2005

COMPETITIVE DYNAMICS IN ELECTRONIC NETWORKS - ACHIEVING COMPETITIVENESS THROUGH INTERORGANIZATIONAL SYSTEMS

Lei Chi
University of Kentucky

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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
2005
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ABSTRACT OF DISSERTATION

COMPETITIVE DYNAMICS IN ELECTRONIC NETWORKS
– ACHIEVING COMPETITIVENESS THROUGH INTERORGANIZATIONAL SYSTEMS

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
COMPETITIVE DYNAMICS IN ELECTRONIC NETWORKS
– ACHIEVING COMPETITIVENESS THROUGH INTERORGANIZATIONAL SYSTEMS

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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 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-opitation” (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

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<td>Collaborative construction</td>
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<tr>
<td>Web services</td>
<td>(software applications identified by uniform resource identifiers and supporting direct interactions with other applications using XML-based messages exchanged via Internet protocols)</td>
</tr>
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<td>XML</td>
<td>(Extensible Markup Language, the universal format for exchanging structured documents and data over the Internet)</td>
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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

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Pooled Interdependency</th>
<th>Sequential Interdependency</th>
<th>Reciprocal Interdependency</th>
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</thead>
<tbody>
<tr>
<td>Coordination Mechanisms</td>
<td>Standards &amp; Rules</td>
<td>Standards, Rules, Schedules &amp; Plans</td>
<td>Standards, Rules, Schedules, Plans &amp; Mutual Adjustment</td>
</tr>
<tr>
<td>Structurability</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Amount of Direct Human Interaction</td>
<td>Minimum</td>
<td>Intermediate</td>
<td>Highest</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Type of IOS</th>
<th>Pooled Knowledge Resources IOS</th>
<th>Value/Supply-Chain IOS</th>
<th>Networked IOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Knowledge Exchanged</td>
<td>Structured</td>
<td>Structured Semi-Structured</td>
<td>Structured Semi-Structured Unstructured</td>
</tr>
<tr>
<td>Focus of Implementation Technologies</td>
<td>“Codification”</td>
<td>“Codification”</td>
<td>“Personalization”</td>
</tr>
</tbody>
</table>

(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

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

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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

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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

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Chapter 3 Prior IOS Research: IOS’s Roles 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 Roles 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, 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.
Figure 3.1 Prior research regarding IOS’s roles in achieving firm competitiveness
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 Prior 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>
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<td>Li &amp; Williams (1999)</td>
<td>Case study</td>
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<td>Hong (2002)</td>
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</tbody>
</table>
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 exemplified 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 Sporadic View to A Systematic 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 do firms achieve competitiveness through IOS?

(2) How do IOS influence competitive behaviors of the competing firms in intertwined electronic networks?

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 to study the network structure and 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.

Figure 3.2 The approach of this dissertation to address the research questions

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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 Research 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-Mediated Collaboration Episode

To engage in collaboration via IOS, a firm tends to go through six common phases: market recognition, partner exploitation, technology matching, partnership formation, operation, and termination (Strader et al. 1998; Wheeler 2002; Hartono and Holsapple 2004). These six phases comprise an IOS-mediated collaboration episode, as illustrated in Figure 4.1.

<table>
<thead>
<tr>
<th>An IOS-Mediated Collaboration Episode</th>
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<tr>
<td><strong>Market Recognition</strong></td>
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<tr>
<td>Challenge/Opportunity Identification</td>
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<td>Opportunity Selection (Market Initiative)</td>
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Figure 4.1 An IOS-mediated collaboration episode
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 Electronic Networks as Loci of Resources

![Collaboration Process Diagram](image)

**Figure 4.2 IOS as common infrastructure between firms**
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 Structural Embeddedness of Competitive Actions in Electronic Networks

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 Boundaries of the Research Model

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. (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 Research Model and Hypotheses

4.2.1 Variable Constructs

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 strength) (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 property), and (3) betweenness centrality (a network-level structural property). These three structural properties are found in many prior studies to have

1 Competitive intent, alertness, and response ability are three antecedents that determine competitive action (Chen 1996). In electronic networks, different structural properties of collaborative relationships can influence and also be influenced by patterns of IOS use. Meanwhile, network structure and IOS use shape a firm’s alertness to competitive context, as well as its resource acquisition thus response ability. But, competitive intent may or may not be directly related to network structure and IOS use. Thus, assuming competitive intent as constant across competing firms would exclude confounding factors and allow for a more accurate examination of how competitive actions are influenced by network structure and IOS use.
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).

Competitive Action

Competitive actions are defined as externally-oriented, specific, and observable competitive moves that a firm takes to enhance performance during a period of time (Smith et al. 2001). Competitive actions can be either tactical or strategic. Strategic actions usually involve a larger expenditure of resources, a longer time horizon, and a greater departure from the status quo than do tactical actions (Miller and Chen 1994). Strategic actions may include major facility expansions, joint collaborative arrangements, and important new product, service or technology developments, while tactical actions include price changes, advertising campaigns, and incremental product or service adjustments. Action events can range from procurement, product development, and production, to marketing & sales, and service. These actions have the
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.

![Figure 4.4 The links between network structure, IOS use, and competitive action](image)

### 4.2.2 Hypotheses

Using the variable constructs described for the three vertices of Figure 4.4, nine hypotheses are generated for characterizing the three pairwise relationships involving these vertices. These hypotheses combine to flesh out a model of competitive dynamics in electronic networks.

(1) **Relationship between Network Structure and IOS Use**

**Structural similarity**

Structurally similar firms occupy similar resource positions in an electronic network. Having access to resources (including assets, knowledge, and status) in similar ways, structurally similar firms tend to have similar attitudes and resource profiles. When two competing firms are structurally similar, they tend to model on and imitate each other (Gnyawali and Madhavan...
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 provides an open, flexible platform for firms to communicate with their

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3 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 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 and groupware 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 interfim 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 provides a platform for communication, rich messaging and interactive discussions, from e-mail, voice mail, fax and bulletin boards to on-screen video. Second, groupware facilitates a rich, shared, and virtual workspace. It makes available a common body of information and promotes shared understanding through shared repository and computer conferencing. Third, groupware also supports workflow automation in the coordination of complex tasks involving a rich mix of delegation, synchronizing, scheduling, and sequential sign-offs. It allows group members to track workflows from a remote location and collaborate on documents and projects. A major advantage of groupware is that all links do not need to be pre-established; authorized users can access and leave the system at will. But on the downside, groupware cannot be used to gain access to remote computers that are not groupware servers (Upton and McAfee 1996). Thus, like EDI systems, groupware only allows connections among companies with similar technological bases.
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) Relationship between Network Structure and Competitive Action

*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) Relationship between IOS Use and Competitive Action

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.
Figure 4.5 A model of competitive dynamics in electronic networks
Chapter 5 Data Collection Methodology

This chapter discusses methods for data collection, data categorization, and coding. It also presents visualizations of partial data.

5.1 Data Collection

Data collection for studying the research model introduced in Chapter 4 involves gathering second-hand data in the sports car segment of the automotive industry. The automotive industry possesses several characteristics that are particularly desirable for this study.

