584920	-0.0385350
iprocx1	0.0015988	0.0006937	2.305	0.021	0.0002392	0.0029584
iprocx2	-1.4215630	0.5760981	-2.468	0.014	-2.5506940	-0.2924314
iprocx3	11.6430900	6.3457700	1.835	0.067	-0.7943873	24.0805700
ibounx2	0.6593058	0.3534053	1.866	0.062	-0.0333559	1.3519680
ibounx4	0.6581597	0.5008680	1.314	0.189	-0.3235235	1.6398430
ibounx5	1.8374550	0.6935047	2.650	0.008	0.4782108	3.1966990
_cons	-0.5170117	1.6057540	-0.322	0.747	-3.6642320	2.6302080
_lnalpha						
_cons	-0.9777953	0.5811928	-1.682	0.092	-2.1169120	0.1613217

alpha .3761395 [_lnalpha]_cons = ln(alpha)
(LR test against Poisson, chi2(1) = 5.759367 p = 0.0164)

Table 6.12.a. Negative Binomial Regression Analysis: Resulting Model for Total Number of Responses within a 2-year window. (Industry-level analysis: N=103)

Dependent variable: nsr2yr
Number of obs = 103
Model chi2(9) = 48.08
Prob > chi2 = 0.0000
Log Likelihood = -215.9168901
Pseudo R2 = 0.1002

nsr2yr	Coef.	Std. Err.	z	P>|z|	[95 %	Conf. Interval]
_lnmean						
numcomp	-0.0196593	0.0130862	-1.502	0.133	-0.0453077	0.0059891
indscore	-0.0001555	0.0000666	-2.333	0.020	-0.0002861	-0.0000248
lsdgpo	0.2489472	0.1394154	1.786	0.074	-0.0243019	0.5221964
itinv5	-1.7904560	1.0259420	-1.745	0.081	-3.8012650	0.2203541
innov	0.1884510	0.7209470	1.648	0.099	-0.2245795	2.6014810
inproc	9.7034500	5.8165320	1.668	0.095	-1.6967440	21.1036400
iservx6	0.0485988	0.0209827	2.316	0.021	0.0074735	0.0897241
iprocx4	-1.2924770	0.7495294	-1.724	0.085	-2.7615280	0.1765732
ibounx5	1.1074700	0.3822881	2.897	0.004	0.3581992	1.8567410
_cons	-9.0270200	5.9801390	-1.509	0.131	-20.7478800	2.6938370
_lnalpha						
_cons	-0.012075	0.2230709	-0.054	0.957	-0.4492859	0.4251359

alpha .9879976 [_lnalpha]_cons = ln(alpha)
(LR test against Poisson, chi2(1) = 167.107 p = 0.0000)

Table 6.12.b. Negative Binomial Regression Analysis: Resulting Model for Total Number of Responses within a 2-year window. (Firm-level analysis; N=85)

Dependent variable = nsr2yr
Number of obs = 85
Model chi2(17) = 69.52
Prob > chi2 = 0.0000
Log Likelihood = -156.0983432
Pseudo R2 = 0.1821

nsr2yr	Coef.	Std. Err.	z	P>|z|	[95 %	Conf. Interval]
_lnmean						
fnumemp	0.0000032	0.0000015	2.221	0.026	0.0000004	0.0000061
indscore	-0.0003063	0.0000708	-4.328	0.000	-0.0004450	-0.0001676
lsdgpo	3.0087350	1.2361960	2.434	0.015	0.5858354	5.4316340
itinv5	-58.2595100	32.3184100	-1.803	0.071	-121.6024000	5.0834160
innov	-0.8344230	0.3186533	-2.619	0.009	-1.4589720	-0.2098741
integr	0.7969997	0.4924158	1.619	0.106	-0.1681175	1.7621170
netpub	-3.5835080	1.4456850	-2.479	0.013	-6.4169990	-0.7500168
inproc	18.7941600	9.8819420	1.902	0.057	-0.5740875	38.1624100
inbound	-11.3600600	3.9066410	-2.908	0.004	-19.0169400	-3.7031850
iservx6	0.0872982	0.0293643	2.973	0.003	0.0297453	0.1448512
iprocx2	-2.7558390	1.2453020	-2.213	0.027	-5.1965870	-0.3150910
iprocx3	57.1367800	32.3246600	1.768	0.077	-6.2183860	120.4919000
iprocx4	0.5562386	0.2895414	1.921	0.055	-0.0112522	1.1237290
iprocx5	2.3950560	1.4122870	1.696	0.090	-0.3729750	5.1630880
iprocx6	-0.8596900	0.4922195	-1.747	0.081	-1.8244230	0.1050425
ibounx4	1.5375110	0.5227790	2.941	0.003	0.5128830	2.5621390
ibounx5	2.1556940	0.6864661	3.140	0.002	0.8102453	3.5011430
_cons	-16.7272200	9.730169	-1.719	0.086	-35.7980000	2.343556
_lnalpha						
_cons	-0.6929023	0.3407716	-2.033	0.042	-1.3608020	-0.0250022

alpha .5001225 [_lnalpha]_cons = ln(alpha)
(LR test against Poisson, chi2(1) = 28.94952 p = 0.0000)

6.6 Analysis of the regression models

The regression models present a very complex picture of the competitive response. The vast array of significant results across main and interaction effects, as summarized in Tables 6.7.a and 6.7.b, indicate that competitive response is affected by many factors, including the industry output information intensity, the environmental demands driven by uncertainty and information complexity, and characteristics of the application itself pertaining to its degree of innovation, integration of knowledge from multiple business functions exchanged between multiple entities, and whether or not the application relies on public networks as a key component. In addition, based on the significance of the dummy variables and interaction terms, it is clear that the results are affected by the type of application carried out with the networked IT to the extent that the application resulted in product innovations, service innovations, process innovations, or innovations that extended beyond the firm's boundaries.

This section is devoted to sorting out these factors. We begin first with an analysis according to the hypothesized factors. Then, the results are re-cast according to the four types of networked IT applications. Throughout the analysis, the main and interaction effects are analyzed in combination, as is necessary whenever the interaction effects are statistically significant (Neter, Wasserman, and Kutner, 1990).

6.6.1 Incentives to respond

Hypotheses 1, 2 and 3 propose factors that will create incentives for competitors to respond to the networked IT action applications. In general, the incentives are posited to be due to the strategic value of using networked IT in conditions where: a) the industry's product is considered to be information-intensive; b) the competitive environment is volatile and creates uncertainty for the firm; and c) the competitive environment is complex and requires capabilities to process extensive amounts of information rapidly. The results of all the hypotheses are summarized in Tables 6.7.a and 6.7.b., and Tables 6.8 through 6.12 show the specific regression results.

Hypothesis 1 proposes that a positive relationship would exist between the responses from competitors and the output information-intensity (*indscore*). The basis for this hypothesis is the expectation that networked IT applications are more valuable when the product or service of an industry is information-based itself, or when the tasks that are a part of the value chain of firms in that industry require extensive amounts of information processing and coordination. Hypothesis 1 provided an argument for competitors' motivation to respond by suggesting that in some industries, the product or the processes provided increased opportunities to exploit the capabilities of information technology. The additional arguments were presented in Hypotheses 2 and 3, pertaining to the uncertainty and information complexity within the industry environment, and not the specific product or service output of the industry.

The sign of the coefficients associated with the variable for the output information-intensity, *indscore*, and interaction terms pertaining to this variable indicate whether or not there is support for Hypothesis 1. The interaction terms were formed to indicate the extent of the rivalry correlated with the output information-intensity in each of the four categories of networked IT applications: product innovations, service innovations, process innovations, or innovations that extend beyond the firm's boundaries. Hypothesis 1 proposed that there would be a positive sign for the coefficient pertaining to output information-intensity in the resulting model. The models assessed the competitive response in a one-year window and a two-year window.

In both the industry-level analysis models and the firm-level analysis models, the main effects of the *indscore* term resulted in either the wrong sign or insignificant results. However, several interaction effects pertaining to the type of the application were significant and in support of the hypothesis. Recall that the tobit models account for the responses per key competitor, while the negative binomial regression models assess the total number of responses. In both a one-year and two-year response window, the tobit models indicate a support for the hypothesis when the application is a product innovation. Within a one-year response window, the tobit models indicate a support for the hypothesis when the application is a process innovation. The negative binomial regression results in the one-year response window differed between the industry-level analysis and the firm-level analysis. In the industry-level analysis, the coefficient had the opposite sign if the application was a service innovation. However, in the firm-level analysis, there was still support for the hypothesis when the application was a process innovation. The interaction terms were insignificant in the negative binomial regression model for the two-year response window. These results are summarized in Table 6.13.

Table 6.13. Hypothesis 1 – Degree of industry output information intensity: Summary of Main Effects and Interaction Effects with the dummy variables classifying the type of innovation.

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit Regression				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industr y	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b.	Table 6.12.a	Table 6.12.b
	Expected Sign = + * = Supports Hypothesis; X = wrong sign (Other results are insignificant)							
Main effects	- X	- X		- X	- X	- X	- X	- X
Interaction effects:								
Product innovation	+ *	+ *	+ *	+ *				
Service innovation					- X			
Process innovation	+ *	+ *				+ *		
Innovation extending beyond the firm's boundaries								

Hypothesis 2 proposes that a positive relationship would exist between the responses from competitors and the volatility of the industry competitive environment. Thus, the sign of the coefficients associated with demand volatility and their interaction terms indicate whether or not there is support for this hypotheses. As described for the first hypothesis, the interaction terms were formed to indicate the nature of competitors' responses correlated with the environmental uncertainty variable in each of the four categories of networked IT applications: product innovations, service innovations, process innovations, or innovations that extend beyond the firm's boundaries. The models tested assessed response in a one-year window and a two-year window.

Several measures for demand volatility were assessed in the models, and two have provided significant results. These measures were originally discussed in Chapter 4, regarding their use as indicators of demand volatility. The first is the logarithm of the standard deviation of the Gross Product Output by industry (*lsdgpo*), and it is used in all of the firm-level analysis models, as well as the negative binomial regression models for the industry-level analysis. The second is the absolute value of the coefficient of first differences of the industry pre-tax income (*avuncpti*), and it is used only in the tobit models for the industry-level analysis. The hypotheses proposed that there would be a positive sign to this coefficient. In all but one of the models, the main effects of this term supported the hypothesis, indicating that the degree of competitive response increased as the degree of uncertainty increased. The main effects, however, cannot be evaluated alone. Some interaction effects were also significant and in support of the hypothesis, while others had the wrong sign.

For the industry-level analysis, the only significant interaction term occurred within a one-year response window. The tobit model for the industry-level analysis indicates that when the application is a product innovation, the interaction term is significant and has the wrong sign. For the firm-level analysis, several interaction terms were significant. Within a one-year response window, both the tobit and negative binomial regression models indicate support for the hypothesis when the application is an innovation that extends beyond the firm's boundaries. These same two models also indicate that the coefficient has the wrong sign when the application is a process innovation. The negative binomial regression model for the two-year window also has the wrong sign for the coefficient when the application is a process innovation. These results are summarized in Table 6.14.

Table 6.14. Hypothesis 2 – Uncertainty created by Demand Volatility: Summary of Main Effects and Interaction Effects with the dummy variables classifying the type of innovation.

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit Regression				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b.	Table 6.12.a	Table 6.12.b
	Expected Sign = + * = Supports Hypothesis: X = wrong sign (Other results are insignificant)							
Main effects		+ *	+ *	+ *	+ *	+ *	- *	+ *
Interaction effects: Product innovation	- X							
Service innovation								
Process innovation		- X				- X		- X
Innovation extending beyond the firm's boundaries		+ *				+ *		

Hypothesis 3 proposes that a positive relationship would exist between the responses from competitors and the information complexity of the competitive environment caused by the level of automation in the industry. The level of automation in the industry is measured by the Computer and Communications Investments over a five-year period, per Gross Output by Industry (*itinv5*). This five-year period matches the time span over which environmental uncertainty was measured. Thus, the sign of the coefficients associated with the variable *itinv5* and interaction terms pertaining to *itinv5* indicate whether or not there is support for this hypotheses. The interaction terms were formed to assess the nature of the rivalry correlated with *itinv5* in each of the four categories of networked IT applications: product innovations, service innovations, process innovations, or innovations that extend beyond the firm's boundaries. Hypothesis 3 proposed that there would be a positive sign for the coefficient of *itinv5* in the resulting model. The models assessed the competitive response in a one-year window and a two-year window.

The industry-level analysis tobit models indicate that there is support for this hypothesis. The two-year response-window negative binomial regression model indicate that the main effects term is significant, but that it has the wrong sign. In the firm-level analysis, the main effects of this term revealed the wrong sign in three of the models, and it was insignificant in the fourth. The interaction effects also produce mixed results. In the industry-level analysis, the tobit model indicates that there is support for the hypotheses within a 1-year response window when the application is an innovation that extends beyond the firm's boundaries. However, when the application is a product, service, or process innovation, the coefficient has the wrong sign. The two-year tobit model for industry-level analysis model also indicates that the coefficient has the wrong sign when the application is a process innovation. The one-year negative binomial regression model for industry-level analysis reveals that the coefficient has a wrong sign when the application is a product or service innovation. In the firm-level analysis, in a two-year response window, the tobit model indicates that the coefficient has the wrong sign when the application is a process innovation. However, in both the one-year and the two-year response windows, the negative binomial regression models indicate that there is support for the hypothesis when the application is a process innovation. These results are summarized in Table 6.15.

Table 6.15. Hypothesis 3 – Information complexity created by the level of automation in the industry: Summary of Main Effects and Interaction Effects with the dummy variables classifying the type of innovation.

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit Regression				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industr y	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b.	Table 6.12.a	Table 6.12.b
	Expected Sign = + * = Supports Hypothesis; X = wrong sign (Other results are insignificant)							
Main effects	+ *		+ *	- X		- X	- X	- X
Interaction effects: Product innovation	- X				- X			
Service innovation	- X				- X			
Process innovation	- X		- X	- X		+ *		+ *
Innovation extending beyond the firm's boundaries	+ *							

6.6.2 Ease of response

Hypotheses 4, 5, and 6 pertain to the ease of competitors formulating a response. These hypotheses propose that the following factors would impede or facilitate competitors formulating a response to a networked IT action application: a) the degree of innovation of the application; b) the degree of compatibility with existing networks; and c) the extent to which the application integrated different business functions and organizations.

Hypothesis 4 proposes that competitors will have more difficulty in responding to networked IT applications that have a higher degree of innovation. The degree of innovation is represented by the variable *innov*. Consequently, the sign of the coefficients associated with the variable *innov* and interaction terms pertaining to *innov* indicate whether or not there is support for this hypotheses. The interaction terms were formed to account for the rivalry associated with *innov* in each of the four categories of networked IT applications: product innovations, service innovations, process innovations, or innovations that extend beyond the firm's boundaries. Hypothesis 4 proposed that there would be a negative sign for the coefficient of *innov* in the resulting model. The models assessed the competitive response in a one-year window and a two-year window.

