ABSTRACT OF DISSERTATION

Lei Chi

College of Business and Economics

University of Kentucky

2005

COMPETITIVE DYNAMICS IN ELECTRONIC NETWORKS − ACHIEVING COMPETITIVENESS THROUGH INTERORGANIZATIONAL SYSTEMS

ABSTRACT OF DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Business and Economics
at the University of Kentucky

By
Lei Chi

Lexington, Kentucky

Director: Dr. Clyde Holsapple, Professor of Decision Science and Information Systems

Lexington, Kentucky

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Many dramatic and potentially powerful uses of information technology involve interorganizational systems (IOS). These systems, defined as distributed computing systems that support shared processes between firms, have become fundamental to business operations, spanning multiple activities in value/supply chains. They have opened avenues to unprecedented collaborative linkages between firms. As IOS-mediated relational networks are rapidly evolving, roles of IOS have progressively changed beyond those of efficiency and power functions.

To fully appreciate modern roles of IOS in e-business, this dissertation addresses two key research questions: (1) *How do firms achieve competitiveness through IOS?* (2) *How do IOS influence competitive behaviors of the competing firms in intertwined electronic networks?* It does so by integrating three research streams – social network analysis, interorganizational systems, and competitive dynamics – into a model of competitive dynamics in electronic networks. This study focuses on the paired relationships between the three constructs of network structure, IOS use, and competitive action, and empirically investigates nine general hypotheses.

Data collection focuses on second-hand data in the automotive industry. A total of 805 collaborative relationships, 106 IOS technologies and applications, and 305 competitive actions

involving nine major automakers are collected. Data sources include databases, major trade publications, Web sites, and industry indices. Data analysis includes network analysis, ANOVA test, and correlation.

Empirical results support the general contention that network structure and IOS use co-evolve and influence competitive action. Building on these results, a framework characterizing IOS's roles in achieving firm competitiveness is concluded and advanced.

This dissertation broadens our view of IOS's roles in e-business. It contributes to IS/IOS theory, methodology, and practice. First, this study examines IOS-mediated networks in multiple levels, including firm-level, pair-level, and network-level. It provides new theoretical conceptualizations of IOS's roles. Second, this study advances a new IT value measure addressing limitations of the traditional measures. Third, it introduces a novel, useful methodology for data collection. Fourth, results from this study can guide a firm's e-business initiatives for using IOS as powerful tools for achieving firm competitiveness.

KEYWORDS: Interorganizational Systems (IOS), Electronic Networks, Network Structure, IOS Use, Competitive Action

Lei Chi

April 26, 2005

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Chapter 1 Introduction

In a 1966 HBR article, Felix Kaufman implored general managers to explore the possibilities of "extra-corporate" systems for linking buyers and sellers or firms performing similar functions. Today, nearly forty years after Kaufman's visionary argument about computer networking, information systems that transcend firm boundaries have highlighted the most dramatic and potentially powerful uses of information technology. These interorganizational systems have become fundamental to business operations through their span of multiple activities in the value/supply chain. They can produce far-reaching impacts on firm performance (Cash and Konsynski 1984; Christiaanse and Venkatraman 2002), interfirm relations (Clemons and Row 1993; Konsynski 1993), and the structure of entire industries (Bakos 1991; Konsynski 1993).

Defined as distributed computing systems that support processes shared by two or more firms, interorganizational systems (IOS) involve technologies such as the Internet, extranet, electronic data interchange (EDI), customer relationship management (CRM), supply chain management systems (SCM), and B2B exchanges. By providing a common infrastructure for managing interdependencies between firms, IOS have opened avenues to collaboration on a wide range of dimensions. They have enabled a new set of organizational design variables beyond the conventional set, such as shared repositories, real-time integration of business processes, electronic communities that foster learning and allow multiple relationships to occur simultaneously, and virtual organizations that enable rapid assembly of external resources and capabilities (Strader et al. 1998). IOS have also opened avenues to collaborative linkages among competing firms, leading to a growing "co-opitition" (i.e., concurrent collaboration and competition) in e-business.

Estimates suggest that in 2001, over 30,000 IOS were in use (Surbramani 2004), and about one third of North American companies used extranets, Internet-based EDI and private exchanges (*Computerworld* December 17, 2001). Today, B2B exchanges have proliferated for almost every industry around the world. To name a few, these include e-Wood for lumber and building materials exchange, Scana Online for online gas and electricity auctions, ChemConnect for chemical exchange, and Orbitz for air travel exchange. Many large companies like Cisco, the Big-Three automakers, and Dell have launched their e-business initiatives for improving

performance via IOS. Cisco has initiated an eHub to drive deep, real-time knowledge exchange among its extended supply chain (including Tier 1 and Tier 2 suppliers). The Big-Three automakers have joined forces on two fronts to fully reap the benefits of economies of scale and scope afforded by IOS: one in establishing a B2B automotive procurement portal for linking the three automakers, other automakers and their suppliers; the other in establishing a B2B repair parts portal for linking the three automakers, other automakers, dealers, auto body shops, insurance companies, as well as retailers. Dell has leveraged the Internet to extend its reach to diverse customers and suppliers to enable agile moves in build-to-order, new product introduction, competitive pricing, and marketing & sales.

1.1 Research Questions of This Dissertation

Traditionally, IOS's roles have been oriented toward improving efficiency (Kaufman 1966; Barret and Konsysnski 1982; Cash and Konsyski 1985; Johnston and Vitale 1988; Venkatraman and Zaheer 1994; Iacovou et al. 1995), or reinforcing power and control (Johnston and Vitale 1988; Webster 1995; Mutch 1996; Chwelos et al. 2001). In recent years, rapid technology advancement, especially the advent and explosive growth of e-business systems, has enabled many IOS innovations. As more and more IOS links have been established, networks of electronically interconnected relations are rapidly spanning across an increasing number of firms. These electronic networks have become the loci of resources and have progressively changed the roles of IOS beyond those of efficiency and power functions.

Key questions for fully appreciating modern roles of IOS are "*How do firms achieve competitiveness through IOS?"* and "*How do IOS influence competitive behaviors of the competing firms in intertwined electronic networks?"* Answers to these questions have important implications. For researchers, they broaden and deepen the understanding of the changing roles of IOS in e-business, highlighting new considerations to take into account in the design of research studies. For practitioners, the answers can provide insights to guide a firm's e-business initiatives at improving firm performance via IOS.

When examining IOS's roles in electronic networks, there is a pressing need to move toward a dynamic, network, and systematic view of using IOS. Yet limited research has been done in this regard (Straub et al. 2004). Prior IOS studies have largely focused on (a) a relatively static view of using IOS (e.g., achieving efficiency through deploying the tangible assets of IOS),

(b) a dyadic view (e.g., using IOS for managing customer-supplier relationships in power jockeying or trust building), and (c) a sporadic view (based on case studies, anecdotes, or personal experiences of IOS use).

In the interest of an expanded view of IOS usage, this dissertation introduces the use of social network analysis and competitive dynamics research into the study of IOS. It examines competitive dynamics in the context of electronic networks, referring to the dynamic market process whereby firms act and react to achieve competitiveness via the use of IOS. Applying social network analysis, electronic networks are viewed as IOS-mediated relational networks, where participating firms may have direct and indirect partnerships. This dissertation particularly focuses on the three paired relationships existing between the three concepts of network structure, IOS use, and competitive behavior. It is contended that IOS use and network structure co-evolve and influence firm performance (Chen and Hambrick 1995; Chen 1996).

1.2 Research Methodology of This Dissertation

Data collection focuses on the automotive industry and involves second-hand data about nine major automakers. A total of 805 collaborative relationships, 106 IOS technologies and applications, and 305 competitive actions are collected. Data sources include SDC database, COMPUSTAT, F&S Predicast's Index, thousands of articles from 19 major trade publications, as well as miscellaneous Web sites. Data analysis includes network analysis, ANOVA test, Pearson's correlation, and non-parametric correlations.

1.3 Research Results of This Dissertation

Empirical results suggest important roles of IOS in influencing firm behavior and network structure that have not been heretofore established. Building on the empirical results from this study, a framework characterizing IOS's roles in achieving firm competitiveness is concluded. This framework is one of the two major frameworks developed in this dissertation. It is advanced with an orientation to IS discipline. The other framework, which appears in Chapter 4, is the research model investigated in this dissertation. The research model has an orientation to a general audience. It is intended to be generalized to and used in other disciplines beyond IS discipline, such as disciplines of competitive dynamics and social networks.

1.4 Research Contributions of This Dissertation

This study empirically investigates the competitive dynamics in an automotive network of electronically interconnected firms. This empirical investigation has broadened our view of how IOS can be used to achieve firm competitiveness in e-business. It contributes to IS theory, methodology, and practice.

Contribution to Theory

First, by introducing a social network perspective, this study examines IOS-intensive networks in multiple levels, including firm-level, pair-level, and network-level. It contributes to IS research by providing new theoretical conceptualizations of IOS's roles.

Second, this study empirically validates and theoretically enriches the D&M IS Success Model (DeLone and McLean 1992; 2003). The D&M IS Success Model, since proposed in 1992, has been widely used as a framework for conceptualizing and operationalizing information system success or effectiveness. In the D&M IS Success Model, the use of information systems is postulated as pivotal to IS success or effectiveness (DeLone and McLean 1992; 2003). Yet, too frequently, simple usage variables (e.g., *frequency of system use*) are used in prior studies. It is strongly desirable to recognize the multidimensionality of system usage so as to capture the richness of this complex construct (DeLone and McLean 2003).

This study empirically investigates the uses of IOS and their impacts on firm performance in e-business. The empirical results suggest strong associations between IOS use, firm behavior, and network structure. These results further validate the D&M IS Success Model by confirming that system use is a key variable in understanding IS success or effectiveness. In addition, this study introduces three new measures to describe system use. These are *IOS reach, range,* and *diversity of use*. These measures enrich the D&M IS Success Model by recognizing multiple dimensions of system use.

Third, this study, by recognizing competitive actions as externally-oriented, specific moves that are first observed after undertaking a firm's IT initiatives in achieving competitiveness, provides the promise of developing an IT value measure that supplements the traditional measures by addressing the limitations of those measures.

Traditional IT value measures, such as *IT productivity*, *IT profits*, and *consumer surplus*, provide a limited view of IT investment returns. Because these measures are aggregate-level measures of IT payoff, they can not be obtained until after a certain period of time. Additionally,

gains from an IT investment sometimes may be transformed into such soft gains as agility, innovation, or market influence rather than less soft gains like profits, productivity, or consumer surplus. So, using *IT productivity*, *IT profits*, and *consumer surplus* may not be able to capture a complete view of IT value.