The first characteristic is the widespread use of IOS in the automotive industry. The automotive industry was among the earliest industries to adopt IOS, such as EDI systems for purchasing, inventory management, and production scheduling (Cash and Konsynski 1985). Some major automakers (such as the Big-Three) are also aggressive IOS users. They are trying to digitize their core business processes and link suppliers, dealers, logistics parties, and customers on common computing platforms. This aggressive use of IOS has spurred many IOS innovations.

The second characteristic is the proliferation of “co-optition” in the automotive industry. Many automakers compete and collaborate at the same time for reducing costs and sharing risks. Collaboration spans a wide range of dimensions, including procurement, product development, production, logistics, marketing & sales, and service.

The third characteristic is the unique setting of buyer-seller relations in the automotive industry. In the automotive industry, federal laws stipulate that automakers cannot sell cars directly to individual buyers. It is thus difficult for automakers to reach and collect information directly from individual customers via conventional means (e.g., sales phone calls). IOS may overcome this consequence of federal regulation by enabling the automakers to establish direct links with individual customers at a low cost, thus changing buyer-seller relations in the automotive industry.

These three characteristics of the automotive industry provide a favorable research background and high quality data for examining IOS’s roles and competitive dynamics in an e-business context.
Choosing the sports car segment has two major reasons. First, focusing on one car segment can exclude confounding factors related to different industry/segment characteristics. Second, sports cars, defined as small low vehicles with a high-powered engine that usually seats two persons (www.wordreference.com), are distinct from the other vehicles like sedans, SUVs, and wagons, and easy to identify. This distinction between sports cars and other vehicles can remove ambiguities in identifying major automakers, their relevant competitors, competitive actions and system usages during the data collection.

Based on the SIC code of sports car segment (3711125), nine major sports car makers have been identified as feasible for the second-hand data collection. The nine automakers are BMW AG, DaimlerChrysler AG, Ford Motor Co., General Motor Corp., Mazda Motor Corp., Mitsubishi Motors Corp., Nissan Motor Co., Toyota Motor Corp., and Volkswagen AG. Second-hand data include automakers’ collaborative relationships, their IOS use, and competitive actions. Automakers’ IOS use is actual and voluntary. Actual use refers to the manner in which IOS are implemented and in effect used, rather than intended use (DeLone and McLean 2003) or self-reported use (Devaraj and Kohli 2003). Voluntary use refers to that the adoption of system is non-mandatory (DeLone and McLean 2003; Devaraj and Kohli 2003).

Data sources include SDC database, COMPUSTAT, F&S Predicast’s Index, thousands of articles from over dozens of major trade publications, as well as miscellaneous Web sites. Table 5.1 lists these data sources.

This study is unique in its collection of actual, voluntary IOS use data from second-hand data sources like news reports and trade articles. Second-hand data sources are widely used in social network analysis and competitive dynamics research for collecting data about collaborative relationships and competitive actions. Prior IOS empirical research generally collects self-reported data. Self-reported data involve asking the same respondents to answer questions on their perceptions of system use and effectiveness (Devaraj and Kohli 2003). Self-reported usage measures can provide an important indicator in assessing IS success or effectiveness. But these measures have several limitations. (1) Self-reported usage might induce biases due to obtaining information from a single source or a same respondent, known as common method variance. In this regard, second-hand data collection increases data reliability by identifying data from multiple information sources. (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). Possible explanations for
the discrepancy between actual usage and perceived usage are subjects’ difficulty in recalling
their past usage, exaggeration of the extent of usage to fit in with their superiors’ expectations,
attention lapses, and bounded rationality (Devaraj and Kohli 2003). As such, there is an
increasing recognition that actual system usage provides better measures than self-reported usage
in assessing IS performance impacts (DeLone and McLean 2003; Devaraj and Kohli 2003). (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.

<table>
<thead>
<tr>
<th>DATABASE, INDEX, &amp; WEB SITE</th>
<th>TRADE PUBLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPSTAT Database</td>
<td>Advertising Age</td>
</tr>
<tr>
<td>SDC Database</td>
<td>Arizona Business Gazette</td>
</tr>
<tr>
<td>F&amp;S Predicast’s Index</td>
<td>Automotive News</td>
</tr>
<tr>
<td>Autoweb.com (Sports Car Center)</td>
<td>BC Business</td>
</tr>
<tr>
<td>Bmw.com</td>
<td>Chemical Week</td>
</tr>
<tr>
<td>Computerworld.com</td>
<td>Crain’s Cleveland Business</td>
</tr>
<tr>
<td>Ford.com</td>
<td>Far Eastern Economic Review</td>
</tr>
<tr>
<td>Gm.com</td>
<td>HFN The Weekly Newspaper for the Home Furnishing Network</td>
</tr>
<tr>
<td>Nissan-global.com</td>
<td>Plastics News</td>
</tr>
<tr>
<td>Vw.com</td>
<td>The Oil Daily</td>
</tr>
<tr>
<td>Ward's Auto World</td>
<td>Ward's Automotive Reports</td>
</tr>
</tbody>
</table>
5.2 Data

5.2.1 Collaborative Relationship Data

Eight hundred and five collaborative relationships involving the nine automakers are collected from COMPUSTAT and SDC. Relationships include formally signed or agreed collaborative arrangements in the subsector of Motor Vehicles and Passenger Car Bodies (SIC code: 3711) between 1985 (the earliest reporting date) and 2003.

A collaborative relationship is defined as any voluntarily initiated collaborative arrangement that involves one or more value activities ranging from procurement, product development, production, logistics, marketing & sales through to service. A collaborative arrangement can include exchange sharing or co-development, and also contributions by partners of capital, technology, or firm-specific assets (Gulati 1995). This definition excludes one-time exchange agreement or co-development.

Relationship Categorization and Coding

Collaborative relationships are categorized into six types based on Porter’s (1985) value chain, including procurement, product development, production, logistics, marketing & sales, and service.

In a network of 805 participants, each of the nine automakers may have some sort of collaborative relationships with the other 804 participants. A collaborative relationship is coded as “n” (the total number of an automaker’s ongoing collaborative arrangements with a specific participant in the network), and as “0” when the automaker has no arrangements with a participant in the network.

For example, with Aisin AW Co, Toyota has initiated two formal arrangements in product development (including software development, R&D in map databases and car navigation systems) and procurement (including supply services in automatic transmission and car navigation systems), whereas all the other automakers have no arrangements established with Aisin. The corresponding coding is BMW (0), DaimlerChrysler (0), Ford (0), GM (0), Mazda (0), Mitsubishi (0), Nissan (0), Toyota (2), and Volkswagen (0). Table 5.2 illustrates this coding.