In the industry-level analysis models, the main effects of this term all have the wrong sign. In the firm-level analysis tobit model for the one-year response window, the coefficient for the main effects has the wrong sign. However, in the case of the two-year response window for both the tobit and the negative binomial regression models, there is support for the hypothesis. Several interaction effects were also significant and in support of the hypothesis.

In the one-year response window in the industry-level analysis, the tobit model indicates support for the hypothesis when the application is a process innovation or one which extends beyond the firm boundaries; however the coefficient has the wrong sign when the application is a service innovation. In the industry-level analysis models for the one-year response, there is also support for the hypothesis when the application is an innovation that extends beyond the firm's boundaries. There is also support for the hypothesis in tobit model for the two-year response window when the application is a product innovation. On the other hand, the industry-level analysis models for the one-year response window reveal that the coefficient has the wrong sign when the application is a service innovation. The negative binomial regression model for the one-year response window also indicates that the coefficient has the wrong sign when the application is a product innovation. In the case of the firm-level analysis, the models pertaining to the one-year response window also show that the coefficient has the wrong sign when the application is a service innovation. In the firm-level analysis of the two-year response windows, the tobit model revealed that there was support for the model if the application was a product or process innovation. However, the negative binomial regression model for the two-year response window indicates that the coefficient has the wrong sign when the application is a process innovation or extends beyond the firm boundaries. These results are summarized in Table 6.16.

Table 6.16. Hypothesis 4 – Degree of innovation of the IT application: Summary of Main Effects and Interaction Effects with the dummy variables classifying the type of innovation.

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit Regression				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b.	Table 6.12.a	Table 6.12.b
	Expected Sign = - * = Supports Hypothesis; X = wrong sign (Other results are insignificant)							
Main effects	+ X	+ X	+ X	- *	+ X		+ X	- *
Interaction effects: Product innovation			- *	- *	+ X			
Service innovation	+ X	+ X			+ X	+ X		
Process innovation	- *		- *	- *	- *		- *	+ X
Innovation extending beyond the firm's boundaries	- *				- *	+ X		+ X

Hypothesis 5 proposes that competitors would be more likely to respond to applications that are compatible with existing networks, as indicated by the use of public networks as a key component in the application. The variable *netpub* indicates whether or not the application relied on public networks. In addition to the main effect of this term, it was hypothesized that there could exist interaction terms with this term and the other five hypothesized terms in the model, all of which would also increase the likelihood of competitive response: industry output information intensity (H1), environmental uncertainty (H2), information complexity in the environment (H3), degree of innovation of the application (H4), and extent to which business functions are integrated in the application (H6). Furthermore, as with the other hypothesized terms, interaction terms were formed with the dummy variables pertaining to the four categories of networked IT applications: product innovations, service innovations, process innovations, or innovations that extend beyond the firm's boundaries. These interaction terms indicate the nature of the response that is correlated with *netpub* in the case of each type of networked IT application. The sign of the coefficients associated with the variable *netpub* and the interaction terms pertaining to the "netpub" indicate whether or not there is support for this hypotheses, with a positive sign indicating that these factors increase the degree of competitive response. Hypothesis 5 proposed that there would be a positive sign for the coefficient of *netpub* in the resulting model. The models assessed the competitive response in a one-year window and a two-year window.

First, none of the interaction terms between *netpub* and the other hypothesized terms in the model were significant. Secondly, in both the industry-level analysis models and the firm-level analysis models, the main effects of this term revealed either the wrong sign or insignificant results. However, several interaction effects associated with the dummy variables pertaining to the four types of applications were significant and in support of the hypothesis. Frankly, these results are especially surprising considering the large influence that public networks were expected to have on the response by competitors. These results lend support to the belief, though, that the firm's organizational capability to use the available technology is the primary source of any potential competitive advantage.

In the tobit model for the one-year response window for the industry-level analysis, there is support for the hypothesis when the application is a product innovation. Within a two-year response window, the tobit models for both the industry and firm-level analysis indicate support for the hypothesis when the application is a product or process innovation. In the case of the firm-level analysis, the tobit model for the one-year response window shows that there is support for the hypothesis when the application is an innovation that extends beyond the firm's boundaries; however the coefficient has the wrong sign when the application is a service innovation. In all of the negative binomial regression results in both the one-year and two-year response windows, there is support for the model when the application is an innovation that extends beyond the firm's boundaries. In the industry-level analysis, the negative binomial regression model showed that the coefficient had the opposite sign if the application was a product innovation. Finally, in the firm-level analysis, the negative binomial regression model indicated that the coefficient had the opposite sign if the application was a service innovation. These results for Hypothesis 5 are summarized in Table 6.17.

Table 6.17. Hypothesis 5 – Network compatibility as indicated by use of public telecommunications networks in the application: Summary of Main Effects and Interaction Effects with the dummy variables classifying the type of innovation.

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit Regression				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b	Table 6.12.a	Table 6.12.b
	Expected Sign = + * = Supports Hypothesis; X = wrong sign (Other results are insignificant)							
Main effects			- X	- X				- X
Interaction effects:								
Product innovation	+ *		+ *	+ *	- X			
Service innovation		- X				- X		
Process innovation			+ *	+ *				+ *
Innovation extending beyond the firm's boundaries		+ *			+ *	+ *	+ *	+ *
Interactions with other Hypothesized terms								

Hypothesis 6 proposes that competitors would have more difficulty in responding to networked IT applications as the applications integrate together increasing numbers of organizations and business functions. The degree of integration of the application is indicated by the variable *integr*. The sign of the coefficients associated with the variable *integr* and interaction terms pertaining to *integr* indicate whether or not there is support for this hypothesis. The interaction terms were formed to assess the rivalry correlated with *integr* in each of the four categories of networked IT applications: product innovations, service innovations, process innovations, or innovations that extend beyond the firm boundaries. Hypothesis 6 proposed that there would be a negative sign for the coefficient of *integr* in the resulting model, indicating that the competitive response would be reduced. The models assessed the competitive response in a one-year window and a two-year window.

In both the industry-level analysis models and the firm-level analysis models, the main effects of this term revealed either the wrong sign or insignificant results. However, several interaction effects were significant and in support of the hypothesis. In the one-year response window, the tobit model of the industry-level analysis reveals that there is support for the hypothesis when the application is a product or service innovation, but that the coefficient has the wrong sign when the application is an innovation that extends beyond the firm's boundaries. Within a two-year response window, the tobit models for both the industry and firm-level analysis support the hypothesis when the application is a process innovation, and their coefficients have the wrong sign when the application is a product innovation. The negative binomial regression results in the one-year response window of the industry-level analysis, revealed support for the hypothesis when the application was a product or service innovation; however the coefficient had the wrong sign if the application was an innovation that extended beyond the firm's boundaries. In the two-year response window for the negative binomial model of the firm-level analysis, there was support for the hypothesis when the application was a process innovation. However, also in the two-year response window, the negative binomial model for both the industry and firm-level analysis indicated that the coefficient had the wrong sign when the application was a service innovation. These results are summarized in Table 6.18.

Table 6.18. Hypothesis 6 – Extent of functions integrated with the networked IT application: Summary of Main Effects and Interaction Effects with the dummy variables classifying the type of innovation.

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit Regression				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b	Table 6.12.a	Table 6.12.b
	Expected Sign = - * = Supports Hypothesis; X = wrong sign (Other results are insignificant)							
Main effects			+ X	+ X				+ X
Interaction effects: Product innovation	- *		+ X	+ X	- *			
Service innovation	- *				- *	+ X		+ X
Process innovation			- *	- *				- *
Innovation extending beyond the firm's boundaries	+ X				+ X			

6.6.3 Influences on the constant term of the models

In several cases the dummy variables that categorized the type of networked IT application had significant coefficients in the models. In addition, there were a few cases where the industry or firm-level control variables were significant. Both of these situations would affect the constant term in the regression model. The constant is not a hypothesized value; it is the y-intercept of the model, representing the value of the dependent variable when all of the independent terms in the model are zero. The constant in the model provides a base-line indication of the expected response from competitors. A positive sign indicates that increased responses are expected from competitors, independent of any additional effects from the other terms in the model. A negative sign indicates that fewer responses are expected from competitors. Therefore, to determine the total response from competitors, one would include the constant term along with the coefficients of the hypothesized effects associated with the independent variables in the model.

In the case of the industry-level analysis, during the one-year response window the industry concentration ratio provided a negative influence on the number of responses per competitor in the tobit model. However, it was insignificant in all other models. During both the one-year and two-year response windows, the negative binomial regression models indicated that the number of competitors exerted a negative influence on the number of responses received by an action.

The industry-level analysis also revealed that the dummy variable classifying the networked IT application as a process innovation had a positive influence on the dependent variables of all of the industry-level analysis models. The dummy variable indicating that the application was an innovation that extended beyond the firm's boundaries also had a positive influence on the dependent variable in both of the tobit models, and on the dependent variable in the negative binomial model in the one-year response window. The dummy variable indicating that the application was a service innovation had a negative influence on the dependent variables during the one-year response window. Finally, the dependent variable indicating that the application was a product innovation had a positive influence on the dependent variable in the case of the two-year response window for the tobit model, and a negative response on the dependent variable in the one-year response window for the negative binomial regression model.

In the case of the firm-level analysis, firm size as indicated by the number of employees exerted a positive influence on the dependent variable of all models. Firm size as indicated by net sales only exerted a significant influence in one case, that being a negative effect on the dependent variable of the tobit model in the two-year response window.

The firm-level analysis results also revealed that the dummy variable classifying the networked IT application as a process innovation had a positive influence on the dependent variables of all but one of the firm-level analysis models. The dummy variable indicating that the application was an innovation that extended beyond the firm's boundaries had a negative influence on the dependent variable in all of the firm-level analysis models. The dummy variable indicating that the application was a service had a negative influence on the dependent variable of the tobit model for the two-year response window. Finally, the dependent variable indicating that the application was a product innovation had a positive influence on the dependent variable in the case of the two-year response window for the tobit model. These results are summarized in Table 6.19.

Table 6.19. Effects on the constant: Summary of the main effects of control variables and the dummy variables classifying the type of innovation.

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit Regression				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b	Table 6.12.a	Table 6.12.b
	+ = Positive influence: - = Negative influence n.a. = not applicable for testing with this model (Other results are insignificant)							
Control Variables								
Industry concentration (industry-level control)	-	n.a.		n.a.		n.a.		n.a.
Number of competitors (Not for use with tobit models)	n.a.	n.a.	n.a.	n.a.	-		-	
Number of employees (firm-level control)	n.a.		n.a.		n.a.		n.a.	
Net sales of the firm (firm-level control)	n.a.		n.a.		n.a.		n.a.	
Dummy Variables								
Product innovation			+	+	-			
Service innovation	-			-	-			
Process innovation	+	+	+	+	+		+	+
Innovation extending beyond the firm's boundaries	+		+		+		+	

6.7 Analysis of rivalrous responses by type of networked IT application

The results of the regression models suggest that the type of networked IT application has an important impact on the response received from competitors, and therefore the advantage created by a firm's networked IT applications differs according to characteristics of the application and of the competitive environment. To aid in the discussion of the strategic value of networked IT applications, the information contained in Tables 6.13 through 6.19 that was originally reported according to the individual hypotheses is now recast in order to highlight the differences in competitive responses as a function of the four types of strategic networked IT applications. Table 6.20 summarizes the competitive responses to the use of networked IT to support product innovations. Table 6.21 summarizes the competitive responses to the use of networked IT to support service innovations. Table 6.22 summarizes the competitive responses to the use of networked IT to support process innovations within the firm's own operations. And finally Table 6.23 summarizes the competitive responses to the use of networked IT to support innovations that extend beyond the firm's boundaries.

The four categories of applications were identified through dummy variables in the analysis in both the one-year and two-year response windows. The rationale and formation of these dummy variables were explained in detail in Chapter 4. They identified the main effects and interaction effects associated with the four types of networked IT applications: product innovations, service innovations, process innovations, and innovations extending beyond the firm's boundaries. These types of applications may require different types of organizational capabilities in order to respond with an application that attempts to duplicate the benefit. As discussed earlier in this chapter, some networked IT applications may be more readily visible or understood by competitors, in which case there could be responses within the first year. Others, such as process and complex service innovations, may be less visible or understood by competitors, and therefore the response may be delayed into the second year or beyond. Other applications, such as those which are intended to innovate products, may require re-tooling, modification of product lines, and other alterations to existing firm operations and resources that are used along with the networked IT to formulate a response. The competitive response in these situations could be delayed into the second year.

Reorganizing the results according to the type of application, as shown in Tables 6.20 through 6.23, places emphasis on the different ways in which organizations choose to use their networked IT resources. These categories represent distinct organizational capabilities to deploy the resources, and reorganizing the results as a function of these categories allows us to assess competitors' responses to these organizational capabilities. This will facilitate a discussion of variations in the response from competitors for one type of an innovative application of networked IT as compared to another.

Each table depicts the trends indicated by the significant coefficients that were found when analyzing the tobit models and the negative binomial regression models for both the one-year and two-year response periods. Additionally, each test shows the results for the firm-level analysis as well as the industry-level analysis of the data. By seeing the data displayed in this fashion, one can identify trends where the models are consistent versus where they have differing results. At this point, the analysis goes beyond analyzing the statistical significance of individual terms and attempts to look at trends in the results. Trends that are indicated in more than one model suggest findings that should be considered more reliable indications of competitive behavior. Likewise, findings that vary across the model should be regarded as 'mixed' results, and consequently a lower degree of reliability should be placed on these results. The term 'reliability' is being used here not in a statistical sense, but rather in a managerial sense to summarize what we have learned from the results that might be worthy of theoretical discussion and for sharing with managers concerned with maximizing the advantage that can be gained from their networked IT resources.

Tables 6.20 through 6.23 each depict the responses attributed to the main effect of the dummy variable for a specific category of networked IT innovation, as well as the interaction effect of the dummy variable with the other terms of the model associated with the six hypotheses. The main effect of the term contributes to the constant term of the model. The actual response from competitors is a combination of the main and interaction effects for each type of application. Consequently, the main and interaction effects may combine constructively, if they are all of the same sign, or destructively, if they are of different signs, to heighten or negate the overall response from competitors. Furthermore, the results from one type of innovation would be combined with those of another if the application involved multiple innovation categories.