On the other hand, as firms increasingly digitize their business processes and rely on IT-mediated interfirm relationships to develop and deploy capabilities, firm behavior becomes increasingly inseparable from IT, either IT-induced or IT-enabled (Subramani 2004). Gains (soft or hard) from an IT investment, more or less, can be transformed into and first observed as one action or a series of patterned actions. In this regard, competitive action provides a different view of IT investment returns that may not be captured by the traditional measures. Furthermore, competitive action can be observed within any length of time windows. The length of time windows can be taken as short as a month or half a year, and as long as five-year or more. Thus, competitive action greatly increases the flexibility (in terms of time scale) of measuring IT value.

As such, competitive action provides the promise of serving as an IT value measure. Competitive action supplements *IT productivity*, *IT profits*, and *consumer surplus*, allowing for a more complete view of IT value.

Contribution to Methodology

This study represents a first attempt in collecting *actual, voluntary* IOS use data from second-hand data sources like news reports and trade articles. Prior IOS empirical research largely collects self-reported data. Self-reported data are limited in that (1) they may induce biases due to having the same respondents answer questions on their perceptions of system use and effectiveness, known as common method variance (Devaraj and Kohli 2003); (2) some studies have suggested that perceived system usage may not be congruent with actual usage (Straub et al. 1995), and thus might not be an appropriate surrogate for actual usage (Szajna 1996); (3) second-hand data sources (like news reports and trade articles) allow data to be collected in a relatively controlled manner, especially when collecting longitudinal data or sensitive data (like collaborative relationships, competitive actions, and significant system implementation and usage), which are generally difficult to obtain in a self-reported manner.

Therefore, second-hand data collection about *actual, voluntary* IOS use may represent a novel, useful methodology for IS/IOS researchers.

Contribution to Practice

The framework of IOS use suggests to IOS users possible ways to disrupt the equilibrium in the product-market space – by launching competitive moves through aggressive pursuit of new opportunities for IOS innovation, exploration, and exploitation.

Building on the framework of IOS use, this dissertation also develops a roadmap for identifying IOS opportunities. This roadmap can guide a firm's systematic search for opportunities of using IOS as powerful tools for achieving firm competitiveness.

Finally, the exploration of possibilities for using competitive action as an IT value measure suggests an alternative direction for IOS users to pursue in evaluating their organizations' IOS use.

1.5 Organization of This Dissertation

This dissertation is organized as follows: Chapter 2 introduces the concept of IOS and develops a collaboration-oriented IOS classification, which is important in developing measures for testing hypotheses at later stage; Chapter 3 reviews prior studies on IOS, summarizes major perspectives on IOS's roles and their limitations, and poses research questions of this dissertation; Chapter 4 introduces the research model and hypotheses; Chapter 5 discusses data collection methodology; Chapter 6 operationalizes variable constructs and their measures; Chapter 7 describes data analysis methods and presents results of these analyses; Chapters 8-11 discuss data results; Chapter 12 recommends a framework of IOS use and a roadmap for identifying IOS opportunities, and concludes with research contributions, limitations, and future research directions.

Chapter 2 Interorganizational Systems: A Definition and A Classification

This chapter describes concepts of interorganizational systems (IOS). Based on Kumar and van Dissel's IOS typology, it develops a collaboration-oriented IOS classification. This IOS classification is useful in identifying IOS candidate technologies and developing IOS use measures for hypothesis testing in the subsequent study.

2.1 An IOS Definition

In 1966, Kaufman implored general managers to explore the possibilities of extra-corporate systems for linking buyers and sellers or firms performing similar functions. Kaufman convincingly argued that these extra-corporate systems could greatly enhance operational efficiency and cooperation between firms. In 1982, Barrett and Konsynski described such systems as "interorganizational information sharing systems." In 1985, Cash and Konsynski used the term "interorganizational systems" (IOS) and defined them as automated information systems shared by firms.

IOS in this study are defined as distributed computing systems that support business processes shared between firms. In a broad sense, any digital technology that allows an interfirm application can be regarded as an IOS candidate technology, such as an EDI system and an extranet. Some well-known examples of IOS technologies and applications are American Airlines' SABRE reservation system, the CFAR system between Wal-Mart and Warner-Lambert, and Cisco's eHub.

2.2 A Collaboration-Oriented IOS Classification

Kumar and van Dissel (1996) develop an IOS framework based on Thompson's (1967) typology of interorganizational interdependencies. By illustrating IOS's roles in managing interdependencies and enhancing trust for sustained collaboration between firms, Kumar and van Dissel's framework provides a good basis for a collaboration-oriented IOS classification. Based on Kumar and van Dissel's framework, this study further identifies and expands the list of IOS candidate technologies, as presented in Table 2.1. This extended IOS classification is important in developing IOS use measures for conducting the empirical testing at a later stage.

Table 2.1 Examples of IOS candidate technologies and applications

Collaborative Work
Collaborative construction (e.g., collaborative design like CAD/CAM, collaborative authoring, joint decision making like multi-participant decision support system)
Relationship management (e.g., supply chain management; collaborative planning, forecasting and replenishment; customer relationship management via multiple points of interaction like call center, Web and wireless)
Task coordination (e.g., scheduling resources and tasks like competitive bidding and auction; workflow automation; collaborative timing and meeting management)
Threaded discussion (e.g., community of practice, community of interests)
Communication Networks
Broadband communication (e.g., high bandwidth services, such as video, image and multimedia)
Peer-to-peer communication (e.g., each partner retains the ownership of information and exchanges information indirectly with one another bypassing central exchanges)
Web portal (e.g., Internet, extranets, intranets, or Web sites providing support via TCP/IP protocols)
Wireless network (e.g., providing support via Wireless Access protocol, such as Radio Frequency Identification System, Global Positioning System)
Knowledge Work
Knowledge derivation (e.g., case-based reasoning, optimization, online analytical processing, rule engines, simulation)
Knowledge discovery (e.g., data mining, text mining, fuzzy logic, neural networks, genetic algorithm)
Knowledge search (knowledge navigation and retrieval, such as Web browser, search engines, expert finder tools, directory services)
[redacted]
Open posting (e.g., electronic bulletin board, WWW forum)
Shared Repositories
Databases & data warehouses o

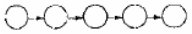
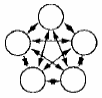
2.2.1 Types of Interdependencies and IOS Classes

According to Thompson (1967, pp. 54-55), firms can be interrelated in three different ways: *pooled interdependency*, *sequential interdependency*, and *reciprocal interdependency*. In *pooled interdependency*, firms share and use common resources; "each renders a discrete contribution to the whole and each is supported by the whole" (e.g., the use of a common data processing center by a number of firms). *Sequential interdependency* refers to the situation where companies are linked in a chain with direct directional and well-defined relations, where the outputs from one firm become inputs to another (e.g., the customer-supplier relationship along a supply chain). *Reciprocal interdependency* describes a relationship where each firm's outputs become inputs to the others (e.g., a concurrent engineering team consisting of customers, suppliers, distribution centers, dealers, shippers, and forwarders).

Pooled interdependency involves minimal direct interaction among the units, and coordination by standardization is appropriate. *Sequential interdependency* involves an increasing degree of contingency because each position in the chain must be readjusted if an upstream position fails to fulfill its expectation, and coordination by plan is appropriate. *Reciprocal interdependency* involves the highest degree of interaction because actions of each position in the set must be adjusted to the actions of many interacting positions, and coordination by mutual adjustment is needed (Thompson 1967).

In correspondence with *pooled interdependency*, *sequential interdependency*, and *reciprocal interdependency*, Kumar and van Dissel (1996) suggest a three-part typology for IOS: *pooled information resources IOS*, *value/supply-chain IOS*, and *networked IOS*. They regard IOS as technologies designed and implemented to operationalize the interfirm relationships. They assume that the structure of the relationship influences the degree to which the relationship can be programmed and embedded in the IOS. Adopting Kumar and van Dissel's three-part typology for IOS, this study further extends the notion of *pooled information resources IOS* to *pooled knowledge resources IOS* to allow for an unstructured dimension of knowledge to be considered in the IOS classification. Table 2.2 illustrates this IOS typology.

Table 2.2 Three-part IOS typology

Type of Interdependency	Pooled Interdependency	Sequential Interdependency	Reciprocal Interdependency
Configuration			
Coordination Mechanisms	Standards & Rules	Standards, Rules, Schedules & Plans	Standards, Rules Schedules, Plans & Mutual Adjustment
Structurability	High	Medium	Low
Amount of Direct Human Interaction	Minimum	Intermediate	Highest
Type of IOS	**Pooled Knowledge Resources IOS**	**Value/Supply-Chain IOS**	**Networked IOS**
Nature of Knowledge Exchanged	Structured	Structured Semi-Structured	Structured Semi-Structured Unstructured
Focus of Implementation Technologies	"Codification"	"Codification"	"Personalization"

(Adapted from Kumar and van Dissel 1996; grey-shaded areas indicate extensions)

Pooled Knowledge Resources IOS

Pooled knowledge resources IOS involve interorganizational sharing of a technological system, such as common repositories (e.g., databases, digital archives), common communications networks (e.g., the Internet, extranet, broadband networks), common communications protocols and standards (e.g., EDI, XML), and electronic markets which may include some combinations of common repositories and common communications infrastructure.

In pooled knowledge resources IOS, the coordination structure in terms of the level of roles, obligations, rights, procedures, knowledge flows, as well as analysis and computational methods used, can be clearly specified and standardized (Kumar and van Dissel 1996). The knowledge exchanged tends to be highly structured, such as product descriptions, customer characterizations, and transaction status. As such, interfaces between firms can be mostly designed as protocols, rules, and standards built in shared software, tools, and systems.

For instance, the Amico Library (www.amico.org) is an Internet-based archive with digital copies of more than 100,000 paintings, sculptures, and photographs initiated and shared by 39 museums from the Metropolitan Museum of Art to smaller institutions like the Newark Museum (*New York Times* May 22, 2003). The National Virtual Observatory represents another

initiative to create a shared cosmic data warehouse using an Internet-based registry for nationwide collaboration in astronomy (*New York Times* May 20, 2003).

Another example of pooled knowledge resources IOS is Cisco's eHub. eHub is a private electronic marketplace for parts procurement between Cisco and its suppliers. eHub involves an extranet infrastructure that uses XML standards, and a central repository that pools together supply chain information for planning and executing tasks (Grosvenor and Austin 2001).

Value/Supply-Chain IOS

Value/supply-chain IOS support structured and semi-structured customer-supplier relationships, which are likely to be implemented through automation. *Value/supply-chain IOS* institutionalize sequential interdependency between firms along the value/supply chain.