<table>
<thead>
<tr>
<th>BMW</th>
<th>DaimlerChrysler</th>
<th>Ford</th>
<th>GM</th>
<th>Mazda</th>
<th>Mitsubishi</th>
<th>Nissan</th>
<th>Toyota</th>
<th>Volkswagen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aisin AW Co Ltd</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Data Visualization

Figures 5.1(a)-(g) visualize various network structures of the automakers. Figure 5.1(a) gives an overall view of the complete network with 805 embedded participants. Figures 5.1(b)-(g) give partial views of each individual automaker’s network structure. Each node in the graph represents a participant in the network. Each line indicates certain collaborative relationship existing between two nodes. Line thickness is determined by the number of collaborative arrangements between two nodes. The thicker the line, the greater the collaboration. Line color is used to differentiate the number of collaboration between two nodes. For example, brownish green is used to indicate 10 collaborative arrangements initiated between two nodes (such as the link between DaimlerChrysler and Mitsubishi Motors illustrated in Figure 5.1(b)), bright green is used to indicate 18 arrangements between two nodes (such as the link between DaimlerChrysler and Ford illustrated in Figure 5.1(b)).

Considering Figures 5.1(b)-(g), we see that Nissan and Volkswagen have relatively sparse networks in comparison to those of the other automakers. The Big-Three automakers (GM, Ford, DaimlerChrysler) have a strong triangle that goes in between them, indicating active collaboration among the three competitors. Toyota presents a unique structure – a dense network where related participants have ties linking to many others, indicating relatively stable relationships among the collaborators.

(a) An overall view of complete network
(b) A partial view of DaimlerChrysler’s network structure

(c) A partial view of Ford’s network structure
(d) A partial view of GM’s network structure

(e) A partial view of Nissan’s network structure
(f) A partial view of Toyota’s network structure

(g) A partial view of Volkswagen’s network structure

Figure 5.1 Automakers’ network structures
5.2.2 IOS Use Data

One hundred and six IOS applications used at the nine automakers between 1994 (the earliest reporting date) and 2003 are identified and collected from Computerworld.com. Publishing since 1967, Computerworld has been the only integrated media company focused exclusively on the IT use in Global 2000 organizations. The company's flagship weekly newspaper and its Computerworld.com Web site form the U.S.-based hub of the world's largest (58-edition) worldwide IT media network. Computerworld has an online audience of 800,000 unique monthly visitors (according to DoubleClick). Thus, Computerworld.com is likely to have an updated, comprehensive news coverage of the significant IOS implementations and practices at the nine automakers under study.

Relevant data categorization and coding of IOS use are illustrated in the variable operationalization section of Chapter 6.

5.2.3 Competitive Action Data

Three hundred and five competitive action events initiated in the sports car segment by the nine automakers in 2003 are identified and collected from F&S Predicast’s Index, thousands of articles in over dozens of major trade publications, and miscellaneous Web sites.

*Action Categorization and Coding*

Competitive actions, viewed as directly resulting from the value activities in which firms engage, are categorized along the six types of collaborative relationships, ranging from procurement, product development, production, logistics, marketing & sales, to service. Table 5.3 illustrates the six action categories and examples for each.

In this study, each action is assumed to be a direct resultant of one major value activity initiative, thus falling into one action category. For example, advertisement campaign or marketing promotion like price cuts, warranty extension, and financing are direct results from an automaker’s marketing & sales initiative. New product/model introduction also falls into the category of marketing & sales. Because in the automotive industry, new product/model introduction typically involves pre-launching activities, such as model displays and new concepts rollout at auto shows, new model announcements at dealer conferences (which often include pricing, incentive programs, sales targets and production plans of the new model). The major purpose of these activities is to collect market information about dealer and public response for
the product marketability, and to arrange distribution networks before the model is put into production. As such, new product/model introduction can be regarded as a direct resultant of an automaker’s marketing & sales initiative. Production capacity increase or new manufacturing facility installation is production-related action.

Table 5.3 Action category

<table>
<thead>
<tr>
<th>ACTION CATEGORY</th>
<th>EXAMPLE OF NEWS HEADLINES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PROCUREMENT</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Initiatives in improving supplier performance, reducing costs (e.g., joint procurement, supplier network management) | 1. Supplier Black Belt Program contributes to parts quality improvement at DaimlerChrysler.  
2. Mitsubishi’s joint procurement with DaimlerChrysler yields competitive advantage.  
3. Toyota hosts 14th Annual Opportunity Exchange, boosting relationships with Tier 1 and 2 suppliers. |
| **PRODUCT DEVELOPMENT** |                       |
| Product enhancement (e.g., improve reliability durability; enforce quality control; in-vehicle navigation and communications)  
New models & variants (e.g., all-new models, minor innovations in materials, components and outlook; model redesign; major innovations in design, engineering and architecture)  
R&D initiatives (e.g., new product testing, new breakthroughs, significant innovations in design, engineering, and platform or architecture like GM's mid-sized car architecture Epsilon; in-vehicle navigation and communications) | 1. Breakthrough indirect led lights on Ford GT less jarring to view.  
3. Hydrogen technology moves into the fast lane, research collaboration paves the way at BMW. |
| **PRODUCTION** |                                         |
| Production process (e.g., process innovation; production cost cuts)  
Capacity increase/new assembly line/new production site  
Capacity decrease | 1. Ford invests $325 million in Michigan and Ohio plants to build an all-new 6-speed transmission, rolling out new global flexible manufacturing system.  
2. Wet-on-wet revolutionizes Ford GT paint process. |
| **LOGISTICS** |                                         |
| Delivery of parts, components and vehicles | 1. Mazda, Caterpillar team up in service-parts logistics agreement. |
| **MARKETING & SALES** |                                                 |
| Marketing (including innovative advertising campaigns, events marketing, public relations initiatives; brand management, market research & positioning, pre-launching activities such as new product introductions, concept model display and new concept rollout at auto shows (market research for product marketability), information/communications services, promotion programs and incentives such as competitive pricing, cash-back offer, rebate, discount, warranty)  
Financing (e.g., lease, loan, insurance)  
Sales (e.g., distribution channels, establishment of distribution networks) | 1. RX-8 ads keep zoom in Mazda marketing.  
2. DaimlerChrysler Introduces Premium Care Plan for 2004 Crossfire.  
3. DaimlerChrysler increases its sports car list prices by an average of 1.6 percent. |
| **SERVICE** |                                                   |
| Service (including after-sale services, e.g., maintenance and repairs, recall/fixing problems, delivery)  
In-vehicle communications service | 1. Mercedes-Benz introduces in-car digital television service.  
2. DVD-based navigation radio debuts on select Chrysler and Dodge sports cars. |
News headlines are first read in search of nine automakers’ action events initiated in 2003. Table 5.3 gives examples of news headlines that are representative for each action category. Body texts of all news articles are also read to ensure the relevancy of the selected events and the accuracy of the action coding.

Next, each of the nine automakers’ actions in 2003 is classified into the six action categories. Actions in each category are then coded and aggregated. Each action is coded as “1” and no weights are assigned to differentiate the six action categories. “0” indicates that no actions are identified or reported for the automakers. Table 5.4 gives the action coding of the nine automakers in 2003.

As indicated in Table 5.4, the nine automakers have a clear focus on initiating actions in marketing & sales and product development.