Table 6.20. Competitive Responses to the Use of Networked IT to Support Product Innovations

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b	Table 6.12.a	Table 6.12.b
Main effect term: Influence on the constant of the model			-	+	-			
Interaction term with Output Information Intensity (H1 = +)	+	+	+	+				
Interaction term with Demand Uncertainty (H2 = -)	-							
Interaction term with Information Complexity (H3 = +)	-				-			
Interaction term with Degree of Innovation (H4 = -)			-	-	+			
Interaction term with Use of public networks (H5 = +)	+		+	+	-			
Interaction term with Extent of business functions integrated (H6 = -)	-		+	+	-			
+ = positive influence - = negative influence (Hn = +/-) = hypothesized relationship								

Table 6.21. Competitive Responses to the Use of Networked IT to Support Service Innovations

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b	Table 6.12.a	Table 6.12.b
Main effect term: Influence on the constant of the model	-			-	-			
Interaction term with Output Information Intensity (H1 = +)					-			
Interaction term with Demand Uncertainty (H2 = +)								
Interaction term with Information Complexity (H3 = +)	-				-			
Interaction term with Degree of Innovation (H4 = -)	-	+			-	+		
Interaction term with Use of public networks (H5 = +)		-				-		
Interaction term with Extent of business functions integrated (H6 = -)	-				-	+		+
+ = positive influence - = negative influence (Hn = +/-) = hypothesized relationship								

Table 6.22. Competitive Responses to the Use of Networked IT to Support Process Innovations

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b	Table 6.12.a	Table 6.12.b
Main effect term: Influence on the constant of the model	+	+	+	+	+		+	+
Interaction term with Output Information Intensity (H1 = +)	+	+				+		
Interaction term with Demand Uncertainty (H2 = +)		-				-		-
Interaction term with Information Complexity (H3 = +)	-		-	-		+		+
Interaction term with Degree of Innovation (H4 = -)	-		-	-	-		-	+
Interaction term with Use of public networks (H5 = +)			+	+				+
Interaction term with Extent of business functions integrated (H6 = -)			-	-				-
+ = positive influence - = negative influence (Hn = +/-) = hypothesized relationship								

Table 6.23. Competitive Responses to the Use of Networked IT to Support Innovations Extending Beyond the Firm's Boundaries

	NUMBER of RESPONSES PER COMPETITOR				TOTAL NUMBER of RESPONSES			
	Tobit				Negative Binomial Regression			
Window of response	1 year		2 year		1 year		2 year	
Level of analysis	Industry	Firm	Industry	Firm	Industry	Firm	Industry	Firm
Table showing regression model results	Table 6.9.a	Table 6.9.b	Table 6.10.a	Table 6.10.b	Table 6.11.a	Table 6.11.b	Table 6.12.a	Table 6.12.b
Main effect term: Influence on the constant of the model	+		+		+		+	
Interaction term with Output Information Intensity (H1 = +)								
Interaction term with Demand Uncertainty (H2 = +)		+				+		
Interaction term with Information Complexity (H3 = +)	+							
Interaction term with Degree of Innovation (H4 = -)	-				-	+		+
Interaction term with Use of public networks (H5 = +)		+			+	+	+	+
Interaction term with Extent of business functions integrated (H6 = -)	+				+			
+ = positive influence - = negative influence (Hn = +/-) = hypothesized relationship								

Table 6.20 summarizes the results pertaining to responses to networked IT applications that support product innovations. By examining Table 6.20 for the main effect term, we see that the value of the constant is positive, indicating that the effect in general is to encourage the response from competitors in the second year of the response window. However, if the firm is in an industry where the output has a high degree of information intensity, these innovative applications result in increased competitive response in both the first and second years, which supports Hypothesis 1. This is the situation where the product itself may be some type of information, as is the case in the financial industry, or the processes are heavily dependent on information transactions. In contrast, the response by competitors is reduced in environments of high demand uncertainty and information complexity, contrary to the relationships proposed in Hypotheses 2 and 3. Therefore, it appears that the influence of the environmental demands is distinct from the influence of the industry output information intensity. In fact, the output information intensity may indicate an 'ease of exploiting' networked IT, but conditions of high demand volatility and a high degree of computer and communications equipment purchased within the 5-year time span, which may not be flexibly adapted to respond to the innovations, may limit the rivalrous responses in the first year.

The consideration of the investment in computer and communications equipment warrants specific discussion at this time. This measure is an indication of the level of automation in the industry, and it is used as measure of the degree of information complexity in the competitive environment. The computer and communications equipment is required to process information and exploit the high-speed capabilities of advanced information technology. The strategic value of innovative networked IT applications were hypothesized to be positive, and therefore to motivate competitors to respond, when the competitive requirement imposed demands on the firm to process large amounts of information very rapidly. The negative findings for this measure indicate the actual influence that it had on the competitive response to the innovative action. It appears that while the information technology was valuable in its ability to process information in this type of a competitive environment, this did not necessarily translate into competitors being able to respond in the two-year window to the innovation. The double-edge sword of the technology suggests that while a firm might be locked in to using it to process information, the configuration of the equipment may not facilitate responding to *innovation* which are likely to process information in a different manner. The difficulty facing firms, however, is that they must continue to use their existing investments in computer and communications equipment to keep pace with their information processing demands, and at the same time find a means to also respond to innovative actions that their competitors may have taken with similar types of equipment. These findings bring to light that the strategic value of the technology does not necessarily translate into ease of response on the part of competitors.

When examining the results concerning the characteristics of the application that affect competitors' ease of response, there is some evidence that the degree of innovation of the application appears to reduce competitive response in the second year, in support of Hypothesis 4. However, there is an indication that the total number of responses, as indicated by the negative binomial regression model, may increase in the first year. The use of the public networks was hypothesized as a characteristic that would more easily enable competitors to formulate a response. The results shown for networked IT applications that support product innovations indicate that competitive response is more likely when the action uses the public network, which supports Hypotheses 5. The degree of knowledge integration is interesting, in that a higher number of business functions integrated by the application appears to reduce responses by competitors in the first year in support of Hypothesis 6 for this time period. However it appears to increase those responses in the second year, which is contrary to the proposed relationship.

Table 6.21 summarizes the influence that applications supporting service innovations have on competitive responses. The influence is considerably different than that indicated for innovations that support product innovations. Applications supporting service innovations appear to have a negative effect on the constant term of the model, which indicates a reduction in competitive response. Also, in the first year of response there is an additional negative influence associated with the industry's information complexity, contrary to the relationship proposed by Hypothesis 3. In other words, in industries where there is a high degree of capital investment in computers and communications equipment, competitors appear to have difficulty responding to service-related applications in the first year. Here, again, is an indication that the strategic value of the information technology does not necessarily translate into increasing the likelihood of competitors responding. Interestingly, the degree of innovation of the application will not reduce competitive response, and in fact appears to increase response as the degree of innovation increases, in contrast to the relationship proposed in Hypothesis 4. This appears to indicate that highly innovative service-related applications gain increased attention from competitors and therefore motivate them to respond. It was found that use of the public network did not increase competitive response, and in fact in the first year it appeared to have a negative influence, which iscontrary to the relationship proposed in Hypothesis 5. The results associated with the extent of business functions interconnected by this type of an application are mixed. Therefore, wide knowledge integration within a service application cannot be counted on to diminish competitive response, contrary to the relationship proposed in Hypothesis 6.

Table 6.22 summarizes the influence that the networked IT applications which support process innovations have on competitive responses. The constant term indicates that there is an overwhelmingly positive main effect that process-related innovations have on competitive response. The positive influence is heightened in the first year when the product is information intensive, in support of Hypothesis 1, but the response is negatively associated with the degree of demand uncertainty in the competitive environment, which is contrary to the relationship proposed in Hypothesis 2. The influence of the industry's information complexity produces mixed results. The results in Table 6.22 also suggest as the degree of innovation of the application increases, the number of responses decreases, in support of Hypothesis 4. The use of public networks as a key element of the application appears to increase responses, in support of Hypothesis 5, although this effect is not seen as well until the second year. Applications that integrate knowledge across multiple business functions and entities appear to lessen competitive response, in support of Hypothesis 6, but the effect is only seen in the second year.

Table 6.23 reveals the trends associated with innovations that extend beyond the firm's boundaries. This category of networked IT application would have been combined with a product, service, or process innovation in order for the case to meet the qualification for entry into the sample. Therefore, while Table 6.23 suggests the individual effects of this type of innovation, the actual competitive scenario would combine this with one or more of the other categories of innovation.

Table 6.23 reveals an overwhelmingly positive effect of these innovative applications on the responses received from competitors, as indicated by the main effect term. The positive influence is further emphasized in the first year with increasing environmental demands associated with uncertainty and information complexity, in support of Hypotheses 2 and 3. The degree of innovation of the application shows somewhat mixed results, but it appears that within the first year competitors respond less to more highly innovative applications, but they respond more in the second year. The results in the first year support Hypothesis 4, and the results in the second year suggest that competitors have learned to respond through diffusion of the innovation in the industry. The use of public networks has a positive influence on competitive response to these applications, in support of Hypothesis 5. Table 6.23 indicates that competitors increase their response when the application integrates knowledge across an increasing number of business functions, which is in contrast to the relationship proposed in Hypothesis 6.

It is clear from Tables 6.20 through 6.23 that the results differ considerably by the type of innovative application of networked IT. Had the dummy variables not been used, the individual influences would have canceled each other out, resulting in statistically insignificant coefficients for the terms in the models.

Tables 6.20 through 6.23 only identify the interaction terms of the hypothesized relationships with the four categories of the innovative applications. However, it is interesting to note the following trends that appear in these tables. First, it is surprising to see the lack of support for Hypothesis 3 that is displayed in these results, which proposed that in an environment with a high degree of information complexity, competitors would be motivated to respond. One explanation is that the measure for information complexity, based on the level of automation in the industry as determined by the industry-level expenditures in computer and communication equipment over a 5-year period, has limited usefulness in assessing the information complexity of the environment. While there is no doubt that the measure underestimates the information complexity since it excludes software, training, and other non-hardware expenditures, it is applicable across multiple industries. An important element of the computer and communication equipment investment that is not revealed in the measure is precisely what is purchased and how is it configured; yet this is not likely to be obtained from any measure. An alternative explanation to the hypothesized relationship is that the embedded base of computer and communications hardware impedes some firms from responding rapidly to competitors who develop innovative applications, because they are using their existing networked IT resources to maintain their current processes. The equipment and configurations may not be easily adaptable to the new innovations. This scenario was described by Haekel (1996) and the National Research Council (1994). Jaikumar (1986) also suggested that firms are not always able to exploit their networked IT resources. The difficulty that firms may have in responding does not change the environmental demands of information complexity imposed on them, requiring them to process large amounts of information rapidly. This finding serves as a warning to managers that while their firm may have a large amount of equipment devoted to extensive information processing activities, this embedded base may not facilitate the firm's ability to respond to competitors who are able to use similar equipment in a very different way to gain an advantage.

Second, it is interesting to see the strong support for Hypothesis 1 when the innovation is directly related to the firm's products or processes, but insignificant findings in the case of the other categories of applications. These appear to indicate that the information intensity of a product does indeed reside in the product or the firm's internal processes associated with the product. However, the output information intensity characteristics of the industry do not necessarily increase competitive responses when the networked IT application innovates services or extends beyond the firm's boundaries in these industries.

Third, it is interesting to see the difference in the competitive responses due to the four categories of the innovative applications. These differences were discussed earlier, based on the degree to which competitors can observe the innovation and understand its implementation. The trends revealed in this study may in fact suggest the relative differences in the way in which these applications diffuse through an industry. Process responses had the strongest effect on limiting response from competitors as the degree of innovation of the application increased. Product innovations may have a negative influence on responses into the second year. Innovations extending beyond the firm's boundaries appear to reduce competitive response in the first year. however they appear to increase competitive response in the second year. Finally, highly innovative service applications increase competitive response even in the first year, as competitors appear to 'jump on the bandwagon' of the innovation.

The fourth interesting observation from the results presented in Tables 6.20 through 6.23 is that the use of the public network was not as strong as expected. It generally increased response from competitors, but not always. The response appeared to be delayed when the application was a process innovation, which provided the initiating firm a slight advantage in the first year. Responses to the service-related innovations appeared to decrease in the first year, again suggesting that the initiating firm has a slight advantage to move quickly while the competitors figure out how to use the resources available before they can formulate a response.

The fifth trend that is interesting to note from Tables 6.20 through 6.23 is that the extent of business functions and entities interconnected by the application did not necessarily impede competitors' response. Such a relationship was hypothesized based on the notion that extensive knowledge integration required considerable organizational know-how, and it created an ambiguous and socially complex system that would be difficult for competitors to duplication. The extent of business functions integrated by an application appeared to reduce competitive response only in the first year if they were product, or service innovations. Process innovations appeared to reduce the response through the second year. However, competitive response increased when the application was supporting an innovation that extended beyond the firm's boundaries.

The results pertaining to the main effect term of each of the hypothesized relationships appeared earlier in Tables 6.13 through 6.18. Based on these results, the following relationships are noteworthy. First, Table 6.13 showed the results for Hypothesis 1. There was lack of support for the hypothesis based on the main effect of the term, but support did exist in terms of the interaction effects. The main effect of increased output information intensity was to reduce competitive response. This may be due to the existing use of IT within the product and processes that makes it difficult to respond to innovations. The innovations may be caused by new firms changing the nature of business in the industry, or creating advantage with technology that is used in ways that vary from the standard applications in the industry. Consequently, although the industry makes a high degree of use of the IT resources, the firms in that industry do not necessarily have the organizational capabilities to respond to innovative uses of the technology. Such a scenario suggests a way for small and new competitors to 'level the playing field,' against existing firms in the industry.

Table 6.14 summarized the results for Hypothesis 2. There appeared to be considerable support for the hypothesis based on the main effect term in the models. The main effect indicated that competitive responses increased as the degree of demand volatility increased. Some interaction terms also supported the hypothesis, while others did not, as just described in the section analyzing the interactions with the four categories of applications. These results suggest that competitors recognize the strategic value of using networked IT in conditions of demand volatility, and therefore are motivated to respond to competitors' actions.

Table 6.15 summarized the results for Hypothesis 3 pertaining to competitors' responses according to the level of information complexity in the environment. Two of the three significant relationships in the tobit models support the hypothesis that there is a positive relationship between the extent of information complexity and the responses from competitors. The tobit model portrays responses per competitor, thus taking into account differences due to different number of key competitors that a firm may have as compared to another. The interaction terms described earlier are largely contrary to the hypothesized relationship. It appears, especially when examining the interaction terms, that the embedded investment base of communications and computer equipment may indeed indicate an industry that is heavily automated with high information demands, but this does not translate into ability to respond to innovative uses of the technology. This result is likely due to the incompatibility between systems and possible inflexibility in reconfiguring certain types of networked IT to respond to the innovative applications. This scenario is consistent with the results for the output information intensity of an industry, and suggests new firms can enter an industry and use information technology in a different way to compete against more established firms, possibly by employing the newer client server technology that might be more easily configurable to specific business applications than other technology platforms. The existing base of technology is used to maintain ongoing operations in the firms. The need to maintain these systems could be exactly what prevents the firms from responding to innovative uses of newer technology.