In *value/supply-chain IOS*, roles and mutual expectations between adjacent parties in a value/supply chain can be structured. Structured interactions could range from tracking EDI-based orders, to examining databases of adjacent partners in the chain for sales forecasting, to transferring CAD-based specifications from customers to suppliers (Kumar and van Dissel 1996). The knowledge shared can range from structured data, such as ordering and customer data, sales data, and production and inventory data, to semi-structured representations, such as market research, category management, and cost-related descriptions (Simatupang and Sridharan 2001). As such, interfaces between participants in *value/supply-chain IOS*, like those in *pooled knowledge resources IOS*, also can be designed as protocols, rules, and standards embedded in the software, tools, and systems (e.g., automated workflow systems).

In recent years, rapid development in the Internet technology and wireless technology have enabled many innovative *value/supply-chain IOS*. For example, in 1995, Wal-Mart and Warner-Lambert (now part of Pfizer) initiated an Internet-based EDI, the CFAR (collaborative forecasting and replenishment system) for joint forecasting (such as expected alterations of store layout) and replenishing pharmaceuticals and healthcare products (*Computerworld* September 23, 1996).

Wal-Mart is also testing a wireless supply chain system with its suppliers, including Pepsi, Bounty, and Gillette. Wal-Mart uses RFID (Radio Frequency Identification) to track shipments of Pepsi soft drinks, Bounty paper towels, and Gillette razors, from manufacturer to warehouse to store to checkout counter. This process is illustrated in Figure 2.1. Information from RFID tags on each item in a Wal-Mart store goes into Wal-Mart's 101-terabyte sales

transaction database. Then suppliers can get a real-time view of what is happening at the store shelf level (Shankar and O'Driscoll 2003).

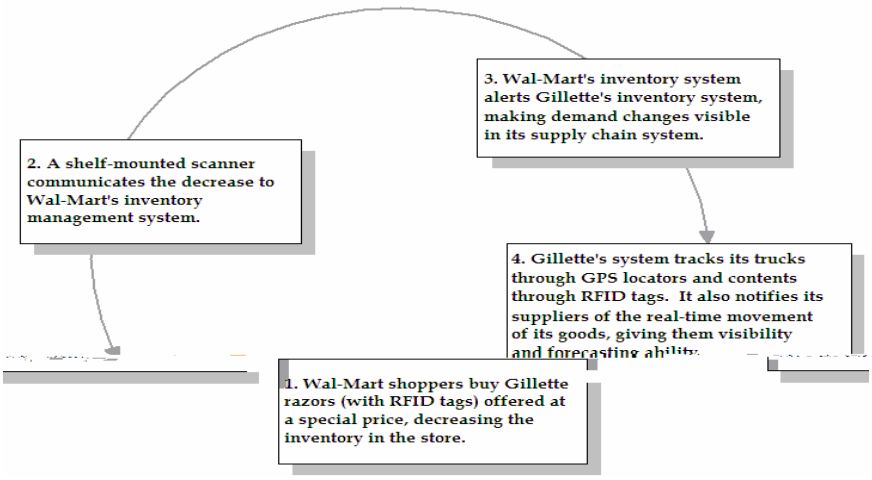


Figure 2.1 Wal-Mart's wireless supply chain system for order tracking and replenishment
(adapted from Shankar and O'Driscoll 2003)

Networked IOS

Networked IOS operationalize and implement reciprocal interdependencies between firms. *Networked IOS* provide a shared virtual space where people collaborate for emerging relationships and learning (Nonaka and Konno 1998). They focus on supporting informal exchange of semi-structured or unstructured knowledge, which sometimes cannot be described as a business process, such as posting a question on the electronic bulletin board, asking an expert for a solution, or directly contacting customer to elicit needs or problems.

With *networked IOS*, the form, direction, and content of the relationships among participants are much less structured than with the other two types of IOS (Kumar and van Dissel 1996). Reciprocal relationships can be viewed as consisting of exchange processes and adaptation processes. Exchange processes represent "the operational, day-to-day exchanges of an economic, technical, social, or informational nature occurring between firms;" "adaptation involves the processes whereby firms adjust and maintain their relationships by modifying routines and mutual expectations" (Kumar et al. 1998 pp. 215). A *networked IOS* thus involves an increasing degree of human interaction and requires mechanisms (such as trust) to identify, assess, and manage the dynamically occurring equivocality and risks in the situation. The nature

of the knowledge exchanged can range from structured (such as product data), to semi-structured (such as reports about industry trends), to highly unstructured (such as expertise, problem-solving skills, and new product ideas or conceptualization). As such, many parts of interorganizational interfaces in *networked IOS*, unlike those in the other two types of IOS, cannot be designed as built-in protocols, rules, and standards. Instead, human processors positioned at organizational boundaries tend to interface with each other, with the aid of IOS.

ComputerLink is an example of the *networked IOS*. ComputerLink is a community health information network built in Cleveland for Alzheimer's caregivers. ComputerLink involves using the Internet, an electronic bulletin board, a decision support system, as well as e-mail and electronic encyclopedia facilities to provide clinical and financial services, and deliver just-in-time knowledge among patients, physicians, hospitals, clinics, and home health agencies. The e-mail facility allows individual users to communicate anonymously with a nurse-moderator and other Alzheimer's caregivers. The nurse-moderator serves as technical liaison by providing systems and health support to ComputerLink users while maintaining all encyclopedia functions related to Alzheimer and care giving. The decision support system guides users through a myriad of scenarios allowing self-determined choices based on personal values. The bulletin board enables users to communicate through an electronic support-group public forum (Payton and Brennan 1999).

The three types of IOS form a Guttman-type scale (Thompson 1967). That is, *value/supply-chain IOS* may possess the characteristics of *pooled knowledge resources IOS*; and *networked IOS* may possess characteristics of both *value/supply-chain IOS* and *pooled knowledge resources IOS* (Kumar and van Dissel 1996).

2.2.2 IOS Candidate Technologies

Based on the characteristics and roles of each IOS class, candidate technologies and application systems are identified correspondingly.

Pooled Knowledge Resources IOS Candidate Technologies

Pooled knowledge resources IOS usually involve a large number of participants, highly structured interactions among participants, and a relatively low degree of human contact. They are used to reduce uncertainty and achieve economies of scale and scope by sharing knowledge resources, costs, and risks among the participants (Konsynski and McFarlan 1990).

Implementation technologies require a focus on "codification" (i.e., "capturing existing knowledge and placing this in repositories in a structured manner") (Milton et al. 1999 pp. 619; Tsui, 2003). Thus, communication technologies and standards & protocols can serve as good application candidates. Table 2.3 illustrates some examples.

Table 2.3 *Pooled knowledge resources IOS* candidate technologies

Communication Networks
Broadband communication (e.g., high bandwidth services, such as video, image and multimedia)
Peer-to-peer communication (e.g., each partner retains the ownership of information and exchanges information indirectly with one another bypassing central exchanges)
Web portal (e.g., Internet, extranets, intranets, or Web sites providing support via TCP/IP protocols)
Wireless network (e.g., providing support via Wireless Access protocol, such as Radio Frequency Identification System, Global Positioning System)
Shared Repositories
Databases & data warehouses (databases or large-scaled databases that bring together data from multiple sources, such as transactional systems across multiple companies)
Digital documents & archives (digital collections of artifacts, such as graphical objects and 3-D objects)
Standards & Protocols
EDI (Electronic Data Interchange, the exchange of standardized business documents, such as invoice via proprietary networks, or value-added networks)
Security mechanisms (e.g., system authentication mechanisms, data security and privacy standards)
Web services (software applications identified by uniform resource identifiers and supporting direct interactions with other applications using XML-based messages exchanged via Internet protocols)
XML (Extensible Markup Language, the universal format for exchanging structured documents and data over the Internet)

Value/Supply-Chain IOS Candidate Technologies

Value/supply-chain IOS involve relatively structured and linear relations between adjacent chain members, whose interaction interfaces can be largely standardized. They are used primarily for purposes of reducing uncertainty, facilitating coordination, and streamlining flows of knowledge, services, and products. Implementation technologies also focus on "codification." It is worth noting that interdependencies between firms are different from the ways in which tasks/activities are interrelated. For example, *sequential dependency* between firms along a supply chain may involve many different tasks/activities relationships, such as "*sharing*," "*flow*," "*fit*," *concurrent tasks*, *task-subtask* (Malone and Crowston 1999 pp. 429; Holsapple and Whinston 2001 pp. 585). "*Sharing*" relationships occur when multiple activities use the same

resource. "*Flow*" relationships arise when one activity produces a resource that is used by another activity, involving sequencing, transfer, and usability. "*Fit*" relationships occur when multiple activities collectively produce one resource. *Concurrent tasks* arise when multiple activities occur simultaneously. *Task-subtask* relationship arises when one activity involves multiple subactivities.

Therefore, the coordination technologies that focus on supporting structured and semi-structured tasks/activities along the value/supply chain may serve as good candidate technologies for *value/supply-chain IOS.* These technologies may include *scheduling resources and tasks across companies* (Malone and Crowston 1999; Holsapple and Whinston 2001 pp. 585), *managing customer-supplier relationships* (Holsapple and Whinston 2001 pp. 585), and *interorganizational workflow automation* (van der Aalst 2000). *Scheduling* techniques involve managing the "*sharing*" relationships based on the mechanisms, such as "first come/first serve," priority order, budget, managerial decision, and competitive bidding, and also the "*flow*" relationships, such as CPM and PERT for project management. *Managing customer-supplier relationships* focuses on the "*flow*" relationships between activities along a value/supply chain. Technologies may involve customer relationship management, supply chain management, EDI systems, as well as collaborative planning, forecasting, and replenishment systems. *Workflow automation* is used for structured business processes across firms with a predefined set of tasks and routing constructs. *Workflow automation* involves managing concurrent tasks, task-subtask relationships, and multi-participant tasks.

Candidate technologies for *value/supply-chain IOS* may also include technologies for handling structured and semi-structured knowledge resources in a sequential manner (e.g., knowledge navigation and retrieval technologies like search engines, knowledge derivation technologies like rule engines, case-based reasoning).

Table 2.4 lists some examples of implementation technologies and applications.