<table>
<thead>
<tr>
<th></th>
<th>Procurement</th>
<th>Product Development</th>
<th>Production</th>
<th>Logistics</th>
<th>Marketing &amp; Sales</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>1</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>3</td>
<td>18</td>
<td>2</td>
<td>0</td>
<td>45</td>
<td>13</td>
</tr>
<tr>
<td>Ford</td>
<td>0</td>
<td>24</td>
<td>8</td>
<td>0</td>
<td>25</td>
<td>4</td>
</tr>
<tr>
<td>GM</td>
<td>0</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>Mazda</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Nissan</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Toyota</td>
<td>2</td>
<td>11</td>
<td>4</td>
<td>0</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 5.4 Action coding of the nine automakers in 2003**

5.3 Data Reliability

This study, based on SIC code and F&S Predicast’s Index, collects data about nine major sports car makers from multiple sources, including SDC database, COMPUSTAT, Computerworld, corporate Web sites of automakers, and major trade publications in the automotive industry.

All data used in this study (including network structure data, IOS use data, and competitive action data) involve categorization and coding. Network structure and competitive action data are categorized based on Porter’s (1985) value chain. IOS use data are categorized based on Chi and Holsapple’s (2005) IOS classification. To ensure the clarity and accuracy of this categorization and coding, all coding categories were discussed at two doctoral seminars.
These categories were fined-tuned through discussions with several academic experts, IS managers, and engineers at Ford, Nissan, and Toyota. The data were then coded into the resultant categories.

To check the reliability of this coding, two academic judges (coders) independently recoded the data. The coding reliability was tested using Perreault and Leigh’s (1989) reliability index. This test yielded a value of 0.9, which indicates a high degree of coding reliability. When disagreements on codes were identified, a third judge (coder) was brought in and the discrepancies were resolved on a majority rule basis.
Chapter 6 Variable Operationalization and Measures

This chapter develops measures and operationalizes variable constructs for testing hypotheses in Chapter 7.

6.1 Variable Measures

This section particularly develops two measures: (a) a similarity measure based on Euclidean distance (Johnson and Wichern 1998), and (b) a diversity measure based on prior studies of diversity index (Shannon 1948; Simpson 1949; Good 1953; Baczkowski et al. 1997; Baczkowski 1998; Baczkowski et al. 1998). Similarity helps identify the association or relationship between two variables, while diversity allows for an examination of the deep structure of the variables under study and helps enunciate the distinction between them as to how they are related to or different from each other.

6.1.1 Similarity Measure

In a clustering algorithm, proximity or similarity between two variable observations is often indicated by the Euclidean distance (Johnson and Wichern 1998). The Euclidean distance, $D$, between two $n$-dimensional observations is expressed as,

$$D(X_i,X_j) = \sqrt{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 + \ldots + (x_{in} - x_{jn})^2}$$

$$= (X_i - X_j)^T (X_i - X_j)$$

To enable comparison between variable samples of different dimensions, the Euclidean distance is further normalized by the square root of the dimension size $n$.

The similarity measure, $S$, is then obtained as,

$$S(X_i, X_j) = \frac{D(X_i, X_j)}{\sqrt{n}} = \frac{(X_i - X_j)^T (X_i - X_j)}{n}$$

(E1)

where,

$$X_i = [x_{i1}, x_{i2}, \ldots, x_{in}]^T$$

$$X_j = [x_{j1}, x_{j2}, \ldots, x_{jn}]^T$$

$i \neq j; i = 1, 2, \ldots, n; j = 1, 2, \ldots, n$

$n$ denotes the number of dimensions
This similarity measure will be used in the next section to help operationalize measures of structural similarity, IOS usage similarity, and action pattern similarity.

6.1.2 Diversity Measure

Shannon’s index (1948) and Simpson’s index (1949) are two widely used diversity measures. Both take into account the number of groups and the degree of concentration of each group, when individuals of a population are classified into groups.

Shannon’s index originated from information theory. It takes the form of \(-\sum p_i \log p_i\), where \(p_i\) are probabilities of occurrence of a set of possible events in a communication system (Shannon 1948). Shannon’s index uses a logarithmic measure to correspond to the binary states of information (or bit). While providing a relatively accurate measure, Shannon’s index is designed to be calculated from sample data and not in terms of population constants. It cannot be used everywhere, as it does not give values that are independent of sample size (e.g., when applied to an infinite population of individuals classified into a finite number of groups) (Simpson 1949).

Compared to Shannon’s index, Simpson’s index takes a simpler form of \(\sum \pi_i^2\), where \(\pi_i\) are probabilities of individuals in various groups of an infinite population (Simpson 1949). Simpson’s index thus addresses some limitations of Shannon’s index by defining a measure in terms of population constants.

In 1953, Good proposed a generalized diversity index,

\[
H(\alpha, \beta) = \sum_{i=1}^{s} \pi_i^\alpha \{-\ln(\pi_i)\}^\beta,
\]

which considers a population of \(s\) species having ordered relative abundances \(\pi' = (\pi_1, \pi_2, \ldots, \pi_s)\), and where \(\alpha\) and \(\beta\) were defined as non-negative integers. Good’s index attempted to give a more general diversity measure which included both Shannon’s index \((H(1,1))\), and Simpson’s index \((H(2,0))\).

Baczkowski et al. (1997; 1998) further generalized Good’s index so that \((\alpha, \beta)\) take values in the real plane \(R^2\). They determined the range of values \((\alpha, \beta)\) for which \(H(\alpha, \beta)\) satisfies two key properties suggested by Pielou (1975):

(P1) for given \(s\), the index should be a maximum when the \(p_i\) are equal;
(P2) if the $p_i$ are equal, the index should be an increasing function of $s$.

Baczkowski et al. suggested that for $0 \leq \alpha \leq 0.3267$, the valid region is given by $0 \leq \beta \leq 4\alpha(1-\alpha)$; for $0.3267 \leq \alpha \leq 1$, the valid region for $\beta$ satisfies $0 \leq \beta \leq 0.53426 + 0.693147\alpha + \frac{1}{2}\sqrt{0.094159+2.772589\alpha}$.

Additionally, in order to satisfy Pielou properties, possible transformations are needed for Simpson’s index (Baczkowski et al. 1997). Consider when $p_i$ are equal, $p_i = 1/s$ for $i = 1, 2, 3, \ldots, s$. For given $s$, the generalized index is $H(\alpha, \beta) = s^{1-\alpha} \{\ln(s)\}^\beta$.

Suppose $H(\alpha, \beta)$ is a continuous function of $s$. Then, if $\beta \neq 0$,

$$\frac{dH(\alpha, \beta)}{ds} = (1-\alpha)s^{-\alpha}\{\ln(s)\}^{\beta} + \beta s^{-\alpha}\{\ln(s)\}^{\beta-1},$$

for which, $H(\alpha, \beta)$ has a turning point at

$$s = e^{\beta/(\alpha-1)}; \text{ if } \beta = 0, \frac{dH(\alpha, \beta)}{ds} = (1-\alpha)s^{-\alpha}.$$

It follows that,

(a) $H \uparrow \forall s \geq 1$ (being a monotonic increasing function of $s$ for all $s \geq 1$), where $\alpha \leq 1$ and $\beta \geq 0$, $(\alpha, \beta) \neq (1,0)$, so that $H(\alpha, \beta)$ satisfies property (P2).