Table 6.16 depicts the results for Hypothesis 4, concerning the degree of innovation of the application. The main effect of this term suggests that highly innovative applications caught the attention of competitors and received a high degree of competitive response. However, there were several interaction effects that identified opportunities for reducing the response by increasing the degree of innovation. Three issues are important to consider here. First, applications that do not appear to be highly innovative may be able to convey an important strategic advantage to firms initiating them because they do not capture the attention of rivals. Secondly, numerous applications which may appear routine and tactical can be combined discretely to form highly innovative end results that can surprise competitors. Third, applications that may appear to be only incremental innovations may be tightly interwoven with the firm's existing resources and processes, giving it the ability to appropriate the value from the innovation in a way that is unique to its firm (Helfat, 1994). By developing IT applications in such as way, as opposed to 'high-impact' types of innovative applications, the firm is reducing its risk by the incremental development of the applications while at the same time it is not gathering attention from rivals. In other words, it is beneficial for firms to 'stay below the radar line' of their competitors, because highly innovative applications are not likely to impede competitive responses.

Table 6.17 summarizes the results of Hypothesis 5 pertaining to the impact of network compatibility as indicated by the use of public networks as a key component of the application. The most surprising revelation in this table is that the main effect is only significant, and of the wrong sign, in the second year of the response window. In other words. using a public network in an innovation does not necessarily cause a high degree of responses by competitors. This is consistent with arguments made concerning the lack of ability of firms to respond to networked IT innovations. even if they had a high degree of computer and communications investments and even if the product was considered to be information intensive. Access to the technology does not appear to translate into ability to respond to competitors. This buys the initiating firm time to gain an advantage through the innovative use of the technology.

Finally. Table 6.18 summarizes the results of Hypothesis 6 regarding the extent to which an application integrated information from multiple business functions and organizations. The main effect of this term did not support the hypothesis: the sign was significant and indicated that competitive responses increased in the second year of the response window as the degree of knowledge integration of the application increased. Consequently. expanding the number of business functions in an application may be useful. but in general it will not impede competitors from responding. There were interaction effects discussed earlier that did support the hypothesized relationship. and these can be used to reduce the number of responses by competitors.

Table 6.24 summarizes the combined effects of all four categories of applications on the hypothesized relationships depicted in the research framework. Table 6.24 takes into account both the main and interaction effects that were found to be significant in the regression models. The reader is reminded that the regression models were shown in Tables 6.9 through 6.12. with the summarized results organized according to the hypotheses in Tables 6.13 through 6.19.

Table 6.24. Summary of the significant Main effects and Interaction Effects of the Four Application Categories on the Hypothesized Relationships of the Research Framework.

Type of effect	Summary of the findings – Influence on the number of responses from competitors
Main effect of industry-related factors	
Information intensity of the industry output	The main effect on competitive response is negative.
Demand volatility	The main effect on competitive response is positive.
Information complexity	The main effect is mixed. Responses per competitor appear to increase, while total overall number of responses appear to decrease.
Main effect of characteristics of the networked IT application	
Degree of innovation	The main effect on competitive response is positive. Competitors appear to respond vigorously to innovative applications, even within the first year.
Use of public networks	The main effect on competitive response is negative, and this appears only within the second year.
Degree of integration between business functions and firms	The main effect on competitive response is positive, but it doesn't appear until the second year.
Main effect according to the type of networked IT application	
Product innovation	Product innovations increase the response from competitors in the second year.
Service innovation	Service innovations decrease the response from competitors in both the first and second year.
Process innovation	Process innovations increase the response from competitors in both the first and second year.
Innovation extending beyond the firm's boundaries	Innovations extending beyond the firm's boundaries increase the response from competitors in both the first and second year.

Table 6.24. (continued)

Interaction effects according to the type of networked IT application	
Product innovation	Product innovations in an information-intensive industry increase the response from competitors in both the first and second year. Product innovations based on the use of the public network encourage response from competitors in both the first and second year. Product innovations that involve a high degree of innovation appear to impede responses in the second year. Product innovations that involve a high degree of integration impede responses in the first year, but responses increase in the second year. The results suggest that these applications of networked IT might be difficult for competitors to respond to, unless the competitors have the necessary resources and capabilities due to industry characteristics and the use of public networks.
Service innovation	Service innovations increase the response from competitors if they are highly innovative, possibly due to the publicity and attention that they receive. Service innovations that involve a high degree of integration impede responses in the first year, but responses increase in the second year. Service innovations reduce the response from competitors as the information complexity of the industry increases, possibly due to incompatibilities between the embedded base of equipment and that used in the innovative application.
Process innovation	Process innovations appear to increase response from competitors if they occur in information-intensive industries or if they make use of the public network. Process innovations appear to impede response from competitors in conditions of high demand volatility or when the industry has an accumulation of IT resources. Process innovations appear to impede response from competitors as their degree of innovation increases, and as they integrate information from multiple business functions and entities. The internal process nature of the innovations appears to prevent competitors from responding easily, except if they are already familiar with such processes due to the information-intensive nature of their work.

Table 6.24 (continued)

Interaction effects according to the type of networked IT application	
Innovation extending beyond the firm's boundaries	In several situations, innovations extending beyond the boundaries of the firm encourage response from competitors, even within the first year. This is particularly true if public networks are used as an important element of the application, if the industry has an accumulation of IT resources, and if the environment is characterized by demand volatility. Highly innovative applications that extend beyond the firm's boundaries appear to impede the response from competitors in the first year, but they encourage the response in the second year.

Based on the results summarized in Table 6.24, it appears that the firm may be able to implement networked IT applications that are more likely to sustain a competitive advantage. One way to achieve this goal is to provide innovative services, and the other is to provide innovative processes internal to the firm's operations. In the case of the service innovations, a firm would want to exploit the situation when both the main effect and the interaction terms are impeding responses from competitors. The main effects have a negative influence, and this can be enhanced by increasing the business functions and entities interconnected by the application. However, highly innovative applications are more likely to receive responses from competitors.

In the case of the process innovations, it appears to be possible to offset the main positive influence of the process innovations with the negative influence of process innovations and other characteristics as revealed in the interaction terms. The goal would be to develop applications that innovate the firm's internal processes, but which do not capture the attention of competitors by being highly innovative.

In some situations, product innovations also appear to sustain a competitive advantage if they are highly innovative. The use of public networks, surprisingly, does not necessarily increase response from competitors. Therefore, they can be used to sustain a competitive advantage, especially when used to support service innovations in the firm.

This is especially meaningful, because the public networks can be used to extend the service innovations to the individual customer.

6.8 Summary

A multi-industry sample of data representing the actions and responses that result from the strategic use of networked IT applications was constructed based on secondary data sources. Both the actions and responses were applications of networked IT which were described in published articles. There were a total of 124 action applications found that occurred within the time period from 1993 to 1994. There were a total of 513 response applications that occurred within a two-year sliding window from the date of the action. In addition to the application data, supplementary data were collected pertaining to industry-level and firm-level variables defined in the research framework.

Dummy variables were used to identify the applications as product innovations, service innovations, process innovations to the firm, or innovations that extended beyond the firm's boundaries. An individual application could be classified as more than one type of innovation. These dummy variables were used to assess the differences in competitive responses that might result from specific types of networked IT applications. Both main effects and interaction terms with the other hypothesized relationships in the model were tested.

The statistical analysis reveals that the hypothesized relationships do indeed vary depending on the nature of the innovation realized in the networked IT application. The hypotheses discussed in Chapter 3 did not explicitly define the interaction effects; nor were they excluded. Given the definition of the strategic networked IT applications, including product, service, or process innovations, and the fact that innovations could extend beyond the firm's boundaries, it was necessary to test for their influence on the results. Clearly, they produced a large impact on the results of the study. The findings reveal that the impact on competitive response is much more complex than originally believed to be the case in the original hypotheses, as it was necessary to take into account the type of innovation: product innovations, service innovations, internal process innovations, and innovations that extended beyond the firm's boundaries. Some patterns of responses supported the hypotheses while others did not. The hypothesized relationships provided a structure in which to explore the effects that were brought to light by the dummy variables that identified the four types of networked IT applications.

The statistical support that was found within the models did not necessarily exist in the main effects terms of the measures pertaining to the hypothesized relationships. Rather, the support may exist in the interaction terms with the dummy variables for the application categories. When the interaction terms are statistically significant, it is not valid to analyze the main effects terms separately from the interaction terms, so the assessment of the hypothesized relationships must take into account all terms pertaining to the hypothesized factor. Of the original hypotheses, the only ones not supported in any model are the interaction effects that pertained to network compatibility associated with the factors represented by the other hypotheses (Hypothesis 5 interaction effects regarding compatibility with existing networks as indicated by the use of public networks). These results appear to reveal a great deal of insight into the different types of influences associated with different types of applications.

The results of the statistical analysis reveal that there are many opportunities for refining the model and proposing directions for future research. We turn now to Chapter 7 for additional discussion of these results.

CHAPTER 7: DISCUSSION OF RESULTS

This chapter begins with a discussion of the overall findings, rationale, and implications of the findings in order to consider plausible explanations for the results and to assess what has been learned from this study. Following this, there is a discussion of the sample and measurement issues that may have an impact on the results. The overall findings will then be discussed in the context of the theoretical streams of research presented in Chapter 2, including comments regarding potential contributions of this research to the theories of the resource based view, diffusion of innovations, and competitive response. Finally, the chapter will conclude with recommendations for refining and building on the work initiated by this study.

7.1 Overall findings and implications of the results

The research results presented in Chapter 6 included relationships that were in support of the hypotheses as well as many unexpected trends. Beyond the data and sample issues, which are discussed in the following section of this chapter, it is valuable to explore the rationale for why certain findings were observed. The study was guided by the research framework presented in Chapter 3 that formed the basis for the hypothesized relationships that accounted for incentives for competitors to respond to strategic actions, as well as factors that would impede such response. However, it was clear from Chapter 6 that the analysis of the hypothesized relationships had to take into account specific differences regarding the ways in which the technology was used.

The research began with a definition of *strategic networked IT application as resulting in product, service, or process innovations that affected the firm's core business processes.* This concept of strategic networked IT was consistent with definitions in the literature which lumped these applications together, under the category of 'strategic,' because they were intended to improve the firm's competitiveness through increased effectiveness and efficiency. This research revealed, however, that there are many differences in the way in which these different types of applications impact the competitive response of rivals. The advantage gained by a firm in deploying its information technology is believed to be improved the longer that competitors are unable to respond. Therefore, the differences in response behavior suggest the differences in the extent to which these applications convey a competitive advantage to the firm.

The definition of strategic networked IT applications led to the need to assess the effects of four types of innovations supported by IT: product, service, or process innovations, and innovations that extend beyond the firm's boundaries. We now explore the rationale for the action and the response in each of these scenarios in an attempt to explain the variation in responses observed that were dependent on the type of application.

The results found pertaining to the case of each individual type of networked IT application must be considered in combination with the general relationships found for the overall hypothesized terms: a) the degree of output information intensity reduced competitive responses (contradicting H1 in the general case); b) the demand uncertainty in the environment increased the likelihood of response (supporting H2 in the general case); c) the degree of information complexity in the environment produced mixed results (no support for H3 in the general case); d) the degree of innovation of the IT application in general increased the response of competitors (contradicting H4 in the general case); e) the use of public networks as a key element of the application had an insignificant impact on competitive responses in the first year, and a negative impact on competitive responses in the second year (contradicting H5); and f) the extent to which applications integrated knowledge across a large number of business functions and organizations had an insignificant impact on response in the first year, and it served to increase responses in the second year (contradicting H6). The explanation for each of these general trends is that the general relationships must be considered in combination with the interaction effects, described below for each of the four types of innovative networked IT applications. When the trends described below contradict the general relationship, the effects tend to cancel each other out. When the relationships are of the same sign, then that influence on the competitive response is heightened.

7.1.1 Networked IT applications to support product innovations

Networked IT applications that support product innovations are cited in the literature as classic ways to exploit information technology. The concept is to 'informate' the product (Zuboff, 1988) with information that is a by-product of other processes and to create 'virtual products' that are customized and which meet immediate and fluctuating consumer demands (Davidow and Malone, 1992; Pine, 1993). These are classic strategic market moves where firms re-define products, create new markets, or move into new competitive markets by exploiting their information technology.

The results of these product innovations are easily visible to competitors because the products must be advertised and sold. Consequently, competitors are able to assess the value that consumers derive from the product innovations, and they can attempt to duplicate them in their own products. Firms that have experience manufacturing products that are already information intensive appear to be readily able to respond, and to do so quickly.

Competitors appeared to require more than one year to respond to product innovations if the environment had a high degree of uncertainty or if their industry had a high degree of embedded automation. The delay associated with demand uncertainty in the industry may occur due to competitors waiting to understand the actual value that customers derive from the innovation, given the pattern of demand fluctuation already in the environment. The embedded automation in the environment would be used to process large quantities of information efficiently. Product innovation, however, may require very different types of uses of the information technology, where throughput is not necessarily the most important role of the technology, especially if it is intended to customize products for customers. Alternatively, in industries with a high degree of embedded automation, the delay in response may be due to competitors undertaking more complex responses that require additional time to be implemented. This still provides the initiating firm a greater period of time before which the response is realized, but it may indicate that the responses, if they occur after the two year window, may be more powerful IT applications. The degree of innovation also appeared to thwart the competitive response to some degree.

The use of the public network to support product innovations appeared to enhance competitive response. This is likely due to the increased direct access that firms had to customers if they used the public network, and the increased ease that competitors would have in deploying its own similar product innovations. This is a classic example of network effects, where firms are driven to 'jump on the bandwagon' to get a piece of the action as an industry might undergo a strategic transformation if the product innovations become institutionalized.

The extent to which the product innovation was used to integrate information from multiple business functions and organizations appeared to create a modest barrier to response as it delayed competitive response for only one year. After that period of time, during which competitors could learn about the value of the innovation as well as how to respond to it, the degree of innovation increased the response seen from competitors.

From a strategic standpoint, it appears that firms can achieve an advantage over competitors if they use IT to innovate products in industries that are not historically information intensive.

In terms of the hypothesized relationships, when the strategic networked IT application supported a product innovation, there appeared to be support for hypotheses H1, H4, and H5, and support for H6 only in the first year of the response window. Hypotheses H2 and H3 were not supported, and H6 was not supported in the second year of the response window. Recall that Table 6.7 summarized the hypothesized relationships.