Table 2.4 *Value/supply-chain IOS* candidate technologies

Collaborative Work
Relationship management (e.g., supply chain management; collaborative planning, forecasting and replenishment; customer relationship management via multiple points of interaction like call center, Web and wireless)
Task coordination (e.g., scheduling resources and tasks like competitive bidding and auction; workflow automation; collaborative timing and meeting management)
Knowledge Work
Knowledge search (knowledge navigation and retrieval, such as Web browser, search engines, expert finder tools, directory services)
Knowledge derivation (e.g., case-based reasoning, optimization, online analytical processing, rule engines, simulation)

Networked IOS Candidate Technologies

Networked IOS have a focus on people and their work styles, especially how they create ideas and what knowledge resources they use. *Networked IOS* are particularly instrumental in three aspects: *agile problem solving* by delivering just-in-time knowledge among individuals across organizations, *expertise co-development* by supporting deeper and more tacit knowledge sharing among professionals, and *innovation* by optimizing interactions with customers and utilizing their knowledge (Nomura 2002). Each of these aspects highlights human ingenuity and involves a tacit and less structured learning process. Thus, implementation technologies focus on "personalization" (i.e., "locating and connecting people") (Milton 1999; Tsui 2003 pp. 6). Groupware, e-mail, instant messaging, teleconferencing, threaded discussion, publishing services (e.g., open posting, FAQs), and collaborative construction tools (e.g., design, authoring) may serve as good candidates. Candidate technologies of *networked IOS* may also include technologies for handling unstructured knowledge resources, such as data mining and fuzzy logic. Table 2.5 lists some examples.

Table 2.5 *Networked IOS* candidate technologies

Collaborative Work
Collaborative construction (e.g., collaborative design like CAD/CAM, collaborative authoring, joint decision making like multi-participant decision support system)
Threaded discussion (e.g., community of practice, community of interests)
Knowledge Work
Knowledge discovery (e.g., data mining, text mining, fuzzy logic, neural networks, genetic algorithm)
Messaging Services
E-mail (electronic messages set for business purposes)

Chapter 3 Prior IOS Research and IOS's Role in Achieving Firm Competitiveness

This chapter reviews prior IOS research and summarizes major perspectives and their limitations regarding IOS's roles in achieving firm competitiveness. It poses research questions and suggests ways to answer these questions that address the limitations of prior studies.

3.1 Four Research Perspectives on the Role of IOS

Based on an extensive review of IOS literature, this study identifies four major perspectives on the roles of IOS in achieving firm competitiveness: the *techno-economic* perspective, the *socio-political* perspective, the *trust* perspective[1], and the *learning* perspective. Figure 3.1 illustrates these four perspectives.

The *techno-economic* perspective views IOS as instruments for increasing organizational efficiency and effectiveness. The *socio-political* perspective focuses on the roles of IOS as competitive weapons for power controls between the IOS participants. The *techno-economic* and *socio-political* perspectives represent the focus of IOS research in the 1960s - 1990s.

In the 1990s, the *trust* perspective was introduced. The *trust* perspective emphasizes the elements of transparent knowledge sharing, shared decision making, and effective governance for conflict resolution in the IOS use. This perspective advances the roles of IOS in enhancing trust and cooperation for achieving collaborative advantage.

The *learning* perspective represents a fourth rationale for studying the roles of IOS. This view focuses on the dynamic roles of IOS and suggests creating sustained competitiveness through aggressive pursuit of new opportunities for joint performance improvements via IOS.

[1] The *techno-economic* perspective, *socio-political* perspective, and *trust* perspective originally came from Kumar et al. (1998). The *techno-economic* perspective holds a similar notion to Kling's (1980) *system rationalism* perspective. The *socio-political* perspective holds a similar notion to Kling's (1980) *segmented institutionalism* perspective.

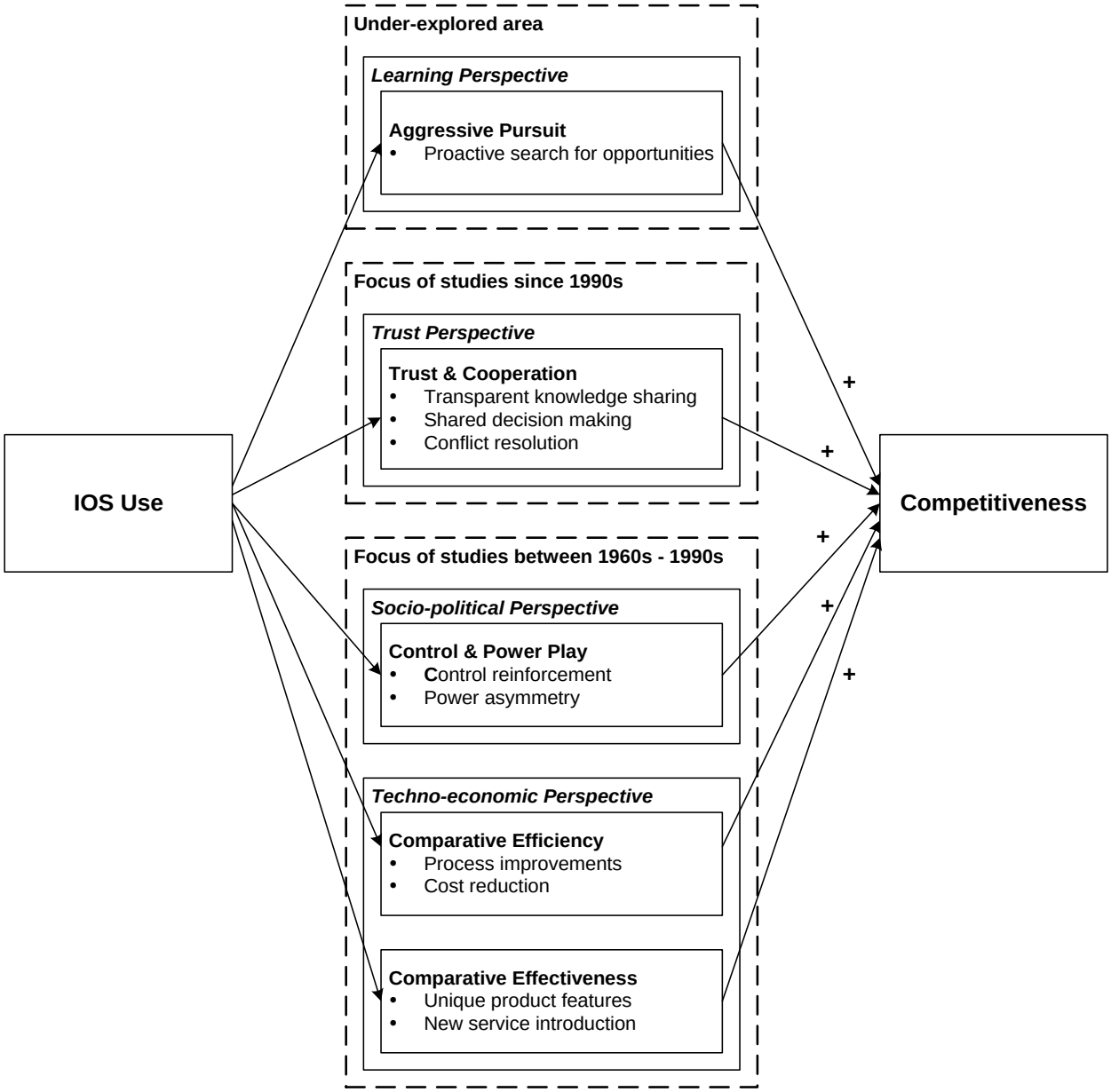


Fig 3.1 Pi e a ig OS's o li a ig o p e

3.1.1 The Techno-Economic Perspective

The central concept of the *techno-economic* perspective is that all actors/stakeholders in an interfirm relationship subscribe to the economic goal of maximizing their firms' economic efficiency and effectiveness through technology (Kling 1980; Kumar et al. 1998). It focuses on the narrowly bounded world of computer use in which the computer user is a central actor and emphasizes the beneficial or positive role that computerized technologies play in interfirm relationships.

As such, studies holding the *techno-economic* perspective are likely to focus on the roles of IOS as instruments for increasing organizational efficiency (e.g., easier data manipulation, faster response, lower order costs) and effectiveness (e.g., unique product features, better customer service). Representative studies include Kaufman (1966), Barret and Konsysnski (1982), Cash and Konsyski (1985), Johnston and Vitale (1988), Venkatraman and Zaheer (1994), Iacovou et al. (1995).

3.1.2 The Socio-Political Perspective

Unlike the *techno-economic* perspective, the *socio-political* perspective is not techno-centric. It does not presume a technological imperative or economic rationality in human behavior, but instead assumes that the interconnected environments within which firms operate represent political or negotiated areas that are characterized by inequality, information asymmetry, manipulation, coercion, or conflict (Kling 1980; Oliver 1990; Kumar et al. 1998). This perspective views the use of IOS as being motivated by power and control. In the drive to achieve competitive advantage, the objective of a firm is to minimize its dependence on other firms and to maximize the dependence of other firms on itself (Reekers and Smithson 1995).

As such, studies adopting the *socio-political* perspective are likely to focus on the roles of IOS as competitive weapons for control reinforcement and power plays (e.g., biasing information display in an IOS to create information asymmetry, increasing switching costs and partner dependence via customized systems). Representative studies include Johnston and Vitale (1988), Webster (1995), Mutch (1996), Chwelos et al. (2001).

3.1.3 The Trust Perspective

Since the 1990s, as the potential for linking the information systems of separate firms has been gradually realized, profound changes have taken place in firm behavior, technology use,

and interfirm relationships. The development and implementation of IOS networks (e.g., EDI networks) have radically altered many firms' internal procedures in procuring supplies, delivering goods and services, and carrying out financial transactions. Results include performance improvements in just-in-time delivery and inventory management, and quick response to customer demand. In order to respond more effectively to changing business conditions, many firms have realized that more cooperative relationship and greater transparency in information sharing are needed. This recognition has given an infrastructural impetus to use IOS for enhancing trust and a shift in the focus of IOS studies from the *techno-economic* and *socio-political* perspectives to a *trust* perspective.

The *trust* perspective goes beyond techno-centric and economic considerations. It assumes that trust, mutual support, harmony, and cooperative relationships rather than coercion, domination, conflict, and control are the predominant values underlying the socio-economic behavior. This perspective recognizes that both the *techno-economic* perspective and the *socio-political* perspective have an underlying focus on self-interest and opportunism, which is likely to create a win-lose view of business transactions and relationships for achieving competitive advantage. In contrast, the *trust* perspective, by recognizing the existence of cooperative relationships, is likely to create win-win strategies in wielding IT for collaborative advantage (Kumar and van Dissel 1996).

Studies using the *trust* perspective suggest that trust and cooperation, in addition to efficiency and power, provide a third rationale for studying the roles of IOS (Kumar et al. 1998). Representative studies include Holland (1995), Kumar and van Dissel (1996), Hart and Saunders (1997), Kumar et al. (1998), Li and Williams (1999), and Gallivan and Depledge (2003).

3.1.4 The Learning Perspective

The *learning* perspective provides a fourth rationale, besides the other three perspectives, for studying the roles of IOS.