(b) $H \downarrow \forall s \geq 1$ (being a monotonic decreasing function of $s$ for all $s \geq 1$), where $\alpha \geq 1$ and $\beta \leq 0$, $(\alpha, \beta) \neq (1,0)$, so that a suitable “inverse” of $H(\alpha, \beta)$ would satisfy property (P2).

Thus, for Simpson’s index where $\alpha = 2$ and $\beta = 0$, modifications are needed to make it a suitable “inverse” of $H(2,0)$ that satisfies (P2). One feasible modification is $1 - H(2,0)$ (Greenberg 1956; Berger and Parker 1970).

Consider a sample of size $n$, of which $n_i$ are observed belonging to category $i$, $i = 1, 2, 3, \ldots, s$. The relative concentration of category $i$ can be estimated using $p_i = n_i / n$, and the generalized diversity index can be estimated by,

$$h(\alpha, \beta) = \sum_{i=1}^{s} p_i^{\alpha} \{-\ln(p_i)\}^{\beta}.$$
In Baczkowski (1998), the moments for Shannon’s index and Simpson’s index were suggested for fitting suitable distributions to \( h(\alpha, \beta) \).

(1) For Shannon’s index, \( h(1,1) \),

\[
E\{h(1,1)\} \approx H(1,1) - \frac{s-1}{2n} + \frac{1-H(-1,0)}{12n^2} + \frac{H(-1,0)-H(-2,0)}{12n^3},
\]

\[
Var\{h(1,1)\} \approx \frac{H(1,2)-H(1,1)^2}{n} + \frac{s-1}{2n^2} - \frac{H(1,1)H(-1,0)-H(-1,1)-H(-1,0)+1}{6n^3}.
\]

(2) For Simpson’s index, \( h(2,0) \),

\[
E\{h(2,0)\} = H(2,0) + \frac{1-H(2,0)}{n} + O(n^{-4}),
\]

where higher order terms of \( n^{-1} \), \( O(n^{-2}) \) and \( O(n^{-3}) \), are zero.

\[
Var\{h(2,0)\} \approx \frac{4\{H(3,0)-H(2,0)^2\}}{n} \frac{2\{-6H(3,0)+5H(2,0)^2+H(2,0)\}}{n^2} - \frac{2\{H(2,0)\{3H(2,0)+1\}-4H(3,0)\}}{n^3}.
\]

Thus, given a sample size of \( n \) and \( s \) categories, Shannon’s estimate and inversely transformed Simpson’s estimate can be written as follows:

Shannon’s Estimate = \( -\sum_{i=1}^{s} p_i \{\ln(p_i)\} - \frac{s-1}{2n} + \frac{1-\sum_{i=1}^{s} p_i^{-1}}{12n^2} + \frac{\sum_{i=1}^{s} p_i^{-1} - \sum_{i=1}^{s} p_i^{-2}}{12n^3} \)

Inverse Simpson’s Estimate = 1 - \( \left\{ \sum_{i=1}^{s} p_i^2 + \frac{1-\sum_{i=1}^{s} p_i^{-1}}{n} + O(n^{-4}) \right\} \)

For a large sample size \( n \), higher order terms of \( O(n^{-1}) \) may be omitted; for a small sample size \( n \), certain higher order terms of \( O(n^{-1}) \) would have significant effects on the results and thus may need to be considered.

This study uses both Shannon’s estimate and inverse Simpson’s estimate as its diversity measure. Due to a small sample size (of nine automakers), the term \( O(n^{-1}) \) is considered in both calculations, while higher order terms of \( O(n^{-2}) \) are omitted. E2 and E3 present the diversity measure developed for this study.
\[
\text{Adj. Shannon's Estimate} = - \sum_{i=1}^{s} p_i \{ \ln(p_i) \} - \frac{s-1}{2n} \quad (E2)
\]

\[
\text{Adj. Inverse Simpson's Estimate} = 1 - \left\{ \sum_{i=1}^{s} p_i^2 + \frac{1 - \sum_{i=1}^{s} p_i^2}{n} \right\} \quad (E3)
\]

where,

\( n \) = sample size,

\( n_i \) = observations in category \( i \), \( i = 1, 2, 3, \ldots, s \),

\( p_i = n_i / n \).

6.2 Variable Operationalization

In this section, variable constructs of network structure, IOS use, and competitive action are operationalized using the similarity and diversity measures developed in the previous section.

6.2.1 Network Structure

**Structural Similarity**

*Structural similarity* is computed using the similarity measure (E1). Considering a network of 805 participants, each of the nine automakers can be regarded as an observation with 805 dimensions. Each dimension represents a relationship between the automaker and one of the 805 network participants. The relationship between the automaker and itself is regarded as 0 to exclude its effects in the calculation.

Then the structural similarity, \( S_{ij} \), between two automakers can be computed as,

\[
S_{ij}(X_i, X_j) = \sqrt{\frac{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 + \ldots + (x_{in} - x_{jn})^2}{n}}
\]

where,

\( i \neq j \)

\( i = 1, 2, \ldots, 9; j = 1, 2, \ldots, 9 \)

\( n \) = network size

Thirty-six structural similarity scores between pairs of the nine automakers are obtained. As indicated in Table 6.1, the structural distance \( S_i \) presents three levels.

(1) \( S_i \leq 0.5 \). The structural distance between BMW and Volkswagen (0.49) is the shortest of all 36 pairs, suggesting that the two automakers have similar network
structures; in other words, BMW and Volkswagen tend to interact with similar others in the network.

(2) $0.5 < S_i \leq 1$. Mazda, Mitsubishi, Nissan, BMW, and Volkswagen fall into this group.

(3) $S_i > 1$. Toyota, DaimlerChrysler, Ford and GM (with structural distances all greater than 1) display distinct network structures from the others.

**Table 6.1 Structural similarity between the nine automakers in 2003**

<table>
<thead>
<tr>
<th></th>
<th>BMW</th>
<th>DaimlerChrysler</th>
<th>Ford</th>
<th>GM</th>
<th>Mazda</th>
<th>Mitsubishi</th>
<th>Nissan</th>
<th>Toyota</th>
<th>Volkswagen</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>1.381</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td>1.246</td>
<td>1.510</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>1.291</td>
<td>1.585</td>
<td>1.501</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mazda</td>
<td>0.779</td>
<td>1.176</td>
<td>1.375</td>
<td>1.108</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>0.774</td>
<td>1.432</td>
<td>1.143</td>
<td>1.240</td>
<td>0.991</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nissan</td>
<td>0.789</td>
<td>1.281</td>
<td>1.263</td>
<td>1.251</td>
<td>0.838</td>
<td>0.970</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toyota</td>
<td>1.155</td>
<td>1.428</td>
<td>1.429</td>
<td>1.577</td>
<td>1.186</td>
<td>1.270</td>
<td>1.180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0.490</td>
<td>1.369</td>
<td>1.232</td>
<td>1.263</td>
<td>0.803</td>
<td>0.817</td>
<td>0.831</td>
<td>1.182</td>
<td></td>
</tr>
</tbody>
</table>

**Degree Centrality**

*Degree centrality* (Freeman 1979) is measured as the total number of direct, active agreements between an automaker and its partners in the network. Degree centrality indicates an automaker’s central connectivity and direct access to resources of the other network participants.