7.1.2 Networked IT applications to support service innovations

Products and services are frequently lumped together when discussing the outputs that firms sell to consumers. However, significant and unexpected results of this study suggest that competitive responses to service innovations implemented through networked IT resources are very different than responses to product innovations. This finding may shed more light on further research regarding distinctions between products and services. Service innovations provide firms with opportunities to exploit information to enhance the value that they provide to customers; however, unlike the IT applications that supported product innovations, the service-related IT generate a different likelihood of response from competitors. In general, service innovations do not illicit the degree of competitive response from rivals that product innovations do.

The firm can provide a service that meets the instantaneous and customized demand of the buyer. Service innovations are basically created by re-packaging the firm's information in a way that is valuable to the customer. The firm, for instance, may provide service to customers by assisting them in using products that they purchased previously, by providing supplementary service such as information about a package delivery, by helping analyze financial transactions, by locating them if they are lost in a rental car, or by acting as a distributor and easing the task of buying goods that are manufactured by other firms.

While the value of a particular service is known to the consumer, that value is not readily observable by competitors. Service innovations, for instance, can range from being available at all times to handle a customer's financial transactions, in which case availability is the value sought by the customer, or the service innovation may involve a personalized analysis of the customer's investment history in order to recommend future financial investments. The extent to which information systems are used in the first example are very different from how they are used in the second to provide the innovative service. It is the uncertainty in knowing where the customer derives value that can be a source of limiting the responses by competitors.

The variety inherent in the type of service innovations can also require that the responding firm adapt more of its own organizational processes in order to implement a response. It isn't only manufacturing processes that are involved, for instance, but it may involve its own integration of organizational capabilities to provide the value demanded by consumers. This would create a barrier to response that could be overcome by sufficient development, but which would allow the initiating firm the opportunity to gain an advantage.

If a service innovation is highly innovative and captures the attention of competitors, however, it is likely to receive a response within the first year. This is possibly due to the perception that the highly innovative application may be signaling a strategic change in the industry, and thus it is necessary to respond as quickly as possible in order to share in even a brief competitive advantage.

In terms of the hypothesized relationships, when the strategic networked IT application supported a service innovation, there appeared to be limited support only for hypothesis H6, in the first year of the response window, which pertained to the responses being impeded due to the degree of knowledge integration of the initial application. Firms, therefore, appear to have the opportunity to use networked IT to support service innovations in a wide variety of environmental settings in order to create a sustainable competitive advantage . The goal would be to structure the innovation so that they do not capture extensive attention from competitors due to their degree of innovation.

7.1.3 Networked IT applications to support process innovations

Strategic networked IT applications to support process innovations dealt with the use of the technology within internal tasks that were associated with the firm's core products. This study did not assess competitive behavior associated with administrative or technical processes, such as the installation of a new billing system or the installation of a new type of networking technology for the sake of the technology alone. The processes included in this study related to internal tasks that were an important element of the firm's value chain and core business tasks.

Process innovations relying on networked IT have traditionally been applications that improve the information processing, coordination, and control activities of the firm (Chandler, 1977). The use of IT has been touted for many years as a means for firms to 'compete in time' (Keen, 1988). For instance, global financial markets rely on the speed and scope of information technology networks in order to cope with the transaction load that is required for doing business. The process innovations also enable the firm to store, retrieve, and analyze large quantities of data, which can lead to later product and service innovations.

The main effect of process innovations was to increase response from competitors, and the output information intensity of the industry further increased such response. This is consistent with the expectation that in industries where the outputs and processes are highly information-intensive, the strategic value of using IT is high and therefore competitors are likely to respond.

While the overall effect of process innovations was to increase the response from competitors, there were many scenarios when the response was reduced. High degrees of environmental demand uncertainty reduced the response of competitors. This could be due to the difficulty in optimizing systems for throughput speed as well as demand flexibility. In industries with a large base of computer and communications equipment, total responses increased. However, responses per competitor actually decreased. This suggests that, as the raw number of key competitors increased, the number of key competitors who were capable of responding did not increase. This implies that there are other organizational capabilities or factors which prevented the competitors from responding, and that the knowledge of how to respond did not diffuse rapidly through an industry.

The factors that were expected to ease or impede response displayed relationships that were largely expected. The degree of innovation of the process innovation appeared to impede the response of competitors, as did the extent to which the innovation integrated knowledge across multiple business functions and organizations or entities. In addition, the use of the public network to support the process appeared to encourage competitive response.

In terms of the hypothesized relationships, when the strategic networked IT application supported a process innovation, there was support for H1, H4, H5, H6, and mixed support for H3. There was no support for H2. For firms seeking to sustain a competitive advantage when they use networked IT to support process innovations, they must attempt to do so by developing highly innovative processes that integrate several business functions and entities. However, competitors are more likely to respond to innovative processes as the output information intensity of the industry increases.

7.1.4 Networked IT applications to support innovations that extend beyond the firm's boundaries

In this research, innovations extending beyond the firm's boundaries are coupled with one of the other types of innovative uses of networked IT: product, service or process. The innovations that extend beyond the firm's boundaries typically capitalize on public telecommunications networks that are available to the firm on a usage-based cost, rather than a capital investment cost. Therefore, the resource is readily accessible to firms of all sizes as there is no significant financial barrier to the technology.

Innovations that extend beyond the firm's boundaries are highly visible to competitors because they occur outside of the firm. The main effect of these innovations is to increase the response from competitors. The output information intensity, however, had no role in the competitive response, possibly due to the vast array of applications for which innovations extend beyond the firm's boundaries. As expected in this case, the networked IT resources are being used largely to extend the geographic scope of the firm, and not necessarily to exploit the output information content of its goods.

The degree of innovation of the application appeared to diminish some competitive response only in the first year. After that, it appears that competitors learned how to respond, or learned the value of the application, and were intent upon developing their own applications.

In terms of the hypothesized relationships, when the strategic networked IT application supported innovations that extend beyond the firm's boundaries, there was some support for H2, H3, and H5, and H4 only in the first year. The findings contradicted the hypothesized results for H6, and for H4 after the first year.

Let us now examine sample related issues that may be influencing the results of this work.

7.2 Sample-related issues that have an impact on the results

The sample of the networked IT applications that form the basis for this research is an important consideration with regard to the impact that it has on the rivalrous responses observed. The firms in the sample are listed in Table 6.3, and the industries in the sample are listed in Table 6.4. The generalizability of the research results is dependent on the representativeness of the sample. The extent to which results can be generalized is limited by the industries and types of firms in the sample.

The size of the sample contained 124 action cases from 109 firms. These actions were not trials, tests, nor public announcements for planned uses of the technology; they represented operational IT systems deployed by the firms to support its commercial tasks. The accuracy of the action cases, as truly representing operational systems, was not tested independently. Rather, the accuracy was accepted since these sources are considered to be credible accounts of the use of information technology as they serve as trade-related news publications. The integrity of the sources is based on their track record in publishing truthful accounts of information.

The strategic networked IT applications that resulted in product, service or process innovations that affect the firm's core business processes represent the organizational capabilities of firms to use information technology to enhance their effectiveness and efficiency in doing business. The responses are also organizational capabilities to deploy the technology; thus the action-response behavior that is observed is considered to be a capabilities-based rivalry that occurred in the industries represented by the firms in this sample.

The sample size used in this study is comparable to that of other similar academic studies. The sample size appeared to be adequate for the statistical techniques used, and there were no unusual outliers that appeared to skew the data. The data pooling, in terms of categorizing the cases and firms into the appropriate industries, was defined based on the firm's primary Standard Industrial Classification (SIC) code. The exception to this is when a case was associated with a subsidiary market that could be distinguished by a separate SIC code. In that case, the case was classified by the SIC code which applied to its market. The correspondence between the SIC codes and the BEA industry classifications was easily accomplished by reviewing the list of SIC codes and titles. The titles of the BEA industry classifications correspond to SIC codes; they just do not have the same degree of granularity. It is noteworthy that the BEA industry classification for electrical machinery and equipment corresponds to the 3-digit SIC code for this industry.

In addition, there is only one BEA industry classification for all wholesale trade, as well as only one for all retail trade. In a similar manner, the correspondence between the BEA industry classifications and the output information intensity categories was accomplished by association of the industry name. Consequently, the pooling of the cases into industries is driven fundamentally by the product market SIC code for the case describing the networked IT application.

The sample is not drawn from a random distribution of firms in the U.S. economy, but rather it consists only of U.S.-based firms with networked IT applications that were described in published cases that were found in the sources available for this research. Consequently, while all firms with action cases in the sample met the definition for innovative use of networked IT within the designated time frame, they do not necessarily represent all firms in the economy.

The sample covers many industries of the U.S. economy, but there are also several omissions. Of the 61 industries that the BEA classifies for the U.S. economy, shown earlier in Table 4.1, only 32 industries were represented in the sample. Therefore, the generalizability of the results may only be valid for the 32 industries that were represented in this study. The sample did not contain any cases from firms in the following sectors and industries: agriculture, mining and construction sectors; durable goods manufacturing sector – the lumber, furniture, and stone industry classifications; non-durable goods manufacturing sector – the tobacco, textile, apparel, paper, and leather industries; transportation sector – the local passenger transport and pipeline industries; communications sector – the radio and TV industry; public utilities sector: the sanitary services industry; financial trade sector – the federal reserve bank, credit agency, and insurance agent industries; personal services sector – the personal service industry; business service sector – the miscellaneous repair service sector; and miscellaneous service sector – the legal and educational industries.

The industries included in this study are those which were reported on in the professional and technical trade journals that served as the sources of the data. This places considerable emphasis on the journalistic reporting of the applications. Although the control for this factor was tested and found to be insignificant in this research, journalistic biases may still exist. Applications that support the firm's internal processes and which are not visible from outside the firm may not be reported on extensively. This sample, however, seems to cover such applications well, as 82 percent of the action applications were classified as supporting a firm's internal processes. Also recall from Table 6.2.a. that 20 percent of the applications in the sample supported product innovations, 27 percent supported service innovations, and 34 percent supported innovations that extended beyond the firm's boundaries. Applications which are perceived as being common place with firms in a particular industry also may not receive significant attention, so the reporting of their responses may be limited. Other applications or responses may not be highly publicized, even if they are known within industry circles through conferences and trade shows. On the other hand, the journalists who write for the networking industry are quite knowledgeable of the technical and business fields. By focusing on such publications, the quality of the information is very detailed, accurate, and reliable. This use of "secondary case-based data" avoids the problem of personal biases creeping into case data when only one researcher is involved in data collection, interpretation, and analysis, in spite of all attempts to minimize such biases.

The response data is another important consideration in the analysis of the results. Chapter 3 discussed many problematic issues pertaining to the public disclosure of responses and the assessment of a competitive advantage based on that disclosure. There are two different effects that can distort the dependent variable in this research. First, there are likely to be fewer responses observed in the sample than actually occur. This is caused by the fact that there is not public disclosure of all responses, due to corporate secrecy on one hand, or due to lack of interest in reporting on the responses. In the case of firms acting to preserve corporate secrecy, these are likely to be very early responders who do not want competitors to know of their actions. In the case of lack of interest in reporting on the application, there is possibly less attention in the trade press devoted to firms which are one of the later responders to an earlier innovation. In addition, there may be some firms that journalists do not monitor at all. Both of these situations serve to reduce competitive responses observed, which raises the likelihood that Hypotheses 4 and 6 would be supported, and that Hypotheses 1, 2, 3, and 5 would be rejected.

Second, the time period between the action and the response may actually be less than what is reported in the results, which again serves to reduce the number of responses observed in a given response window in the data analysis periods. Again, the reduction in responses would increase the likelihood that Hypotheses 4 and 6 would be supported, since these were the only two that proposed that the factors of interest would have a negative influence on the number of responses from competitors, and that Hypotheses 1, 2, 3, and 5 would be rejected.

Based on the summaries of the hypothesis testing, it appears that the data sample has presented a conservative view of competitive response to organizations using networked IT to gain a competitive advantage. If one only examines the main effects terms representing the hypothesized relationships, Hypotheses 1, 4, 5 and 6 were rejected. Therefore, the data sample is not fueling unwarranted support for the hypotheses. There was support for these hypotheses within the interaction terms categorizing the type of innovation carried out with the networked IT application.

7.3 Measurement-related issues that have an impact on the results

Chapter 5 discussed many measurement-related issues associated with the variables representing the constructs for the proposed relationships. The measurement issues revolved largely around the appropriateness of the definition of a firm's industry as an indicator of its competitive environment, and the assessment of characteristics of the networked IT application.

Regarding the industry-level data used to represent constructs of demand uncertainty and information complexity in the competitive environment, the reliability of this objective data is quite high. The question is the definition of the industry and the representativeness of the data. It may be argued that the industry classification by the BEA is too broad, and therefore does not measure the firm's true environmental uncertainty accurately. As discussed extensively in Chapter 5, the specificity of the environmental measures is open for debate. On one hand, no industry classification will perfectly match a firm's actual task environment as it is unique from that of other firms. Also to be considered is the evolution of industries and the blurring of industry boundaries. For instance, banks, securities dealers and insurance carriers frequently compete against each other, which spans at least three distinct industry classifications recognized by the BEA. The intent of the environmental measures in this research were to assess differences across a wide range of industries regarding the varying information demand levels that firms faced; these were the demands of uncertainty and information complexity, which required that the firm adapt its processes flexibly to varying demand conditions, and that it process vast amounts of information rapidly. The use of the environmental data in this study was based on the assumption that within an industry defined by the BEA, the information demands of the industry are reasonable proxies for the information demands facing specific firms in the industry. In particular, the data on the output volatility and level of investment in computer and communications capital within a BEA industry classification generally reflect the information demands facing firms in that industry.

The alternative to using objective environmental information from external sources is to collect subjective data from the firm. The result, then, is not an industry-level account of the environmental conditions, but the perception of each individual firm. The data on demand uncertainty appears to be better than any alternative perceptual measure. The perceptual measures suffer from significant problems, and it is not possible to say with certainty whether or not the data used as an indicator for the environmental construct in this research over- or under-inflate the true degree of environmental demand uncertainty facing the firms in the industry.

The data on information complexity of the competitive environment were first described in Chapter 3, with later discussion in Chapters 4 and 5. These data represent very conservative measures because they include only hardware investments over a five-year period. This five-year period was matched to the five-year period over which demand uncertainty was measured. It is also reasonable to expect that this is the appropriate investment time frame for firms that used the technology to implement working applications in 1993 through 1994, with responses spanning a two-year window following the application. The data are under estimates of the actual information demands because they do not include software, training, and related investments that are required as well. Furthermore, this measure does not indicate what specifically was purchased and how it was configured. The degree to which a firm can rapidly adapt its technology purchased in a five year period to respond to a newly revealed action by a competitor depends a great deal on how the firm can re-configure the systems, while at the same time still support its ongoing processes. It is reasonable to assume that with a large investment in IT, the firm has some experience with the technology, and the technology has proven to be valuable in that specific industry. However, as the results indicated, there still may be other factors that prevent the firm from responding even if it is motivated to do so based on the value of the technology. As a conservative indicator of information complexity, this measure increases the likelihood that Hypothesis 3 would be rejected. The main effects reported for the variable used to test Hypothesis 3 exhibited mixed results, which could be interpreted as only marginal support for the hypothesis. It is possible, therefore, that if more accurate data were available, then Hypothesis 3 would have been supported to a greater degree.