Like the *techno-economic* perspective, the *learning* perspective also sees increases in organizational efficiency and effectiveness through exploiting IOS capabilities. But unlike the *techno-economic* perspective, the *learning* perspective implies that performance improvements through merely deploying the tangible assets of IOS are relatively static. These improvements cannot create sustainable advantage, because they are usually achieved spontaneously along with work practices and organizational routines in the use of IOS. When the competitive environment

changes (e.g., increasing use of IOS by competitors), these advantages (e.g., data entry efficiency obtained via IOS) are likely to disappear quickly.

The *learning* perspective is also different from the *socio-political* and *trust* perspectives. The latter two perspectives view IOS as instruments for managing relationships, while the *learning* perspective emphasizes the dynamic roles of IOS in achieving sustained competitiveness, through aggressive pursuit of opportunities for using IOS or IOS innovations. Aggressive pursuit can lead to dynamic capabilities that are adaptable to environmental changes and are not easily imitated by rivals, because firms that begin to ride a learning curve ahead of their competitors realize a head start that will endure as long as new opportunities continue to be revealed and exploited (Copeland and McKenney 1988).

The *learning perspective* is represented by three studies: Copeland and McKenney (1988), Zaheer and Zaheer (1997), and Christiaanse and Venkatraman (2002).

3.2 Limitations of IOS Research

The four perspectives have provided some insights into the roles of IOS in achieving firm competitiveness, but they provide limited insights into the process of how sustained competitiveness is created through IOS. The *techno-economic* perspective represents a relatively static view of using IOS. The *socio-political* and *trust* perspectives largely focus on the roles of IOS in managing dyadic relationships. The *learning* perspective emphasizes a more dynamic dimension of using IOS, but it remains under-explored. Additionally, many IOS studies are ideas and conceptual frameworks or case-based approaches. They are interpretative, subject to sporadic anecdotes, personal opinions, and experiences rather than systematic research. With the proliferation of IT-mediated interfirm collaboration, electronic networks are rapidly evolving and spanning across an increasing number of firms, industries, and value/supply chains. The emergence of these networks warrants a change in the focus of IOS's roles– from a relatively static view to a more dynamic view, from a dyadic dimension to a network dimension, from a sporadic, interpretative approach to a more systematic empirical examination.

Table 3.1 A summary of IOS studies and their findings related to IOS, development approaches

AUTHORS	METHODOLOGIES	LEVELS OF ANALYSIS	STATED ROLES OF IOS	RESEARCH PERSPECTIVES
Kaufman (1966)	Ideas & conceptual framework	Dyadic (1:1)	Increase efficiency	*Techno-economic*
Barret & Konsynski (1982)	Ideas & conceptual framework	Industry Dyadic	Increase efficiency Increase effectiveness	*Techno-economic*
David & Spector (1983)	Case study	Organizational Dyadic (1:1)	Increase efficiency Increase effectiveness	*Techno-economic*
Ives & Learmonth (1984)	Ideas & conceptual framework	Organizational Dyadic (1:1)	Increase efficiency Increase effectiveness	*Techno-economic*
Cash & Konsynski (1985)	Ideas & conceptual framework	Organizational Industry Dyadic	Increase efficiency Increase effectiveness Power jockeying	*Techno-economic*
Johnston & Vitale (1988)	Ideas & conceptual framework	Organizational Dyadic (1:1)	Increase efficiency Increase effectiveness Power jockeying	*Techno-economic* *Socio-political*
Copeland & McKenney (1988)	Ideas & conceptual framework	Organizational Industry	Increase efficiency Increase effectiveness Increase market power Enhance learning/expertise exploitation	*Learning*
Bakos (1991)	Ideas & conceptual framework	Industry	Increase efficiency Increase effectiveness Power jockeying among participants	*Techno-economic*

3.2.1 From a Static View to a Dynamic View

As indicated in Table 3.1, prior research on IOS has a heavy focus on the *techno-economic* perspective, which holds a relatively static view of IOS.

The *learning* perspective highlights a shift in the focus of studying IOS from a relatively static dimension to a more dynamic dimension, yet it remains under-explored. The *learning* perspective emphasizes that sustained performance improvements via IOS come from a dynamic learning process of continuously seeking IOS opportunities, exploiting identified opportunities and generating new IOS-based applications. Success of aggressive IOS users, such as American Airlines, has examplified this dynamic view of IOS's roles.

Evidence from some empirical studies has also revealed the importance of this dynamic view. For instance, Venkatraman and Zaheer (1994) have conducted a quasi-experiment design in the insurance industry. They studied the effects of IOS on performance improvements in efficiency and effectiveness. Their results presented weak evidence for efficiency improvement, while providing no support for effectiveness improvement. Venkatraman and Zaheer suggest that their results may be attributable to their experiment design, which failed to account for the learning effects related to IOS.

Clearly, a dynamic perspective is much needed for studying the roles of IOS.

3.2.2 From a Dyadic View to a Network View

Prior IOS research has focused on three primary levels of analysis: the firm-level, the customer-supplier dyad, and the industry-level, as illustrated in Table 3.1. At the firm-level, IOS can induce changes in (1) internal business procedures (e.g., order entry, production planning, report formats, and communication patterns); (2) training and selection of employees; and (3) organizational structure and business strategy (e.g., cost reduction and product differentiation) (Cash and Konsynski 1984; Johnston and Vitale 1988). At the dyadic-level, IOS can radically change the balance of power in the customer-supplier relationship and greatly influence their joint performance (Holland 1995; Webster 1995; Hart and Saunders 1997). At the industry-level, some IOS can bring significant impacts on the industry structure. They provide entry and exit barriers in industry segments, and shift the competitive position of intra-industry competitors (Cash and Konsynski 1984; Copeland and McKenney 1988; Bakos 1991).

However, with the proliferation of IT-mediated interfirm collaboration, a firm's performance becomes increasingly dependent on its embeddedness in a network of electronically

interconnected relations. Electronic networks can span multiple firms and industries along the value/supply chain. As such, a network perspective is much needed in studying IOS's roles in achieving firm competitiveness.

3.2.3 From A Single View to A Synthesized View

As indicated in Table 3.1, prior IOS research largely focuses on ideas and conceptual frameworks, and case studies. They are interpretative studies, subject to sporadic anecdotes, personal opinions, and experiences, rather than systematic research. Given IOS are a rapidly evolving and widespread phenomenon, a systematic empirical examination is much needed for providing better insights about the roles of IOS.

3.3 Research Questions

Literature review has revealed that prior IOS research largely holds a relatively static view of IOS. Many of the studies focus on the customer-supplier dyad and are based on interpretative, case-oriented approaches. They do not provide sufficient account for IOS's roles in achieving firm competitiveness.

As such, the following research questions are stimulated:

(1) How does the use of IOS?

(2) How do IOS affect the relationship between the use of IOS and firm performance?

Answers to these questions can deepen our understanding of IOS's roles in today's e-business. They can also guide a firm's e-business initiatives in improving performance via IOS.

To address the limitations of prior IOS research, this dissertation introduces social network analysis and competitive dynamics research into the study of IOS. Social network analysis applies mathematical models (in graph theory) to study the network structure and the influence of network structure on resource flows and firm behaviors. Social network analysis allows for a multi-level analysis (including firm-level, pair-level, and network-level) of IOS-mediated networks.

Competitive dynamics research is grounded in Schumpeter's (1934) theory of creative destruction and Austrian economics. It emphasizes the dynamic process of how firms act and react to the competitive environment in order to achieve competitiveness. There are three distinguishing characteristics of competitive dynamics research (Smith et al. 2001). The first is

its focus on the specific, observable firm actions in the market. Each of these actions is distinctive with regard to the time they occur (day/month/year) and where (the market) they take place. The second is its focus on competitive interdependence. In other words, firms are not independent; they feel the moves of one another and tend to interact. The third is its broad attempt to explain both the causes and consequences of action and reaction with particular emphasis on the performance consequences of these dynamics. These three characteristics of competitive dynamics research add value to the IOS study that is conducted in this dissertation. The first characteristic introduces observable measures (i.e., specific firm actions) to examine IOS impacts in interfirm networks. The latter two characteristics bring in a dynamic view of using IOS in influencing firm behaviors and the resultant firm performance.

To conduct a systematic research, this dissertation identifies critical constructs of *IOS use*, *network structure*, and *competitive behavior* and the relationships among these constructs, formulates hypotheses that can be generalized across various cases of IOS, and conducts an empirical testing based on the second-hand data collected in the automotive industry.

Figure 3.2 illustrates the approach used in this dissertation to address the two research questions posed earlier and the limitations of prior IOS studies. The bolded parts indicate new focuses of this dissertation.

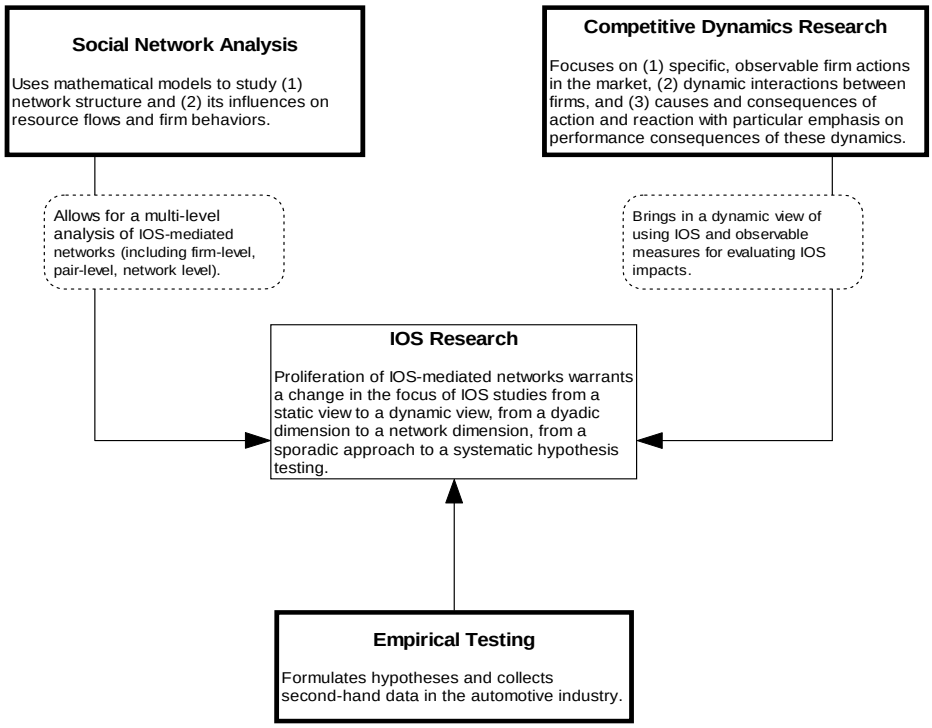


Fig 3.2 T

Chapter 4 Research Model: Competitive Dynamics in IOS-Intensive Networks

This chapter introduces a model of competitive dynamics in IOS-intensive networks. This research model examines how a firm's network position and its IOS use co-evolve and subsequently influence the firm's competitive actions undertaken to improve performance. By bringing a dynamic, network, and systematic perspective into the IOS study, this model adds depth to our understanding of IOS's roles in influencing firm performance in e-business.