**Table 6.2 Degree centrality of the nine automakers in 2001-2003**

<table>
<thead>
<tr>
<th>Degree Centrality</th>
<th>2003</th>
<th>2002</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>59</td>
<td>55</td>
<td>53</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>288</td>
<td>285</td>
<td>264</td>
</tr>
<tr>
<td>Ford</td>
<td>271</td>
<td>271</td>
<td>258</td>
</tr>
<tr>
<td>GM</td>
<td>300</td>
<td>293</td>
<td>275</td>
</tr>
<tr>
<td>Mazda</td>
<td>71</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>97</td>
<td>94</td>
<td>87</td>
</tr>
<tr>
<td>Nissan</td>
<td>175</td>
<td>170</td>
<td>166</td>
</tr>
<tr>
<td>Toyota</td>
<td>330</td>
<td>311</td>
<td>284</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>76</td>
<td>74</td>
<td>73</td>
</tr>
</tbody>
</table>

Degree centrality scores of the nine automakers are computed using UCINET 6 (Borgatti et al. 2002). Table 6.2 presents degree centrality scores of the nine automakers.

(1) Toyota has the highest degree centrality in 2001-2003, followed by GM, DaimlerChrysler, and Ford, suggesting that these four automakers have been able to
directly access many resources of their partners through actively establishing many ties in the automotive industry.

(2) BMW has the lowest degree centrality of the nine automakers, indicating that BMW has engaged in relatively less external collaboration than its competitors in 2001-2003.

**Betweenness Centrality**

*Betweenness centrality* (Freeman 1979) measures the probability that a network participant $p_k$ falls on the shortest path of pairs of other firms $p_i$, $p_j$ in the network. Figure 6.1 depicts a network with $p_k$ falling on the shortest path between $p_i$ and $p_j$.

![Figure 6.1 A network with $p_k$’s falling on the shortest path between $p_i$ and $p_j)](image)

Using UCINET 6 (Borgatti et al. 2002), this study obtains normalized betweenness centrality scores $C_B(p_k)$, which are computed as the betweenness divided by the maximum possible betweenness expressed as a percentage,

$$C_B(p_k) = \frac{\sum_{i}^{n} \sum_{j}^{n} b_{ij}(p_k)}{C_{max}}$$
where,

\[ b_{ij}(p_k) = \text{the probability that } p_k \text{ falls on a randomly selected geodesic connecting } p_i \text{ and } p_j \]

\[ = \frac{g_{ij}(p_k)}{g_{ij}} \]

\[ g_{ij} = \text{the number of geodesics linking } p_i \text{ and } p_j \]

\[ g_{ij}(p_k) = \text{the number of geodesics linking } p_i \text{ and } p_j \text{ that contains } p_k \]

\[ C_{\text{max}} = \text{the maximum value when } p_k \text{ falls on all the shortest paths between any two pairs of other firms, which is expressed as a percentage} \]

\[ = C_{805-1}^2 \% = 3228.06\% \]

\[ p_i, p_j, p_k = \text{network participant } i, j, k \]

\[ i \neq j \neq k; i = 1, 2, \ldots, 805; j = 1, 2, \ldots, 805; k = 1, 2, \ldots, 805 \]

**Table 6.3 Normalized betweenness centrality of the nine automakers in 2001-2003**

<table>
<thead>
<tr>
<th>Normalized Betweenness Centrality</th>
<th>2003</th>
<th>2002</th>
<th>2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>6.62</td>
<td>6.135</td>
<td>6.066</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>29.712</td>
<td>29.639</td>
<td>29.335</td>
</tr>
<tr>
<td>Ford</td>
<td>27.35</td>
<td>27.857</td>
<td>22.721</td>
</tr>
<tr>
<td>GM</td>
<td>31.57</td>
<td>32.03</td>
<td>32.325</td>
</tr>
<tr>
<td>Mazda</td>
<td>4.657</td>
<td>4.781</td>
<td>4.952</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>5.576</td>
<td>5.527</td>
<td>5.486</td>
</tr>
<tr>
<td>Nissan</td>
<td>15.814</td>
<td>16.023</td>
<td>16.386</td>
</tr>
<tr>
<td>Toyota</td>
<td>31.332</td>
<td>30.103</td>
<td>29.76</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>9.474</td>
<td>9.204</td>
<td>9.313</td>
</tr>
</tbody>
</table>

Table 6.3 gives normalized betweenness centrality scores of the nine automakers.

(1) Toyota has the highest betweenness centrality of all nine automakers, followed by GM, DaimlerChrysler, and Ford, suggesting that these four automakers are well positioned to leverage resources (particularly knowledge flows) for arbitrage in the product-market space.

(2) Mazda has the lowest betweenness centrality, indicating a relatively weak position in resource acquisition.

(3) Of particular interests are BMW and Volkswagen. Although BMW has the lowest degree centrality, it possesses higher betweenness centrality than Mazda and Mitsubishi. Similarly, Volkswagen has a lower degree centrality but a higher betweenness centrality than Mitsubishi. The network structures of BMW and Volkswagen indicate that these two automakers are better able to position in a
resource-rich (particularly knowledge-rich) position by establishing significant ties in the network than Mazda and Mitsubishi.

6.2.2 IOS Use

**IOS Reach**

IOS reach (Keen 1991) measures the total number of different types of partners that are linked via IOS. Here, partners are classified into six categories along the value/supply chain (Porter 1985): parts suppliers/outsourcers, external design partners, logistics partners, dealers, customers, (financial) service providers, and competitors (other automakers).

For example, DaimlerChrysler participates in a B2B repair parts portal for linking to various dealers, auto body shops, insurance companies, retailers, as well as other automakers. Each linkage with one type of interaction points is first categorized and then coded as “1.” In this study, all types of interaction points are treated equally, and no weights are assigned to distinguish them. Table 6.4 illustrates an example of this coding.

<table>
<thead>
<tr>
<th>Parts Suppliers/ Outsourcers</th>
<th>(Financial) Service Providers</th>
<th>External Design Partners</th>
<th>Logistics Partners</th>
<th>Dealers</th>
<th>Customers</th>
<th>Competitors (Other Automakers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

After coding, an automaker’s IOS reach is then obtained by aggregating all interaction points across various IOS applications used by the automaker.

**Table 6.5 IOS reach of the nine automakers in 2002-2003**

<table>
<thead>
<tr>
<th>IOS Reach</th>
<th>2003</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>49</td>
<td>36</td>
</tr>
<tr>
<td>Ford</td>
<td>72</td>
<td>67</td>
</tr>
<tr>
<td>GM</td>
<td>63</td>
<td>56</td>
</tr>
<tr>
<td>Mazda</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Nissan</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Toyota</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 6.5 gives the IOS reach for each of the nine automakers in 2002-2003.
(1) Ford has the largest IOS reach during 2002 and 2003, followed by GM and DaimlerChrysler, indicating that the Big-Three automakers are more aggressive in using IOS to link to diverse partners than the other automakers.

(2) Mazda and Nissan, having the smallest reach of all automakers in 2002 and 2003, are relatively passive IOS users.