The characteristics of the firm's networked IT applications are encoded in the sample based on information obtained solely from the article describing the application. The reliability of the encoding technique was reported earlier in Table 6.6. However, the assessment of the application's innovation and integration score are more likely to be very conservative values as compared to the actual situation. For instance, regarding the extent to which the application integrated multiple business functions and entities, the author of the article probably only described the most interesting or important functions that were linked by the application. This would result in a deflated integration score. Similarly, the degree of innovation is likely to be a conservative account, since the firm might have had incremental developments leading to the innovation that were not alluded to in the article. Both of these situations result in lower innovation and integration scores for a given number of responses, making it appear easier to respond to the action that in fact is the case. The result is that Hypotheses 4 and 6 are more likely to be rejected with these conservative measures. Had the measures been more accurate estimates of the true degree of innovation and knowledge integration of the application. Hypotheses 4 and 6 might possibly have received greater support.

Overall, the measures employed for this research appear to be conservative indicators of the rivalry that occurs due to factors in the competitive environment as well as factors associated with characteristics of the networked IT innovation. It is preferable to have this type of error, as compared to measures which are more likely to provide greater support for the hypotheses than is, in fact, the case. Let us now return to the theoretical issues to assess the results according to the initial foundations that support this research.

7.4 Omitted measure: economic value of the action application

An aspect closely related to the measurement issue is that of omitted measures. This research did not attempt to measure the economic value, effectiveness, or impact of the action application. Its strategic value was implied through the industry-related measures of output information intensity, environmental uncertainty, and environmental information complexity. One may argue, therefore, that perhaps competitors did not respond to an action because it had very low economic value, impact, or effectiveness.

There is enormous difficulty in assessing economic value of IT applications, and for that reason the value of the application in this research was implied through the industry factors. Claims regarding the economic value of an IT innovation are suspect for several reasons. First, it is widely reported that when a firm planned an information system, they frequently intended to accomplish something other that the end result. For instance, a system intended to process calls and reduce the time that sales representatives spend on each call with a customer actually resulted in the agents spending more time encouraging customers to buy products. The end result was that the system was successful because the yield on sales calls increased from 20 percent to over 70 percent. However, this was not expected. If the system had been evaluated on the intended goal to reduce the time per sales call, the system would be considered a failure.

Secondly, how one judges the impact of a system is very subjective. Each of the applications in this study already had a positive impact on the firm initiating them, in that they were systems that were contributing to the firm's operations, capabilities, and general work processes. Some applications also had an impact on the industry or created a new industry. However, such an impact was not necessarily foreseen at the inception of the application. The evidence of this impact was seen not in the application itself, but in the responses from competitors that turned it into an institutionalized event across the industry, changing the way business was conducted.

Third, assessing an economic value of an IT application is frequently criticized because of the lack of construct validity between the IT application and the impact being observed in the end. This is especially true when financial measures such as firm profitability or market share are used as indicators of value. The trouble with these indicators is that so many other factors also contribute to their outcome, it is difficult to imagine that the primary result is attributable to the IT application. Even measures such as return on investment for an IT application must be scrutinized. Questions arise regarding how to account for both initial and recurring costs, such as training and software upgrades, in the cost of the system, or are these considered general operational expenses. Furthermore, the initial purchases of equipment, software, and personnel costs are difficult to track because they may be justified under vastly different budget categories, ranging from R&D investments to personnel costs.

Fourth, another important question to consider when assessing the impact of IT applications concerns what effect one is considering: the first-order effect of the system, or second- and third-order effects that are unexpected but often arise. For instance, as a firm integrated IT more heavily into its other processes, those processes and the organization overall adapt and exploit the use of IT. Work methods change, communications change, and the role of workers changes. There are all impacts of the IT application that are important to consider when assessing its value.

The issues raised in this section are common challenges when dealing with IT. For this reason, the approach taken in this research was not to assess economic value directly, but rather look at the *potential value* of the technology implied by the characteristics of the industry's output, and the information demands in the competitive environment.

Since the economic value of the IT action was not measured explicitly, the response variable was used to indicate, in a limited sense, the strategic value of an action. The interpretation of the response must be qualified: lack of response could indicate that the application was valuable, in that the initial firm would have a longer period of time in which to gain a competitive advantage. However, one can argue that lack of response can indicate that the IT application was as waste of resources and therefore had little value. This qualification must be kept in mind throughout the interpretation of the results, because we do not know which is the true case. For that reason, the industry-related variables were used to suggest the cases in which IT applications were likely to be valuable. However, we do not know its value with certainty.

7.5 Theoretical assessment of the results

The trends revealed by the statistical analysis suggest many areas for further discussion that are prompted by the initial theoretical foundation of this research. This section will review the relevance to the literature. A later section in this chapter will make specific recommendations for further areas of research that stem from these theoretical observations.

The results summarized in Chapter 6, in Tables 6.20 through 6.23, in particular, are a first step in addressing the call for more application-level research as suggested by the National Research Council (1994). The results provide us with considerably more information now, than at the start of this research, regarding the innovative and strategic uses of the technology, the impact of the competitive environment, and the impact of characteristics of the applications on the response of rivals. The discussion continues in this section by following the parallel discussion of the literature streams that were presented originally in Chapter 2.

7.5.1 Results relevant to strategic resources and capabilities

The results of this research indicate factors that increase or decrease competitive responses associated with a firm's use of networked IT. Given that the responses have an impact on the advantage associated with the use of the technology, it appears that the firm's ability to deploy networked IT is part of its strategic resources and organizational capabilities.

The characteristics of the applications influenced the response of competitors, though not always in the ways expected. Barney's (1991) initial suggestion that strategic resources are valuable, rare, socially complex, and causally ambiguous were the foundation for this discussion, which were then extended to include the firm's organizational capabilities for conducting its tasks (Collis, 1994; Grant, 1996a). The social complexity and causal ambiguity of the networked IT resources were associated with the firm's tacit know-how to use IT so as to integrate knowledge in complex ways within the organization as well as with other organizations. The results regarding the strategic influence of socially complex and ambiguous processes, such as the innovative uses of networked IT that were the focus of this research, provided only limited support for the theoretical arguments of the resource based view and characteristics of resources that might be able to sustain a competitive advantage. However, the results are valuable in that they provide one of the first assessments of the strategic use of networked IT.

The results suggest that the complexity and perceived ambiguity of the application do not necessarily impede responses from competitors. The rival firms were in many cases more likely to respond to highly innovative applications, even if they integrated knowledge across many business functions and among many distinct entities or organizations. The reason for this situation is not revealed in the research, and might therefore be an appropriate area of future investigation.

Perhaps an interpretation that is important to consider here is the proposal by Helfat (1994) that a firm's incremental innovations that are tightly interwoven with the firm's existing resources and processes provide it with the ability to appropriate value from the innovation in a way that is unique to its firm. By developing IT applications that may be regarded more as incremental innovations, the firm is able to integrate the application into its own unique organizational processes which will allow it to appropriate value and limit the attention that it attracts from competitors.

These results suggest that the theory of strategic resources and organizational capabilities could be refined to acknowledge how value is created through combined uses of the firm's resources. Specific integration of IT and non-IT related resources is likely to be a factor driving the results in this research, as the results varied considerably in terms of the use of the resource. The combined use of resources also appears to be dependent on factors that correspond to the characteristics of the products and services produced by the firm, as well as the ability of the firm to extend its influence beyond its borders. These product, service, and scope related factors also appear to have an important impact on the strategic nature of the resources, which deserves further study.

7.5.2 Results relevant to the information demands in the competitive environment

The firm's competitive environment creates information demands and opportunities for firms to exploit the capabilities of networked IT. The results suggest that based on the argument that these capabilities are useful in the context of high information demands on the firm, one would expect a greater degree of competitive response since the value of the technology is higher under these conditions. In particular, in the conditions of high demand volatility and information complexity, networked IT can be used to provide flexibility to adapt to the changing conditions as well as the speed and coordination capabilities necessary to process large amounts of information from a wide variety of sources. This research represents the first attempt to quantify the information demands of the environment in an objective way, and therefore provide insight into an area that had been largely neglected in prior research.

The research assessed the competitors' actual responses enacted through the use of networked IT. Consequently, data only entered into the dependent variable of the models once a firm was successful in deploying the IT resources. Based on the results of the research, it appears necessary to distinguish more carefully between the value of responding versus the firm's organizational capabilities to realize a response to an innovation carried out by another firm. The value in responding to a competitor's innovation is based largely on market issues, such as opportunities for growth, serving new customers, establishing new market niches, meeting customer demand, and limiting the strategic advantage of competitors. This research did not differentiate between the different strategic value in responding to one innovation as compared to another. The value may even be firm specific. where it makes more sense for a specific firm to respond and not others. In that case, the choice that some firms make *not* to deploy an IT application may be their most appropriate strategic response. The responses were treated identically. except for identifying the fact that they were a response. Similarly. the innovative actions were treated largely the same. Perhaps some actions warrant different types of responses. This research did not explore this issue. In future research. it may be appropriate to revisit this aspect of action-response behavior and how it may affect the resulting rivalry.

The firm's organizational capabilities also affect the actual responses observe. The model was based on a firm's motivation to respond. and then characteristics of the innovative action that may have a bearing on competitors' likelihood of response. However. there may be factors associated with organizational aspects of the responding firm that may also have an impact on the likelihood of response. For instance. in the case of high information demands created by the degree of automation in the industry. some results showed a negative correlation to the number of responses from competitors as opposed to the positive relationship that was proposed. It is highly likely that this indicates that some IT equipment investments required for the existing operations were not easily adaptable to respond to innovative uses. To some this is an assumption that is taken for granted. but this research provided some quantitative evidence to support this assumption. Another explanation for such a result is that these investments were already being used to full capacity to support the existing applications and the firm could not free up additional resources in an attempt to respond immediately.

The organization's capability to respond can also be driven by the cost to respond as well as the organizational knowledge required. In the case of the adaptability of the existing computer and communications equipment. for instance, the cost associated with responding to an innovation possibly includes the need to acquire new equipment. adapt processes. and keep the existing systems running while implementing the new systems in response to the initial action. These costs are associated with the information demands of the environment. because the firm cannot just stop its current operations in order to design new ones in response to a competitor's actions. In addition, unlike other types of innovations, the firm cannot build a new plant with a new set of information technology and just close the old plant when it is ready to adopt the new technology. With information technology, the IT systems are integrated into the tactical and strategic business functions that occur daily in the firm, and they cannot be separated from these functions when a firm implements a new generation of IT resources. While a firm in such a position may be motivated to respond, it may not be able to realize the response as quickly due to these organizational factors associated with the demand for ongoing information processing.

The results also indicated that a great deal of variation occurs in competitors' responses based on the type of application that was supported by the networked IT. This research did not distinguish between environmental conditions where different types of applications would be more valuable, such as process innovations versus product innovations. Process innovations are likely to be of value to the firm if they streamline the control and coordination of the firm's tasks and increase the overall throughput of its systems. Product and service innovations are likely to be of value to the firm as they exploit the IT resources to increase customer value and ultimately be a source of revenue generation. These distinctions between processing versus exploiting information were described by Zuboff (1988). They introduce the notion of fit and congruency with the competitive environment, a subject which is closely related to the work of organizational theorists on the firm as an information-processing entity. The added dimension now is the element of exploiting information. This area deserves further investigation in future research.

7.5.3 Results relevant to the output information intensity

The industry output information intensity was an assessment associated with theoretical arguments that stemmed from both the strategy and the IT literature. It had been suggested that when a firm's products were information intensive, there were greater opportunities to exploit the benefits of networked IT (Porter and Millar, 1985; Jarvenpaa and Ives, 1990; Swanson, 1994). While the environment may create opportunities for the firms to exploit the capabilities of networked IT resources, so do the characteristics of the actual products.

The results suggested that the way in which the networked IT is used along with the product is an important contributing factor when evaluating competitors' responses. The impact of the output information intensity on response was highly dependent on how the technology was used: within product, service, or process innovations, or innovations that extended beyond the firm's boundaries. It appears that the product characteristics play a significant role in determining which networked IT applications are most valuable.

7.5.4 Results relevant to the strategic role of networked IT

The IT literature frequently asserts that telecommunications and information technology have changed the nature of competition and have heightened the intensity of competition in many industries. However, there were no research results available regarding the specific ways that IT applications affected the response of competitors. This research provides considerable insight into this issue.

The results reveal that there is a great deal of variety in competitive response based on the characteristics of the applications and the competitive environments in which they are used. However, the responses are not necessarily thwarted by increased innovation and increased extent of knowledge integration realized through the application. In some cases, it appears that the increased degree of innovation of the application may signal to competitors that the action is worthy of their attention and therefore motivates them to respond with their own use of networked IT resources. In some cases, the firm's ability to integrate the technology in complex ways in its value chain impeded the responses by competitors, but not consistently in all cases.

The results suggest that less innovative applications may receive reduced attention by competitors, and consequently fewer responses. This issue was alluded to by the National Research Council (1994) when they reported that incremental changes can have important strategic and competitive results that might stem from tactical uses of networked IT such as innovative billing and logistics. It is highly likely that in these cases, the revelation of a firm's actions become apparent to competitors in incremental steps. thus creating 'strategic ambiguity' regarding the full extent and impact of the innovation.

The research results may also support the argument that not all investments in IT create a competitive advantage. The lack of a consistently positive influence associated with the embedded base of computer and communications capital equipment in an industry is perhaps an indication that prior investments may not have been valuable in responding to new competitive actions carried out by firms. This arises due to equipment incompatibilities with new technologies. Given the time frame of the research. it may result given a shift from the need to have private networks to the ability to use public networks. The use of public networks. such as the Internet for instance. would likely require different network access techniques and communication protocols. The conversion from 'legacy' systems of the older technology to the newer systems that were designed for accessing the public network could have created a competitive hurdle for some firms.

Finally. it is appropriate to acknowledge that some firms may have different response behavior patterns based on their own propensity to innovate or to follow in the adoption of new technology. Firms respond to information technology innovations at different rates. for strategic as well as technological reasons (Maier. Rainer and Snyder. 1997). Some firms are comfortable living on the 'bleeding edge of technology' and will aggressively introduce new IT innovations. while other firms may prefer the 'wait and see' approach and may even choose not to adopt a particular innovation in favor of leapfrogging to an alternative that is perceived to be better suited to their needs and for which the development of the technology has stabilized. Within this study there was no evidence of firms electing to wait to respond to an innovative IT application, but it should be acknowledged that this situation could occur and might be an element that is examined in future research.