4.1 Background

Interorganizational systems, by providing a digital infrastructure for sharing task performance between firms, have greatly enhanced the competitiveness of many firms.

4.1.1 An IOS-Enabled Collaboration Process

To engage in collaboration via IOS, a firm tends to go through six common phases: *market recognition, partner exploitation, technology matching, partnership formation,*

An IOS-mediated collaboration episode starts with a firm's *recognition of market opportunities (or needs)*. It then exploits the market opportunity through *identifying and selecting potential collaboration partners* and *matching with appropriate IOS candidate technologies*.

In the *partnership formation* phase, a firm *establishes electronic partnerships* with the collaborating firms through activities of technology implementation and governance structure establishment.

The *operation* phase involves collaborating with partners in value activities ranging from *procurement, to product development, to production, logistics, to marketing & sales, and service*.

A collaboration episode *terminates* when collective objectives of the collaborating firms have been attained or when collaboration yields intolerable conflicts. The operation ends and partnership assets are dispersed.

4.1.2 E N L R

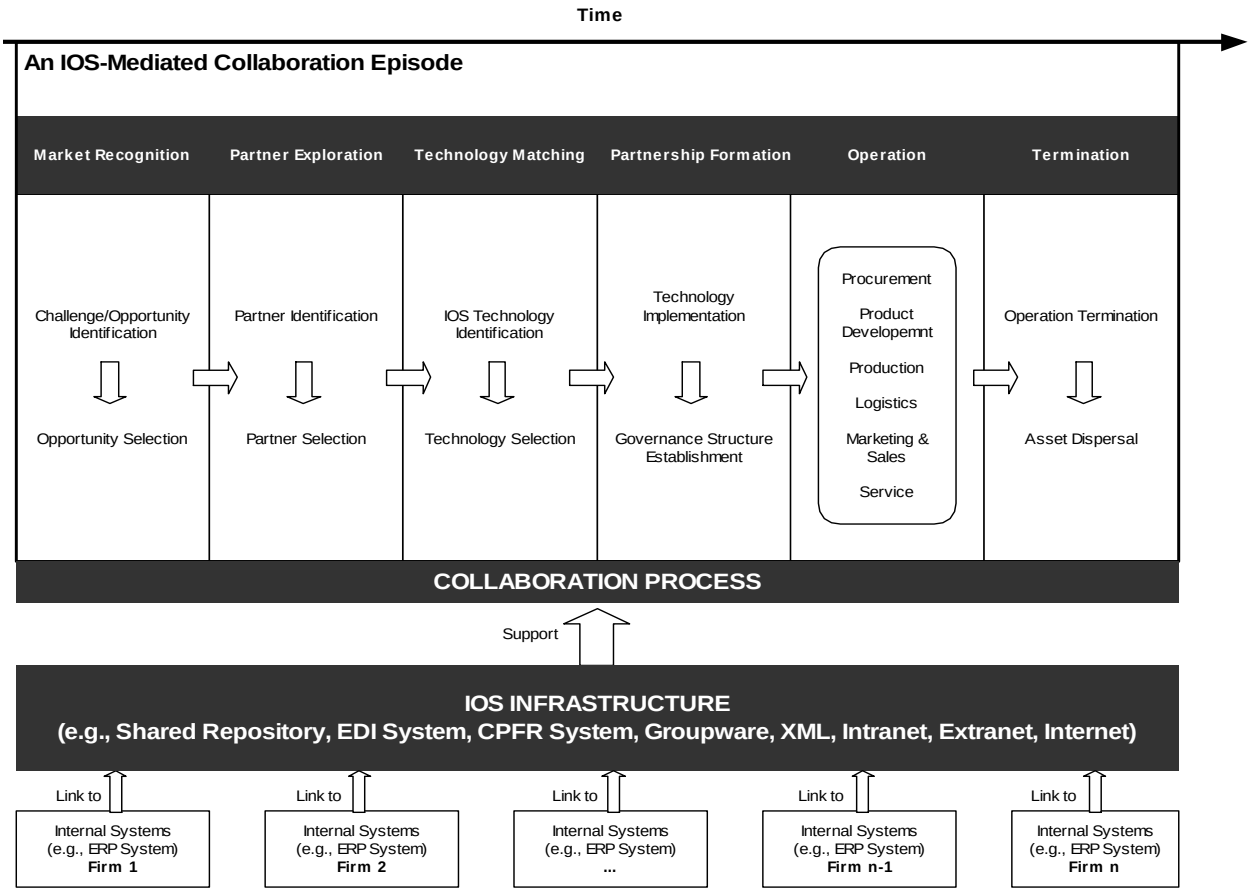


Fig 4.2 IOS

As indicated in Figure 4.2, during an IOS-mediated collaboration episode, a firm may collaborate with one or more partners by configuring and reconfiguring IOS resources to collectively produce a product or deliver a service. Concurrently, a firm may engage in several collaboration episodes with the same or different partners. A firm may engage in joint marketing arrangements with its partners through shared repositories. It may allow its customers to place orders through the company's intranet. It may jointly schedule production and forecast sales with its suppliers through an EDI system. It may also use groupware or an extranet for joint product design with its partners.

IOS extend a firm's ability to reach and collaborate with diverse partners – of whom, some may be old relationships, some may be new, some may be difficult to reach in the conventional setting. Once the firm begins collaborating via IOS, it develops experience at managing interorganizational interdependencies and a reputation as an electronic partner (Ching et al. 1992). Over time, the firm develops capabilities for interacting with other firms electronically. Experience with IOS collaboration proves a fertile ground for both further formal electronic partnerships and an expanding array of informal relationships (Powell et al. 1996). It reveals market opportunities, collaboration opportunities, and/or IOS-based innovations a firm would otherwise be unaware of. When two firms share a common third electronic partner, even in the absence of prior direct relationships, they are likely to have information about each other and may be mobilized to enter into electronic collaboration in the future (Gulati 1995).

As more and more IOS links are established, over time, these links create patterned networks of electronic partnerships, in which a firm and its IOS partners are embedded. These electronic networks, in their various arrangements and patterns, become the loci of resources. They provide timely access to resources that cannot be generated internally, and further develops a firm's internal competencies (Powell *et al.* 1996). Typically, three types of resource flows – *asset flows, knowledge flows,* and *status flows* (Gnyawali and Madhavan 2001) – reside in an electronic network. *Asset flows* involve such resources as money, equipment, technology (including IOS technologies), and organizational skills that flow or are shared between electronically connected firms in the network; *knowledge flows* include knowledge that flows or is shared across network firms about their strategies, resource profiles, as well as market and technology opportunities; *status flows* are flows of legitimacy, influence, and recognition from higher-status firms to lower-status firms.

4.1.3 Effects of Network Structure and IOS Use on Competitive Actions

In sociology and management literature, there is a growing understanding that (1) economic action is embedded in a network of interfirm relations (Granovetter 1985; Uzzi 1996; Uzzi 1997), and (2) network structure shapes resource flows, awareness of competitive context, and intent to act, and thus actions that are subsequently taken to compete against rivals (Chen 1996; Gnyawali and Madhavan 2001). Extending these notions of structural embeddedness to a network of electronically linked relations, IOS use can tighten process integration between the participants and also extends a firm's reach to those significant partners who may not be reachable at a low cost, enabling real-time access to critical knowledge that would otherwise be inaccessible via conventional means. Meanwhile, by bringing forth disruptive forces of digitization, unbundling information and physical value chains, and disaggregating organizational infrastructures for customer/supplier relationships and business processes, IOS have offered significant opportunities for enabling agile moves (Sambamurthy et al. 2003).

IOS have also offered greater avenues for competitive actions by providing innovative functionalities and applications (e.g., wireless customer relationship management and supply chain systems, Internet-based EDI). Furthermore, through joint problem solving and cooperative arrangements among IOS participants, knowledge transfer can be more fine-grained, tacit, and holistic (and thereby more transparent) than the typical price data of pure market exchanges (Uzzi 1997). As such, this electronic network not only provides the resources upon which the firm may draw for actions to enhance its performance, but also can serve as an important search and monitoring mechanism to promote a firm's awareness of feasible actions that would take advantage of emerging market opportunities (Gnyawali and Madhavan 2001). A firm that is able to place itself in an advantageous position in the network and use IOS effectively is more likely to have access to resources that offer a greater potential for superior firm performance than that available to firms that do not have such resource access.

Therefore, this dissertation contends that in an electronic network, network structure and IOS use are two key determinants of competitive actions for improving firm performance. Firm performance may be gauged in P^2AIR, where P^2 stands for profits and productivity (or efficiency), *A* for agility (or alertness and responsiveness), *I* for innovation, *R* for reputation (or market influence) (Holsapple and Singh 2001).

4.1.4 Bi[illegible]M

This section introduces a competitive dynamics model that examines competitive actions in IOS-intensive networks. It is based on several premises. (1) The relevant network is defined as consisting of a collection of competitors and their IOS partners and involving flows of assets, knowledge, and status among member firms. (2) The competitive dynamics model applies in the general setting where cooperation and competition co-exist in the network. Participating firms have formal, contractual ties or electronic partnerships with others in the network. Competing firms in the network may or may not have collaborative relationships with each other. (3) The research model assumes that all competing firms have a similar competitive intent (i.e., to achieve superior performance relative to their competitors), but competing firms may differ in both their alertness of competitive context and their ability to act or react against competitors[1]. (4) All competing firms under study have voluntary use of IOS. In other words, their adoption of an IOS and its usage is non-mandatory.

4.2 [illegible]Hp

4.2.1 [illegible]Cs

Network Structure

In prior research, three levels of structural properties have been used to explain network structure. They are firm-level properties (e.g., *degree centrality, tie strengt*h) (Granovetter 1985; Gnyawali and Madhavan 2001), pair-level properties (e.g., *structural equivalence*) (Chen 1996; Ferrier and Smith 1999; Gnyawali and Madhavan 2001), and network-level properties (e.g., *betweenness centrality, density*) (Granovetter 1985; Gnyawali and Madhavan 2001). Integrating previous studies, this section introduces a research model that treats all three levels of structural properties (firm-level, pair-level, and network-level) in terms of three network constructs. These three constructs are: (1) *structural similarity* (a pair-level structural property), (2) *degree centrality* (a firm-level structural p6 200.57938 Tm(9 Tf0.0005 200.57938 Tm(6 20The8 Tm740.0005 200.5793

key influence on firm behavior and firm performance (e.g., Rice and Aydin 1991; Rice 1994; Brass and Burkhard 1993; Powell et al. 1996).