**IOS Range**

*IOS range* (Keen 1991; Weill et al. 2002; Chi & Holsapple 2005) measures the total number of technological functionalities and services provided or supported by IOS. IOS range is categorized based on the collaboration-oriented IOS classification developed in Chapter 2. Eight categories are used in this study:

(a) *communications networks* (including broadband communications, peer-to-peer communications, Web portals, wireless networks),

(b) *standards & protocols* (including EDI, XML, Web services, security mechanisms),

(c) *collaborative work* (including collaborative construction, relationship management, task coordination, threaded discussion),

(d) *shared repositories* (including databases/data warehouses, digital documents/archives),

(e) *knowledge work* (including knowledge derivation, knowledge discovery, knowledge search),

(f) *messaging services* (including e-mail, instant messaging, teleconferencing),

(g) *publishing services* (including controlled publishing, open posting),

(h) *other functionalities*.

Each supported functionality or application service is first classified into one of the eight categories and then coded as “1.” All functionalities or services are treated equally, and no weights are assigned to distinguish them.

For example, DaimlerChrysler uses a B2B exchange for its aftermarket parts procurement. The B2B exchange primarily provides nine application services, including Web portal, relationship management, task coordination (such as bidding, auction, workflow automation), databases, digital archives, knowledge derivation (such as online analytical processing),
knowledge search, e-mail, as well as controlled publishing (such as FAQs). Table 6.6 illustrates this coding example.

Table 6.6 A coding example of IOS range

<table>
<thead>
<tr>
<th>IOS Functionalities &amp; Application Services</th>
<th>Supported or Provided Functionalities &amp; Services</th>
<th>Total Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadband Communications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer-to-Peer Communications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web Portals</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Wireless Networks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XML</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Web Services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Security Mechanisms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaborative Construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relationship Management</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Task Coordination</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Thraeded Discussion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Databases/Data Warehouses</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Digital Documents/Archives</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Knowledge Derivation</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Knowledge Discovery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge Search</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>E-mail</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Instant Messaging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teleconferencing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controlled Publishing</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Open Posting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Functionalities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Range</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

After coding, an automaker’s IOS range is then computed by aggregating all instances of IOS applications used by the automaker.

Table 6.7 gives the IOS ranges of the nine automakers in 2002 and 2003.

(1) Ford provides the largest IOS range of the nine automakers, followed by GM and DaimlerChrysler, suggesting that the Big-Three automakers use relatively more sophisticated IOS than the others to support their business functions.

(2) Mazda and Nissan use less sophisticated IOS by having much fewer functionalities and services than the other automakers.
Table 6.7 IOS range of the nine automakers in 2002-2003

<table>
<thead>
<tr>
<th>IOS Range</th>
<th>2003</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>53</td>
<td>30</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>173</td>
<td>128</td>
</tr>
<tr>
<td>Ford</td>
<td>216</td>
<td>205</td>
</tr>
<tr>
<td>GM</td>
<td>197</td>
<td>184</td>
</tr>
<tr>
<td>Mazda</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>51</td>
<td>30</td>
</tr>
<tr>
<td>Nissan</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>Toyota</td>
<td>57</td>
<td>48</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>62</td>
<td>48</td>
</tr>
</tbody>
</table>

Diversity of IOS Use

Diversity of IOS use is calculated using Shannon’s estimate (E2) and inverse Simpson’s estimate (E3).

To obtain diversity of IOS use, IOS technologies used by the nine automakers are first categorized into six types (including procurement, product development, production, logistics, marketing & sales, and service), based on the IOS applications for supporting those business functions. For each function, each instance of IOS application in support of that function is coded as “1” and then aggregated. In this study, all functions are treated equally, and no weights are assigned to distinguish them.

For example, Ford uses the C3P system (Computer-Aided Design, Manufacturing and Engineering and Product Information Management) to support the collaborative design process between its internal engineers and external design partners. For supporting its sales and customer service, Ford has FocalPt (an extranet) in service. Table 6.8 illustrates the coding for this example.

Table 6.8 A coding example of diversity of IOS use

<table>
<thead>
<tr>
<th>IOS Technologies</th>
<th>Procurement</th>
<th>Product Development</th>
<th>Production</th>
<th>Logistics</th>
<th>Marketing &amp; Sales</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3P System (product design)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FocalPt (sales, service)</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total applications</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
After coding, the Shannon’s estimate (E2) and inversely transformed Simpson’s estimate (E3) are then calculated by omitting the higher order terms of $O(n^{-2})$. $O(n^{-1})$ are still considered in the calculation due to the small sample size of the nine automakers.

$$
\text{Adj. Shannon's Diversity of IOS Use} = -\sum_{i=1}^{s} p_i \{\ln(p_i)\} - \frac{s-1}{2n}
$$

$$
\text{Adj. Simpson's Diversity of IOS Use} = 1 - \left( \sum_{i=1}^{s} p_i^2 + \frac{1}{n} \sum_{i=1}^{s} p_i \right),
$$

where,

$s = 6$, which denotes the six categories of collaborative functions that are supported by IOS, including procurement, product development, production, logistics, marketing & sales, and service;

$p_i = n_i / n$, which denotes the extent to which collaborative function $i$ ($i = 1, 2, 3, \ldots, 6$) is supported by IOS;

$n = \text{total number of IOS applications}$.

Table 6.9 gives both Shannon’s and Simpson’s diversity scores for the nine automakers.

(1) Mazda presents the lowest diversity scores with a relatively heavy focus on supporting its marketing & sales function.

(2) DaimlerChrysler and Ford present the highest diversity scores, suggesting that the two automakers use IOS to support a relatively diversified set of business functions.

**Table 6.9 Diversity of IOS use at the nine automakers in 2003**

<table>
<thead>
<tr>
<th>Automakers</th>
<th>Total IOS Applications</th>
<th>Procurement</th>
<th>Product Development</th>
<th>Production</th>
<th>Logistics</th>
<th>Marketing &amp; Sales</th>
<th>Service</th>
<th>Adj. Simpson’s Diversity of IOS Use</th>
<th>Adj. Shannon's Diversity of IOS Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>13</td>
<td>0.077</td>
<td>0.308</td>
<td>0.308</td>
<td>0.077</td>
<td>0.154</td>
<td>0.077</td>
<td>0.710</td>
<td>1.413</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>46</td>
<td>0.152</td>
<td>0.152</td>
<td>0.174</td>
<td>0.000</td>
<td>0.239</td>
<td>0.283</td>
<td>0.769</td>
<td>1.522</td>
</tr>
<tr>
<td>Ford</td>
<td>57</td>
<td>0.140</td>
<td>0.140</td>
<td>0.070</td>
<td>0.070</td>
<td>0.281</td>
<td>0.298</td>
<td>0.769</td>
<td>1.598</td>
</tr>
<tr>
<td>GM</td>
<td>53</td>
<td>0.170</td>
<td>0.151</td>
<td>0.057</td>
<td>0.019</td>
<td>0.302</td>
<td>0.302</td>
<td>0.748</td>
<td>1.500</td>
</tr>
<tr>
<td>Mazda</td>
<td>5</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.200</td>
<td>0.400</td>
<td>0.512</td>
<td>0.555</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>10</td>
<td>0.100</td>
<td>0.300</td>
<td>0.100</td>
<td>0.000</td>
<td>0.200</td>
<td>0.300</td>
<td>0.684</td>
<td>1.255</td>
</tr>
<tr>
<td>Nissan</td>
<td>8</td>
<td>0.125</td>
<td>0.125</td>
<td>0.125</td>
<td>0.000</td>
<td>0.375</td>
<td>0.250</td>
<td>0.656</td>
<td>1.182</td>
</tr>
<tr>
<td>Toyota</td>
<td>13</td>
<td>0.308</td>
<td>0.000</td>
<td>0.077</td>
<td>0.077</td>
<td>0.231</td>
<td>0.308</td>
<td>0.688</td>
<td>1.266</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>13</td>
<td>0.308</td>
<td>0.077</td>
<td>0.154</td>
<td>0.000</td>
<td>0.231</td>
<td>0.231</td>
<td>0.710</td>
<td>1.332</td>
</tr>
</tbody>
</table>