7.5.5 Results relevant to the diffusion of innovative applications of networked IT

The diffusion of IT innovations is closely related to firms' propensity to adopt such innovations. The expected progression of the diffusion of innovations was observed only partially in the results. Innovations that extended beyond the firm's boundaries appear to receive a high degree of competitive response. Therefore they do not seem to warrant the high degree of innovation classification as suggested in Swanson's typology (1994) because they did not appear to be difficult for competitors to respond to, as suggested by Swanson. The results do provide evidence to support the argument that competitors could readily observe and therefore respond to product innovations (Damanpour and Evans, 1984). However, it appears that service innovations are more difficult to respond to than process innovations. The original argument regarding process innovations is that they are embedded within the firm's operations and are therefore difficult for competitors to observe (Damanpour and Evans, 1984; Pennings, 1987). However, networked IT applications that support service innovations may also be difficult to observe if they integrate various operations together within the firm in order to provide that service. The service innovations may also require extensive integration with organizational processes and structure, both on the part of the innovating firm as well as those responding. This can make it more difficult for firms to respond, which provides additional opportunities for the innovating firm to gain an advantage base on the use of its IT resources in this manner.

A refinement to the theories on the diffusion of innovations seems warranted based on the importance of the dependence of the innovation with other organizational processes and possibly the organizational structure. Although these were not formally studied in this research, the difference in competitive responses for service-related innovations in comparison to other innovations suggests that there are important elements internal to the firm that are affecting the diffusion of the innovations. These factors are not based on traditional impediments to diffusion, such as access to materials, financial hurdles, or other resource issues. These factors are related to how technology can be used to innovate the firms' processes, especially in terms of providing services to customers. Services, unlike products, do not come off of manufacturing lines or CAD systems; they essentially create value for the customer through some adaptation of information, in combination with the firm's other processes. Thus, the ability for the innovation to diffuse appears to be based simultaneously on technology, organizational processes, and customer demands.

This research did not show results similar to those observed by MacMillan, McCaffery and Van Wijk (1985) regarding organizational barriers that impeded firms' attempts to respond to easily imitated products. In fact, the opposite was true: firms seemed to be able to respond easily to the more highly innovative IT applications that supported product innovations, as well as those IT applications that extended beyond the firm's boundaries. There is some evidence, though, that organizational barriers explain some of the difficulty that competitors had in responding to highly innovative process applications of networked IT resources.

Perhaps a more important element of responding to innovations may have to do with the expected value of the innovation. If the value of an innovation is highly uncertain, then firms will wait to respond (Spatt and Sterbenz, 1985). If the value is known with more certainty, then firms are more likely to respond because they can assess their potential risks and benefits. Furthermore, what was once an innovation may become a requirement for operating in an industry (Dean and Snell, 1996; Hannan and McDowell, 1987). If firms anticipate this occurrence, they may choose to respond as quickly as possible in order to maximize whatever brief advantage that they can before it becomes institutionalized across the industry. This may address the reason why innovations that should cause competitors difficulty in responding actually received a high number of responses. If competitors can assess the value of an innovation accurately, and if they perceive that it will have such a large impact so as to change the way business is conducted, they may be willing to allocate organizational resources to respond to the innovation even if it is difficult to do so.

The effects of network externality (Katz and Shapiro, 1985) were not observed uniformly across all applications, but rather appeared to be moderated by the applications conducted with the network. The use of public networks in an innovative application did not necessarily increase the response from competitors. The main effect of the term was negative. Interaction effects indicated that the degree to which network externalities appeared to influence competitive response was determined in part by the type of innovation.

The most obvious case where the results supported the concept of network externality pertained to competitors' responses to applications that supported innovations extending beyond the firm's boundaries. The use of the public network in the original application was positively associated with increased competitive response. If it is true, as proposed by Swanson (1994), that innovations extending beyond the firm's boundaries are more highly innovative than other applications, then it appears that the benefits of network effects of the innovation outweighed the hurdle required due to organizational resources in responding to these innovations.

Variations in response due to the nature of the technology were not included in this research, but they may be important factors to consider in future research. For instance, the underlying telecommunications and networking technology used to support certain innovations may facilitate rapid response by competitors if the technology is based on stable standards, if it widely available as a network service, and if its use is widely understood and acknowledged in the industry. However, not all information technologies share the same degree of stability and acceptance. Firms that may be innovation leaders may choose to adopt innovations rapidly, and these firms may play a key role in the formation of the technology through participation in user-forums and standards organizations such as the Asynchronous Transfer Mode (ATM) User's Forum, ISDN User's Forum, ANSI or IEEE committees that develop networking standards. In addition to the degree of stability and acceptance of the underlying telecommunications and networking technology, the aggressiveness in vendors and consultants promoting specific IT solutions may also have an impact on the competitive response. While there was no evidence that a shortage in the availability in an underlying technology impeded competitive response, this may be a factor to consider in future research. In particular, international research in this area that may encompass regions where telecommunications and IT is not as accessible to all competitors should account for the impact of available technology.

7.5.6. Results relevant to competitive rivalry

The competitive rivalry literature suggested factors that motivated firms to respond to competitors' actions, given that they were aware of those actions and had the capabilities to respond (Chen and Miller, 1994; Chen, Smith and Grimm, 1992). Prior research had found that actions that were easy to respond to would be more likely to receive such response. Distributed actions were shown in prior research to receive fewer responses due to their reduced visibility and therefore ambiguity (Chen and Miller, 1994). However, the results in this research were not consistent with the prior research. The earlier research did not assess actions carried out specifically with networked IT, nor actions that relied on organizational capabilities to use technology that was readily available to competitors. The results found in this research suggest that even as networked IT applications are disperse in terms of their scope and business functions interconnected, competitors are likely to respond. The nature of the response was found to be much more complicated, and depended on the types of applications conducted. It was expected that 'distributed' implied geographic and functional distribution, and the integration of the firm's know-how across multiple business functions. However, this did not have the expected result of overwhelmingly lessening competitive response.

The research results found in this study suggest that an extension to the rivalry theory may be the notion of 'strategic distribution' as an alternative interpretation of 'distributed innovation.' The findings of this work suggest that firms would benefit if they could strategically disperse the components of the application, so as to give the appearance that they are engaging in a series of small operational tactical innovations, rather than in a larger strategic initiative. By distributing the apparent strategic activities of their networked IT applications, the firms would effectively disguise the overall strategic intent and impact of the application. This suggestion is consistent with the recommendation that firms deploy applications so that they appear to be very incremental in terms of their innovation, as the degree of innovation and the extent of knowledge integration are highly correlated. This reduces the apparent degree of innovation of the application, with the hope that it does not attract the attention of rivals.

7.6 Additional limitations of the study - not elsewhere classified

There are several limitations to this research. First, the reader is reminded of the earlier discussion in Chapter 7 pertaining to data and measurement issues, for they are one limiting element of the research. Also recall the discussion regarding the omission of a measure for the economic value of the IT actions in this study. Related to the information in Chapter 7, there were also discussions in Chapters 4 and 5 that pertained to measurement limitations. This included matters regarding the under-reporting of competitive responses, the representativeness of the sample, the industry classifications, the validity and reliability of the measures, and the extent to which the results can be generalized.

Secondly, the model specifies a narrowly defined form of rivalry; that enacted with networked IT. However, it is clear that the model does not reflect the firm's overall rivalrous behavior, nor its strategy carried out with its complete arsenal of strategic resources. Consequently, the measures of the model pertaining to the environment, the rivalry, knowledge integration, and innovation are specifically defined for the scope of this research. The model is only intended to examine how a firm uses its networked IT resources in a strategic way, and therefore it does not take into account the firm's more general use of other strategic resources. Similarly, the competitive rivalry that is studied is limited to only those actions and responses enacted through networked IT. In reality, a much wider scope of competitive rivalry takes place, including but not limited to corporate takeovers and legal action filed with the U.S. Department of Justice. These are only two examples of competitive moves that are excluded from this study.

Third, the model does not take into account firm-related factors that may contribute to the likelihood of a competitor responding. For instance, the competitor's size, financial position, organizational slack, organizational structure, management of IT within the organization, geographic scope, degree of diversification, and other factors may contribute to the motivation and ease that it has in responding to a competitive action. This research does not shed light on these issues. Rather, the stated purpose of this research is to examine the attributes of the resources of the initial action to determine the extent to which they are likely to sustain a competitive advantage. The focus of the inquiry was on the characteristics of the action, since the initiating firm is only able to control the characteristics of its own applications and accommodate the demands of its competitive environment.

7.7 Additional theoretical contributions

Several theoretical aspects to this research were discussed earlier in this chapter regarding how the results may give rise to alternative explanations and extensions to the theories of the resource based view, diffusion of innovations, and competitive rivalry. In summary, this research reveals new insights for academicians in both strategy and information technology by studying competitive behavior carried out through the use of networked information technology from the standpoint of the resource-based view and the dimensions of strategic resources. It allows us to test, in a limited context, the extent to which the firm's capability to use networked IT in a strategic manner can potentially sustain a competitive advantage as suggested by the resource-based view. The contributions to specific literature streams have been described in detail above, but key areas of contribution to strategy and information technology are highlighted in this section.

7.6.1 Theoretical contributions to strategy

The results of the research raise questions about the strategic advantage conveyed by particular characteristics of the firm's resources. The dimensions of social complexity and causal ambiguity did not appear to convey a significant competitive advantage for the initiating firm, within the context of how the firm deployed its networked IT resources. The use of these resources required considerable organizational capabilities because it was based on extensive tacit knowledge in order to integrate the technology into the firm's tasks. However, these organizational capabilities did not seem to carry the expected sustainable competitive advantage, given the fact that they were difficult for competitors to observe. Some results found in this study allude to the notion of different types of organizational capabilities: those required to carry out the firm's current operations, those required to respond to innovations initiated by rivals; and those that enable the firm to operate in such a way so as to minimize competitive behavior by rivals. Although the research focused specifically on organizational capabilities surrounding the use of information technology, it points to potential sources of future investigation.

Another area of contribution of this research to strategy is to demonstrate the conflicting issues that should be more closely addressed: one is the value of the firm's organizational capabilities that are expected to be a source of competitive advantage, and another is the strategic value to be gained by extending the firm's capabilities in order to respond to a competitors' actions. This extension may involve responding to an innovation that is expected to be a source of advantage by nature of its uniqueness. The research results indicated that even under conditions of likely under-reporting of responses, firms were able to respond to organizational capabilities that were considered to be highly innovative and required considerable resources on the part of the responding firm. This raises questions about the path dependency of developing the organizational capabilities if another firm is able to develop similar capabilities to respond to significantly innovative resource utilization.

A third area of contribution to strategy is to examine a rivalrous situation that involved the firm's ability to deploy a rich set of technological resources in a variety of competitive environments. The research setting that focused on the use of information technology also allowed the research to encompass a wide range of industries. The results emerging from this research are more applicable to a wide range of firms operating in similar industries, instead of focusing on a single industry.

7.6.2 Theoretical contributions to information technology

An important contribution of this research to information technology is that it focuses closely on the actual networked IT applications, and it considers the distinct competitive results that can be attributed to different types of applications. This research examined the competitive process directly across multiple industries in order to assess how the use of the technology affects the degree of competition faced by the firm. Unlike other IT research which does not have a direct linkage between a firm's use of information technology and the expected outcome, this research examines the direct influence of IT on rivalry. This will lead to a better understanding of the ways in which networked IT plays a strategic role for the firm.

7.8 Methodological contributions

There are several methodological contributions associated with this research. While these areas have been described in detail as part of the discussion of the results, they are highlighted in this section specifically as methodological contributions. First, this research extends the action-response analysis technique for assessing rivalry to include the strategic organizational capabilities of the firm. The research technique used in this study also specifically accounts for non-responses through the analysis of a censored dependent variable in the tobit regression analysis. The non-response situations are important, for they are the ones which are more likely to enable a firm to sustain a competitive advantage. However, non-responses to actions had not been analyzed in earlier action-response research.

Secondly, the research analyzed the interaction and main effects that resulted from the different types of networked IT applications that were deployed by firms across many industries. While IT applications can be general in nature, and they can also be very specific to the business setting. Therefore, they provide a rich context for evaluating subtle influences in competitive response that may derive from particular characteristics of the application itself.

Finally, the research relied on technical and professional industry publications for data on the IT applications. This provided an accurate and detailed account of the use of the technology in a wide variety of industry settings. There is a plethora of publications available that describe uses of IT by business, and they can be useful sources of information for future managerial research.

7.9 Managerial implications

This research provides considerable insight for managers regarding the potential strategic value of the firm's networked IT capabilities, and the likelihood of sustaining a competitive advantage with those capabilities. The findings suggest that the firm can plan ways in which to reduce competitive responses to its networked IT applications. First, applications that support innovative services appear to have a significant potential for sustaining a competitive advantage, due to the difficulty that competitors have in responding to these applications. This is an important finding from this research that was not obvious from prior research in this field, and it provides incentives to carry on further work investigating the strategic role of services deployed by the firm. Following that, applications that support internal firm processes also appear to have the potential for sustaining a competitive advantage. Third, product innovations that appear in industries that are not traditionally information intensive may be able to sustain a competitive advantage, possibly due to the fact that competitors are less familiar with ways in which to use the technology. Finally, the public network can successfully be used in applications, and its use does not necessarily incite responses from competitors. This is especially true if the public network is supporting services and internal processes. This result can be used to increase the development of the firm's Internet and Intranet applications, as they rely on a public network to provide services to customers and to support the firm's internal processes. In this way, the firm is able to benefit from the scope and reliability of the public network.

The findings also suggest that strategic advantages arising from uses of IT may not in fact be those that are touted as the most innovative. Instead, the strategic advantage may be gained through applications with a lesser degree of innovation that are closely integrated with the firms existing processes. The benefit of such applications is that they may be less costly and risky for a firm to implement, they may provide the firm with more ability to appropriate the value since they are linked to the firm's existing resources, and they are less likely to attract the attention of competitors.