Structural similarity refers to the network position of two firms that have a similar pattern of relations with others in a network (Rice and Aydin 1991). Structurally similar firms may or may not have direct ties with each other. *Structural similarity* is a pair-level measure of how similar two firms' patterns of network relations are.

Degree centrality measures the extent to which a focal firm is connected with other firms in a network (Freeman 1979). It is a firm-level measure of a firm's position in acquiring resources in a network by virtue of directly linking to others.

Betweenness centrality measures the extent to which a focal firm falls on the shortest paths of pairs of other firms in a network (Freeman 1979; Burt 1992). It is a network-level measure of a firm's relative position in acquiring resources in comparison to other participants in the network.

IOS Use

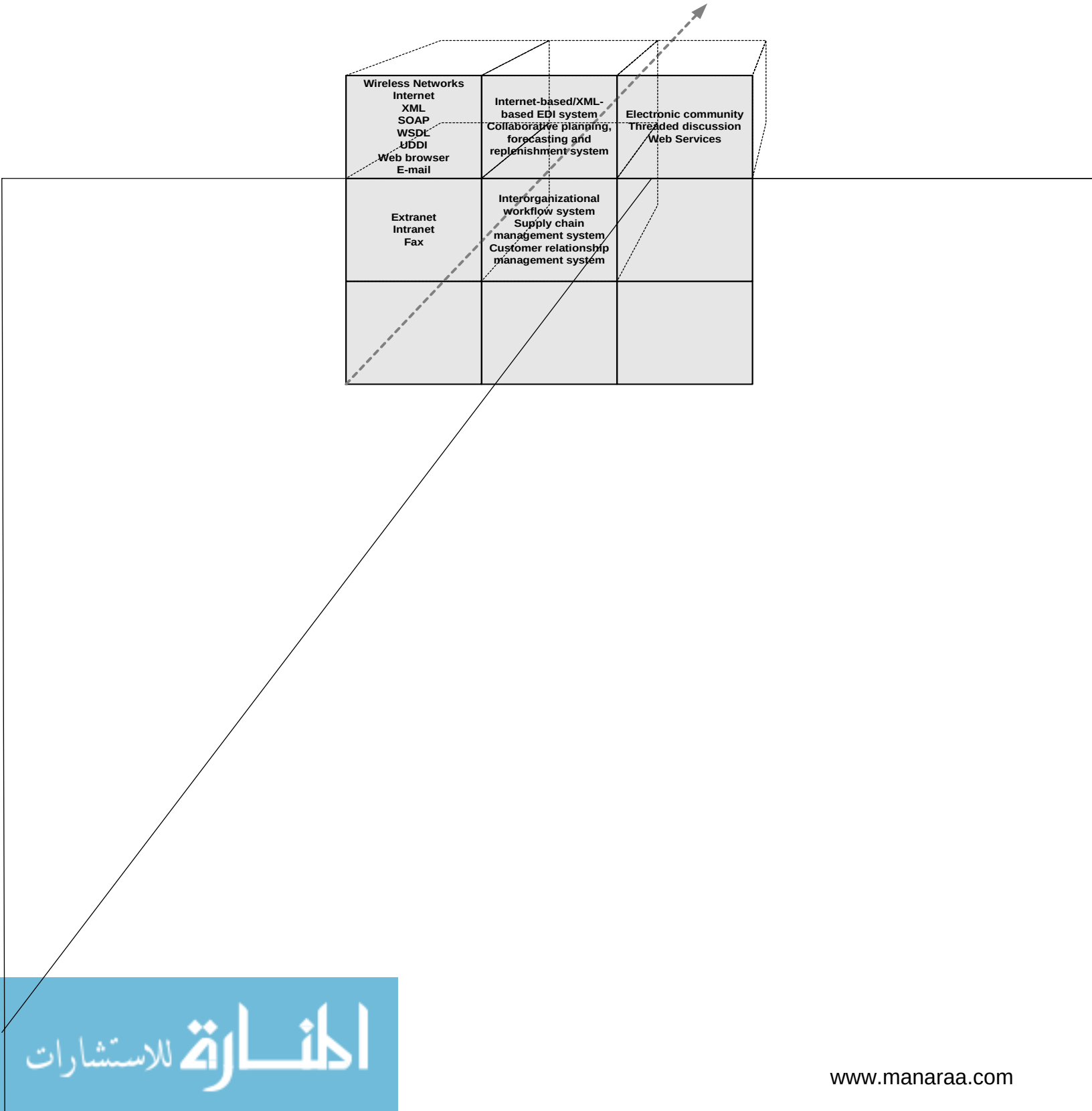
IOS use is examined at three dimensions: (1) *reach*, (2) *range*, and (3) *diversity of use*. These three dimensions are identified as relevant to IOS use in prior IOS studies (e.g., Johnston and Vitale 1989; Keen 1991; Kumar and van Dissel 1996; Zmud and Massetti 1996). Figure 4.3 illustrates these three dimensions.

IOS Reach refers to the extent to which different types of partners (e.g., customers, suppliers, and competitors) are linked via IOS (Johnston and Vitale 1989; Keen 1991). Reach ability may vary from IOS to IOS. Some IOS only allow linkages to firms with a similar technological base (e.g., proprietary EDI). Some IOS allow linkages to firms with different technological bases (e.g., extranets). Some others are able to reach any firm at any place (e.g., the Internet and e-mail systems).

Range refers to the extent to which different technological functionalities and application services are shared and supported by IOS (Keen 1991; Weill et al. 2002; Chi & Holsapple 2005). Based on the collaboration-oriented IOS classification introduced in Chapter 2, range is categorized in terms of three IOS classes – *pooled knowledge resources IOS*, *value/supply-chain IOS*, and *networked IOS*.

A firm may use IOS to support collaborative activities in different business functions, such as procurement, product development, and marketing & sales. *Diversity of IOS use* reflects

the extent to which each specific business function's overall messages, tasks, and operations are supported by IOS (Zmud and Massetti 1996).



potential to disrupt the competitive status quo, causing disequilibrium in the product-market space (Ferrier and Smith 1999).

This study centers on the firm-level analysis of competitive action in a given repertoire year, i.e., an entire set of competitive actions carried out by a firm in a given year. Prior research at this level of analysis has studied a variety of action characteristics (e.g., the *action timing*, the average *duration* of an uninterrupted series of actions, the within-firm *variability* or *unpredictability* of a series of actions taken over time) and their consequences on firm performance. (See Smith et al 2001 for a comprehensive review.) A robust link between competitive action and firm performance has been identified in competitive dynamics research (Deephouse 1999; Ferrier et al. 1999; Miller and Chen 1994, 1996; Ferrier 2001). The existence of this link is important in developing the research model introduced in the next section.

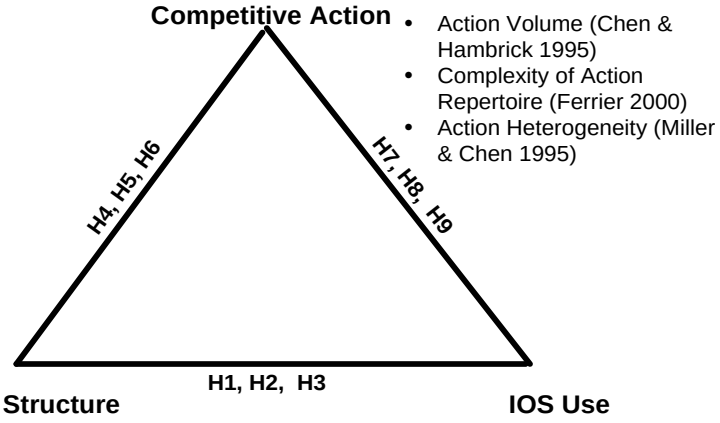
This study has a particular focus on three important characteristics of competitive action: *action volume, complexity of action repertoire,* and *action heterogeneity*. These characteristics are among the most salient and robust constructs in the competitive dynamics research. *Action volume* is found to have the strongest and most consistent impacts on firm performance (Smith et al. 1991, 1996, 1997; Chen and MacMillan 1992; Chen and Hamrick 1995; Hamrick et al. 1996; Young et al. 1996; Ferrier et al. 1999, 2002; Ferrier 2001). *Action heterogeneity* is found to have a strong influence on changing market shares and shifting the rules of competition (Cave and Ghemawat 1992; Gimeno 1999; Ferrier et al. 1999). *Complexity of action repertoire* (or *simplicity of action repertoire*) has been identified as a key factor in predicting firm performance (Miller and Chen 1996). Action simplicity sometimes can be a powerful competitive tool by yielding numerous economies and allowing firms to concentrate on whatever they do best. But in today's increasingly uncertain or turbulent environment, simple repertoires may contribute to overspecialization *vis-à-vis* the wide range of market contingencies and thus may be insufficiently comprehensive to cope with the many challenges posed by the hypercompetition in the product-market space. So *complexity of action repertoire* is also of interest to this study.

Action volume denotes the total number of competitive actions carried out by a firm in a given time period (Chen and Hambrick 1995).

Complexity of action repertoire refers to the extent to which a series of a firm's competitive actions carried out in a given time period is comprised of a wide (versus narrow) range of actions of different types (Ferrier 2000).

Action heterogeneity is the extent to which a firm's entire set of competitive actions carried out in a given time period deviates from the industry norm (Miller and Chen 1995).

As illustrated in Figure 4.4, this study examines three paired relationships of *network structure-IOS use*, *network structure-competitive action*, and *IOS use-competitive action*. The subjects under study are competing firms embedded in a network of electronically linked relations.



- Structrual Similarity (Rice & Aydin 1991)
- Degree Centrality (Freeman 1979)
- Betweenness Ce

2001). Thus, they are likely to display similar patterns of IOS use (e.g., with whom to establish IOS links, which activities to engage in via IOS, as well as which IOS candidate technologies to implement for supporting certain interfirm applications). On the other hand, in an IOS-intensive network, two competing firms with a similar IOS usage pattern are likely to possess similar experiences and capabilities for managing interfirm interdependencies, and thus tend to have a similar pattern of interactions with others in the network (e.g., to interact with similar partners who possess similar technological capabilities, to engage in similar collaborative arrangements that may be managed with existing IOS capabilities).

Therefore, the following hypothesis is advanced:

Hypothesis 1: All else being equal, structural similarity between a pair of competing firms in an electronic network is positively related to their similarity in (a) IOS reach, (b) IOS range, and (c) diversity of IOS use.