This research was conducted using a sample of sample of networked IT application actions that were implemented between 1993 and 1994, and responses that were implemented between 1993 and 1996. Now that this era has ended, it is fair to ask if the results of this research are still relevant to managers. One can expect to still see competitive responses to strategic actions undertaken through the firm's use of networked IT. Certainly the use of public networks, such as the Internet, would increase. However, one would also expect to find that more organizations could better integrate their IT applications with their organizational processes. This would better enable these firms to achieve a strategic advantage through the integration of IT with existing organizational processes. Additionally, one could expect to see organizations adapt by creating new process and new structures that rely intensively on the IT applications, and that can adapt more rapidly to the information demands of the firm's competitive environment. These expectations for the future suggest that while the current research results are relevant, a greater understanding is required regarding the ways in which organizations generate competitive responses through their use of IT, and the information demands of the environment

Finally, given the strategic benefits that can be gained through the use of networked IT to support both the firm's innovative services offered to customers and the firm's internal processes, and the future expectations for networked IT applications, the role of the Chief Information Officer (CIO) is becoming increasingly important in firms and should be given careful attention. It appears that many strategic benefits are available if managerial influence is directed toward the firm's IT resources, and this influence requires considerable technical expertise in order to fully exploit the resources that can generate revenue for the firm as well as innovate its own business processes.

7.10 Implications for future work

There are many promising areas where further research is warranted based on the results of this study. Much of the discussion of the results of this research pertained to unexpected findings concerning the perceived strategic value of complex and tacit organizational capabilities. It seems appropriate to examine more closely how a firm actually develops the capabilities to use networked IT. A widely held belief is that an organization's strategic resources, as well as its capabilities, are not developed rapidly, but rather rely on a long-term factors that influence their development (Dierickx and Cool, 1989; Grant, 1996a). Questions to be addressed include: How relevant are those long-term processes in creating true organizational capabilities that bring strategic benefit to the firm? Are there other long-term processes that also result in organizational capabilities that do not convey strategic advantage? How does the management of the information technology resources affect the organizational capabilities required for strategic use of the technology?

For instance, in the case of managing IT, firms adopt different models which range from in-house integrated operations centers, complete outsourcing of all IT functions, separate in-house data and voice operations, or a decentralized divisional organization of managing IT rather than a centralized corporate-level managerial function. In addition, some firms actively exploit technology trials as an opportunity to learn about a technology as it is developing and to assess whether or not it is appropriate to develop organizational applications using that technology. In other firms, the experimentation with IT is done in more of a covert fashion, hid from the view of higher corporate levels and pursued by technological 'hackers,' for lack of a better term. Only when word leaks out that the innovation was a success in some way does the innovation receive corporate recognition and approval for wide-spread deployment.

Secondly, the range of competitive responses generated is another area deserving of further investigation. This research did not examine the characteristics of the responses; only the applications. Hence, the responses were all given equal weight. It would be especially helpful to know what types of applications influenced specific types of responses, and how these varied across industry settings. Responses may vary from a technological stand point as well as a market standpoint. For instance, some responses were targeted at duplicating the benefit realized by the initiating firm, while other responses matched that benefit and in addition developed further innovative uses of the technology to enhance their strategic advantage. Some responses were focused at the existing market of the firm, while other responses were undertaken so as to enable a firm to expand its market by reaching new customers and possibly extending beyond the traditional industry boundaries.

A third area worthy of future research has to do with the value of networked IT applications for the firm, and how that value depends on the firm's environmental context as well as the characteristics of the products or services that it sells to customers. As we look toward the future into the next century, we face the threat of information overload, or the capability to use information technology to communicate and analyze vast amounts of information. One factor that is crucial to deriving value from information system, and not drowning in information overload, is developing the ability to get the right information to the right people rapidly. This does not mean that all people in an organization should have access to all information. Rather, the information demands and the roles to be carried out must be analyzed in order to determine the value of specific IT applications in advance of their deployment. The firms that develop this capability will be able to exploit the benefits of information technology.

Hepworth (1990) has proposed that the strategic value of networked IT lies in the linkages, rather than the nodes of the network. Zuboff (1988) suggested that tasks could be 'informated,' by developing ways to produce information that could be used as new sources of value for the firm. Is in fact the strategic value of the IT resources in the tasks that it carries out, is it in the communication linkages that it establishes for other processes, or is it in the sheer versatility of the technology when it is used as a source of innovation in the firm's processes? This area is deserving of considerably more investigation.

Finally, a fourth area of future research, and one related to assessing the value of IT applications, has to do with the notion of the firm as an information processing entity. Is this an accurate portrayal of the firm, as originally suggested in the organizational theory literature (Egelhoff, 1991; Galbraith, 1977; Tushman and Nadler, 1978)? If so, then what is the information processing capacity of the firm, and is it actually meeting the information demands of its environment? This issue raises the notion of information entropy of the firm as a system. How is it able to transfer truly valuable information to the revenue-generating operations in the firm, when that information exists amidst the noise of the other non-valuable bits of encoded information that are also present. In other words, if uncertainty is the lack of information, then can firms benefit by reducing the degree of uncertainty by processing greater amounts of information, and exploiting what it learns from unexpected events?

Shannon's work on information entropy (Shannon and Weaver, 1949) provides an elegant way of accounting for the information capacity required in order to accurately transport desirable signals through a system in the context of unwanted signals, referred to as 'noise.' However, these mathematical principles have not been applied to the notion of organizations as information-processing entities. By considering the firm in this way, it may be possible to identify specific areas within the firm's processes that limit its information processing capacity – for instance, the control systems, the external linkages, or even the human interfaces to its automated processes. These questions continue to grow in importance as firms are faced with ever increasing information demands. It will become that much more important to understand how organizations can best process the information in its systems, and to ensure that the right information gets to the right people rapidly.

The benefits to be gained from future work are largely dependent on the measures and data sources that are available. The actual types of innovations would not vary significantly, as the categories of product, service, and process innovations, as well as innovations that extend beyond the firm's boundaries, appear to fit the strategic objectives well. The most troubling aspects of this research revolved around the measures associated with actions, responses, and industry-level measures of information-related demands and opportunities that exist in the competitive environment.

In the ideal measurement and research world, a pure information meter would be desirable in order to track to speed and traffic patterns of the information flows into and out of the firm and those of its competitors. In this manner, the nature of the information flows could be assessed directly, with powerful signal processing technologies applied to analyze the characteristics. Time-based studies, to study the changing information patterns of firms and their competitors, would also be valuable as they would likely indicate the true transformation of industries brought about by this technology, as well as the information demands present in the competitive environment. Ideally, the study of information into and out of firms could be assessed with the same power as used in the engineering disciplines to assess signal, noise, bandwidth, bandwidth bottlenecks, attenuation, dispersion, and other impairments that corrupt the transfer of information between entities. With these capabilities, not only could we analyze the information patterns of firms, we could design better information networks that would consist of the linkages that carried the information flows between firms and other entities.

Lacking these ideal measures, we must settle for counting objects at the endpoints of the information networks, and looking for evidence of how the networks are used. This requires better data on the equipment, supporting resources, configuration of information flows, and processes supported by the information flows. More information is also required regarding the value of specific IT applications in different environments, the degree of responses from competitors, and characteristics of the firms who are able to respond successfully. Historically, this information has been very difficult to obtain, and it isn't even tracked by firms in a uniform manner. However, as business and society rely more heavily on information and information technology to fuel its growth, these measures might be forthcoming. Furthermore, it will be important to expand the scope of this research to an international level, especially as some nations are still developing their communications infrastructures which will enable firms to use the resources strategically and for the economic benefit of the nation.

7.11 Summary

This research focused on the question: "*What aspects surrounding strategic networked information technology applications increase the response from competitors and what aspects reduce their response?*" The findings revealed that there are characteristics of the applications that appear to influence competitive behavior exhibited by rivals. The characteristics pertain to specific application categories of the technology, the degree of innovation of the application, the use of public telecommunications networks as a key component of the application, the extent to which the application interconnected multiple entities and business functions. Competitors' responses were also affected by the extent to which the industry output was information intensive, the demand volatility in the competitive environment, and the information complexity of the competitive environment caused by the degree of automation as indicated by the industry's computer and communications hardware investments.

The results suggest that a firm can use networked information technology strategically so that competitors are not able to immediately duplicate the advantage. However, the use of the technology is not as straightforward as one would expect. It is not enough to develop highly innovative and intricate applications, as competitors appear to be able to respond with similar applications. Rather, the strategic application of the technology appears to depend on how best to exploit the capabilities of the technology within the firm's products, services, and processes. Under differing environmental and product characteristics, specific types of networked IT applications appear to be more difficult for competitors to respond to than others.

Three questions created the underlying driving force for this research, and the results obtained begin to provide some answers to these questions. First, the question of why a firm would need to invest in networked IT appears to depend on specific competitive environmental characteristics as well as product characteristics that allow the firm to exploit the benefits of the technology. Secondly, in terms of what firms actually do with the technology, we have a much better picture of the strategic applications that support product, service, and process innovations, as well as those innovations that extend beyond the firm's boundaries. Finally, in terms of how competitors respond, we have a much clearer indication of the nature of competitive responses that occur within a two-year window from the time the application is deployed. By focusing on the strategic and innovative applications of the technology, the research results indicate the benefits and rivalrous responses surrounding the use of the technology in specific strategic contexts.

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Zuboff, S., (1988). In the age of the smart machine. New York, NY: Basic Books.

VITA

VITA

EDUCATION

Ph.D. Strategic Management. Purdue University. 1998. Dissertation: "Competing with telecommunications and information technology: Rivalrous responses to strategic IT network applications and the degree of innovation."
M.S. Electrical Engineering. Purdue University. 1982.
B.S. Electrical Engineering. Purdue University. 1981. Graduated with highest distinction.

ACADEMIC APPOINTMENTS

1991 - present	Associate Professor, Electrical Engineering Technology. Purdue University
1986-1991	Assistant Professor. Electrical Engineering Technology. Purdue University
1983-1986	Program Coordinator. Continuing Engineering Education. Purdue University
1982	Systems Training Specialist – Technology Transfer. Laboratory for Applications of Remote Sensing (LARS). Purdue University
1980-1981	Measurements Engineer. Laboratory for Applications of Remote Sensing (LARS). Purdue University

INDUSTRIAL. BUSINESS. and GOVERNMENTAL POSITIONS

1989. 1990	NASA/ASEE Summer Faculty Fellow. Advanced Communications Technology Satellite (ACTS) Program. NASA Lewis Research Center. Cleveland. Ohio

COMMUNITY MUSICAL POSITIONS

1991 - present	Lafayette Sumphony Orchestra. second trombone. Lafayette. Indiana.
1992 - present	Lafayette Citizens Band. second trombone. Lafayette. Indiana.

PROFESSIONAL AWARDS

1997	Electrical Engineering Technology. CTS Outstanding Undergraduate Teaching Award.
1993	American Society for Engineering Education -- Centennial Certificate – Awarded for "exceptional contribution to ASEE and to the profession of engineering."

MEMBERSHIP in SCHOLASTIC HONOR SOCIETIES (Dates inducted.)

1980	Phi Kappa Phi - National Honor Society
1979	Eta Kappa Nu - National Electrical Engineering Honor Society
1979	Tau Beta Pi - National Engineering Honor Society

MEMBERSHIP in ACADEMIC and PROFESSIONAL SOCIETIES

1996 - present	Pacific Telecommunications Council (PTC)
1986 - present	The Institute of Electrical and Electronics Engineers (IEEE)
1989 - 1992	North American ISDN Users' Forum (NIU Forum). Chair, Bandwidth Negotiation Application Profile Team (1989-1990); ISDN Implementors' Steering Committee (1989-1990); Executive Steering Committee (1989-1990); Interim Chair of the Satellite Expert Working Group (1990); Ad-hoc committees to develop ISDN applications (1989-1991).
1983 - 1993	American Society for Engineering Education (ASEE). New Engineering Educators' (NEE) Committee: Chair, (1990-1991); Program Chair (1990-1991); Vice Chair (1989-1990); Executive Board (1987-1992). Engineering Technology Division member (1986-1992); Educational Research and Methods Division (1986-1992).

RESEARCH AREAS

- Strategic applications of information technology and telecommunications.
- Competitive responses to innovative uses of information technology.

TEACHING AND COURSE DEVELOPMENT

Course Coordinator – with Lecture and Laboratory development responsibilities

1987 - present	EET 463 – Communications II -- Digital telecommunications
1997 - present	TECH 581F -- Fiber optic communications
1998 -	EET 109 – Digital Fundamentals

Additional lecture courses taught in the past 3 years

EET 159 - Digital Applications

Additional laboratory courses taught in the past 3 years

EET 497 - Senior Design Project, Phase II
EET 496 - Senior Design Project, Phase I
EET 491 - Senior Design Project, Phase II
EET 490 - Senior Design Project, Phase I
EET 396 - Group Design Project
EET 233 - Electronics and Industrial Controls
EET 214 - Electricity Fundamentals
EET 196 - Exploring Electrical Engineering Technology
EET 159 - Digital Applications
EET 117 - Circuits Problem Solution Methods

RECENT GRANTS

1995. "An advanced communication curriculum for undergraduate technology students integrated around a fully functional cellular telephone base station." Additional co-principal investigators: Professor Mike Muñoz and Professor Ross Heitzmann. Amount received: $100,000 (matched by industrial and university contributions of $100,000). National Science Foundation. Awarded in November, 1995, for work through May of 1998.

SELECTED PUBLICATIONS AND PRESENTATIONS

Recent Conference Presentations

Garrod, S. (1998). Strategic Networked Information Technology Applications: Empirical Results of Competitive Behavior. Fourth Annual Consortium for Research on Telecommunications Policy and Strategy (CRTPS), University of Michigan Business School, June 5-6, 1998, Ann Arbor, Michigan.

Garrod,* S., & Woo, C. (1997). Competing in an interconnected world. Seventeenth International Strategic Management Society Conference, October 5-8, 1997, Barcelona, Spain.

Muñoz,* M. & Garrod, S. (1997). In-process development of an advanced undergraduate communications laboratory. Presented at the IEEE/ASEE Frontiers in Education Conference, November 6-8, 1997, Pittsburgh, Pennsylvania.

Lightner, N., Chaturvedi, A., & Garrod, S. (1996). Comparison of 3-D visualization and regression. Proceedings of the Association of Information Systems Conference, August, 1996, Phoenix, Arizona.

Scholarly Research Book Chapters

Garrod, S. R. (forthcoming). Information technology investment payoff: the relationship between performance, information strategy, and the competitive environment. Measuring information technology investment payoff: contemporary approaches. M. A. Mahmood and E. J. Szewczak, eds. Harrisburg, PA: Idea Group Publishing, (approx. 40 manuscript pages).

Journal Articles

Wright,* G., Chaturvedi, A., Mookerjee, R., & Garrod, S. (1998). Integrated modeling environments in organizations: an empirical study. Information Systems Research, 9(1), 64-84.

Garrod, S. R. (1994). Laboratory activities for pulse code modulation. Journal of Engineering Technology, 11(1), 19-22.

Garrod. S. R. (1991). Strategies for the development and application of ISDN in the engineering technology curriculum. Journal of Engineering Technology. 8(2). 15-19.

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