Centrality

A firm possesses a high centrality when it places itself in a central position of a network by virtue of being involved in many (significant) electronic partnerships. The central firm may possess a high *degree centrality* by directly linking to diverse partners and thus having direct access to its partners' resources. The central firm may also possess a high *betweenness centrality* and play an important intermediary role by occupying the sparse region in a network called a "structural hole" (Burt 1992). A structural hole exists between two firms that are connected through another firm and thus do not have direct links with each other. Structural holes present opportunities for brokering resource flows among participants in a network. So, a central firm with structurally advantageous position is better able to sense the growth opportunities for leveraging IOS than less central competitors.

Linking to diverse partners with different IT capabilities, different formats or proprietary software and hardware requires the use of different IOS technologies. Each technology may possess advantages and disadvantages, and offer different IOS reach and range capabilities. For instance, the Internet[2] provides an open, flexible platform for firms to communicate with their

[2] The Internet integrates technologies, such as WWW, HTTP, Telnet, FTP, NTTP, and E-mail. It provides a high flexibility for quick electronic access to external data and access to potential customers and partners around the world. But as an open platform, security concerns have posed problems for the use of the Internet (Strader et al. 1998).

external environment (e.g., potential customers, suppliers, competitors). An intranet/extranet[3] provides a common platform that is more flexible than EDI and groupware, is not geographically constrained like a LAN or WAN, and is also more secure than the Internet (Strader et al. 1998). EDI[4] and groupware[5] are efficient when there is a stable community of group members (Upton and McAfee 1996). Thus, a firm with a high centrality (degree centrality and/or betweenness centrality) is likely to have an extensive IOS reach and range, and to use IOS to support its participation in diverse collaboration.

On the other hand, extensive IOS reach (by reaching many significant partners that otherwise would be difficult to realize at a low cost), range (by providing broad, innovative functionalities), and diversity of use (by supporting diverse collaborative arrangements) can help (1) strengthen existing relationships, (2) create new relationships, and (3) alter undesirable relationships (Konsynski 1993; Holland 1995). They enhance a firm's ability to locate in an advantageous network position and thus are likely to increase the firm's centrality in the network.

Furthermore, extensive IOS reach, range, and diversity of use can increase a firm's knowledge and experience in managing the technological infrastructure. Accumulation in this knowledge and experience is likely to prompt the firm to engage in new, significant value

[3] Intranets/extranets combine the advantages of the Internet (global access) with those of local area networks (LANs) (security, easy management of resources and client/server functionality). Based on Internet technology and protocols, intranets/extranets provide information in a way that is immediate, cost-effective, easy to use, rich in format, versatile and secure over a private network (Strader et al. 1998). They allow connections between companies with different technological bases.

[4] EDI system is among the oldest forms of IOS used among companies with similar technological bases. It is used most frequently to exchange data such as purchase orders, to execute transfers of electronic funds, or to provide delivery information to customers. EDI standards specify how each of these information transfers should be structured so that any party using those formats can accept transmission from any other party using them. Despite the existence of some common standards, many EDI systems are inflexible and proprietary. As a consequence, it is expensive and time-consuming both to add new members to such a network and to expand the types of information exchanged on it. Depending on the particular network, it can cost tens of thousands of dollars to add an EDI link and to mold one's own computer protocols to those used by the dominant customer. Such attributes mean that conventional EDI is best suited for linking the members of a relatively small, stable community—particularly a community in which one member is powerful enough to demand adherence to its communications standards. Conversely, it is ill-suited for communities with a large number of transient members or members with limited IT resources. With traditional EDI, every time a new member is added to the existing system, a dedicated line—and in many cases, a special terminal on the member's premises—must be installed. Conventional EDI has other limitations. It does not easily permit members of the community to exchange information with one another, because the system has to be specially configured to create each link between each pair of members that want to communicate. EDI networks tend to be used only to send information in batches and are awkward for creating real-time links between sites (Upton and McAfee 1996). Currently, more and more EDI systems are migrating toward Internet-based. The Internet has greatly extended the reach of EDI for supporting interfirm collaboration.

[5] Groupware addresses some of EDI's drawbacks and has become popular for building collaborative environments. Groupware encompasses previously considered independent technologies (e.g., messaging, conferencing, collaborative authoring, workflows and coordination, and group decision support) and has the ability to support the dynamic movement between and through three modes of group work: communication, coordination, and cooperative work. First, groupware pro

activities or establish new, significant relationships by exploiting different levels of IOS capabilities. This accumulation in technological expertise thus can lead to increased network centrality.

Therefore, the following hypotheses are advanced:

Hypothesis 2: All else being equal, degree centrality is positively related to (a) IOS reach, (b) IOS range, and (c) diversity of IOS use.

Hypothesis 3: All else being equal, betweenness centrality is positively related to (a) IOS reach, (b) IOS range, and (c) diversity of IOS use.

(2) R p v N h n C p A n

Structural similarity

Structurally similar competitors in a network interact with similar others in similar ways. Even though they may not directly link to each other, they tend to have access to similar assets, knowledge, and status flows (Gnyawali and Madhavan 2001), thus leading to similar alertness, similar resources, and similar competitive actions that are subsequently taken.

Therefore, the following hypothesis is suggested:

Hypothesis 4: All else being equal, structural similarity between a pair of competing firms in an electronic network is positively related to their similarity in action patterns.

Centrality

High centrality can lead to greater volume and speed of resource flows (Gnyawali and Madhavan 2001). Because network ties are conduits for resources (asset, knowledge, and status), a central firm tends to have greater access to external assets of connected partners, such as technology, money, and management skills. Being at the confluence of a greater number of knowledge sources through its ties, a central firm is likely to obtain new knowledge (Rogers 1995), and enjoy earlier access to important new developments than less central competitors (Valente 1995). In addition, high centrality implies higher status and power (Wasserman and Faust 1994), because a firm that receives many ties (Brass and Burkhardt 1992) and engages in many collaborative arrangements (Powell et al. 1996) is considered to be a prestigious firm and enjoys a high market influence (Zaheer and Zaheer 1997). Thus, a central firm is better able than less central competitors to place itself in a structurally advantageous resource position and to benefit from a positive resource asymmetry.

Resource flows and resulting asymmetry among competitors in a network influence competitive behavior (Gayawali and Madhavan 2001). First, greater access to assets through network ties enables the central firm to undertake a greater number and diversity of asset-intensive competitive actions. Second, earlier access to relevant new knowledge and technological developments will position the central firm well for initiating competitive actions against or responding to competitors. Greater access to knowledge also promotes the central firm's alertness of its competitive environment (e.g., what is going on with competitors, their competitive motives, strategies, and potential action agendas), broadens the central firm's range of feasible competitive actions, and enhances the firm's ability to undertake moves in a manner different from others. Finally, high status and market influence associated with high centrality also strengthens the central firm's resource position for launching competitive moves.

Therefore, the following hypotheses are advanced:

Hypothesis 5: All else being equal, degree centrality is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.

Hypothesis 6: All else being equal, betweenness centrality is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.

(3) R p w d C A

By linking to many significant partners, extensive IOS reach not only promotes a firm's awareness of opportunities for competitive actions, but also allows a firm to achieve greater operational (both internal and interorganizational) efficiency and effectiveness, enhancing the firm's ability to respond to external environment (e.g., how effectively the firm responds to customer needs, how fast the firm competes against aggressive actions from competitors, how adaptable the firm is to regulatory or economic changes). Thus, extensive IOS reach increases a firm's ability to launch a greater number and variety of competitive actions.

Extensive IOS range offers the opportunity of providing advanced functionalities and process support. These advanced functionalities and process support enable innovative actions (e.g., e-auction, Web hosting, Web-based customer innovation, online interactive multimedia marketing campaign), and broaden the range of action repertoire.

Extensive use of IOS in a diverse set of collaborative activities enhances a firm's ability to coordinate the interdependencies among various partners and activities. When a firm engages

in a collaborative activity, collaboration can both increase the economies of scale and scope and the rate of learning. The firm accumulates experiences through collaboration. A broader range of collaborative efforts can provide greater opportunities for refining organizational routines for cooperation, and render a firm more versatile in more diverse activities (Powell et al. 1996). As such, enhanced capability for managing interdependencies electronically enhances a firm's response ability to undertake a greater number and variety of actions. Meanwhile, the firm is also in a better position to learn what to benefit from which electronic partner, what difficulties may arise, and how to function within a context of multiple cooperative ventures. Insights about these opportunities and challenges will increase the firm's awareness for identifying more targeted actions.

An extensive use of IOS also promotes process integration and coordination between a firm and its partners. Tight integration reduces process delays and information distortion. It increases visibility of partner performance, thus enhancing trust between the firm and its partners. A trusting relationship facilitates tacit knowledge transfer and further promotes the firm's awareness of opportunities for competitive actions of which it would otherwise be unaware.

Furthermore, an extensive use of IOS (*reach*, *range*, and *diversity of use*) allows more timely access to diverse external environment data, such as market data, customer/supplier data, technology innovation data, global financial data, and economic data (Strader et al. 1998). Real-time access to critical knowledge (information) enhances a firm's ability to locate itself in a knowledge-rich position for exploiting more market opportunities, thus launching moves with greater precision, speed, variety, and surprise.

Therefore, the following hypotheses are advanced:

Hypothesis 7: *All else being equal, IOS reach is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.*

Hypothesis 8: *All else being equal, IOS range is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.*

Hypothesis 9: *All else being equal, diversity of IOS use is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.*

4.2.3 Competitive Dynamics in Electronic Networks

Figure 4.5 illustrates a model of competitive dynamics in electronic networks that summarizes the nine foregoing hypotheses. The model contends that in a network of structurally embedded electronic partnerships, network structure and IOS use co-evolve and influence competitive behavior. To improve performance, a firm may initiate an IOS-mediated collaboration episode or a series of episodes by terminating old links, establishing new links, and engaging in new value activities. As such, network structure determines IOS use. On the other hand, IOS extend a firm's reach to those significant partners who can not be reached conventionally, and thus influences the network structure that subsequently evolves.

By shaping resource flows (asset, knowledge, and status) in the network, network structure and IOS use influence the range of competitive actions that may be taken. Successful actions (actions which may generate new customers and profits, or greater efficiency or innovation, or larger market influence) can stimulate countermoves from competitors (Smith et al. 2001) and induce changes in the market (e.g., supply-demand conditions, market segmentations, entry-exit barriers, or industry competitive forces). Market changes, emerging technologies, and accumulation of technological expertise, in turn, present new opportunities and challenges, which further change the patterns of IOS use, network structure, and the subsequent actions taken against rivals.

The co-evolving pattern of network structure, IOS use, and competitive action describes the competitive dynamics in electronic networks. The foregoing nine hypotheses characterize this dynamics. This study focuses on the paired relationships between the three constructs of network structure, IOS use, and competitive action, and empirically investigates these nine hypotheses. The link between competitive action and firm performance has been well-established in competitive dynamics literature and is therefore not investigated here.