Diversity scores quantify how varied each automaker is in using IOS to support its business functions. Yet, they do not answer the question of “How much do two automakers
differ in their IOS’s support of different business functions?” The corresponding analysis is not straightforward, because the data here are categorical (qualitative) in nature and total variability in diversity may be due to a number of factors, such as the functional difference within an automaker, or the functional difference between two automakers. The following analysis is discussed to address the above question.

Rao (1982) discussed a decomposition of the diversity measure in case of categorical data. Rao suggested calculating the diversity difference \( D_{ij} \) between two populations \( i \) and \( j \) as,

\[
D_{ij} = H_{ij} - \frac{1}{2}(H_i + H_j)
\]

\[
= 2\{H(\frac{P_i + P_j}{2}) - \frac{1}{2}H(P_i) - \frac{1}{2}H(P_j)\}
\]

where,

\( H(P) \) denotes the diversity within a population \( \pi \) characterized by the probability measure \( P \);

\( H_{ij} \) denotes the diversity within a mixed population \( \pi_i \) and \( \pi_j \).

Based on Rao’s decomposition, the diversity dissimilarity between two automakers are derived as,

\[
\text{Simpson's Dissimilarity} = \frac{1}{2} \sum_{i=1}^{k} (p_{ia} - p_{ib})^2
\]

\[
\text{Shannon's Dissimilarity} = \{-\sum_{i=1}^{k} (\frac{p_{ia} + p_{ib}}{2}) \ln(\frac{p_{ia} + p_{ib}}{2})\} - \frac{1}{2} \sum_{i=1}^{k} p_{ia} \ln(p_{ia}) + \sum_{i=1}^{k} p_{ib} \ln(p_{ib})
\]

where,

\( k = 6 \), which denotes the 6 collaborative functions;

\( n \) = total number of IOS applications;

\( p_i = n_i / n \), which denotes the degree of concentration of IOS applications in support of function \( i \);

\( s \neq t; s = 1, 2, ..., 9; t = 1, 2, ..., 9 \).

Table 6.10 presents the diversity differences of IOS use between all pairs for the nine automakers in 2003. Of all the paired differences, the biggest difference exists between BMW-Mazda, while the smallest difference is for Ford-GM. This indicates that BMW and Mazda are most different in their IOS use, whereas Ford and GM are least different (or most similar) in their IOS use.
(1) BMW-Mazda. BMW mostly focuses on supporting joint car development and production, while Mazda tends to use its IOS exclusively for selling cars.

(2) Ford-GM. Ford and GM are similar in their IOS support for almost all the functions ranging from procurement to service. Part of the reason may be that Ford and GM not only compete fiercely in the technology use by closely watching and imitating each other, but also collaborate actively in a diversified set of activities and share many technological infrastructures, such as Covisint (a B2B procurement portal), a B2B repair parts portal, ANX (the automotive network exchange), as well as RouteOne system (a Web-based credit application management system).

Table 6.10 Diversity differences of IOS use between the nine automakers in 2003

<table>
<thead>
<tr>
<th>SIMPSON’S DISSIMILARITY OF IOS USE</th>
<th>BMW</th>
<th>DaimlerChrysler</th>
<th>Ford</th>
<th>GM</th>
<th>Mazda</th>
<th>Mitsubishi</th>
<th>Nissan</th>
<th>Toyota</th>
<th>Volkswagen</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>0.052</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td>0.077</td>
<td>0.009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>0.086</td>
<td>0.009</td>
<td>0.002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mazda</td>
<td>0.188</td>
<td>0.078</td>
<td>0.043</td>
<td>0.053</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>0.051</td>
<td>0.016</td>
<td>0.020</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nissan</td>
<td>0.077</td>
<td>0.012</td>
<td>0.010</td>
<td>0.008</td>
<td>0.008</td>
<td>0.055</td>
<td>0.033</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toyota</td>
<td>0.130</td>
<td>0.032</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.076</td>
<td>0.070</td>
<td>0.041</td>
<td></td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0.083</td>
<td>0.017</td>
<td>0.025</td>
<td>0.025</td>
<td>0.022</td>
<td>0.111</td>
<td>0.051</td>
<td>0.029</td>
<td>0.012</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SHANNON’S DISSIMILARITY OF IOS USE</th>
<th>BMW</th>
<th>DaimlerChrysler</th>
<th>Ford</th>
<th>GM</th>
<th>Mazda</th>
<th>Mitsubishi</th>
<th>Nissan</th>
<th>Toyota</th>
<th>Volkswagen</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>0.092</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ford</td>
<td>0.105</td>
<td>0.037</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>0.128</td>
<td>0.024</td>
<td>0.009</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mazda</td>
<td>0.342</td>
<td>0.250</td>
<td>0.147</td>
<td>0.181</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>0.092</td>
<td>0.021</td>
<td>0.046</td>
<td>0.032</td>
<td>0.263</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nissan</td>
<td>0.117</td>
<td>0.011</td>
<td>0.033</td>
<td>0.019</td>
<td>0.208</td>
<td>0.035</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toyota</td>
<td>0.222</td>
<td>0.103</td>
<td>0.066</td>
<td>0.075</td>
<td>0.162</td>
<td>0.160</td>
<td>0.103</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0.138</td>
<td>0.021</td>
<td>0.056</td>
<td>0.039</td>
<td>0.279</td>
<td>0.069</td>
<td>0.032</td>
<td>0.063</td>
<td></td>
</tr>
</tbody>
</table>

6.2.3 Competitive Action

Action Pattern Similarity

Action pattern similarity is computed using the similarity measure (E1). Consider the similarity between two automakers’ action patterns in 2003, each automaker can be regarded as an observation with 72 dimensions. Each dimension corresponds to action category i in month j.
of 2003, \( i = 1, 2, ..., s \), \( s \) denotes six action categories, including procurement, product development, production, logistics, marketing & sales, and service.

Then the action pattern similarity, \( S_2 \), between two automakers can be computed as,

\[
S_2(X_i, X_j) = \sqrt{\frac{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 + ... + (x_{i,72} - x_{j,72})^2}{72}}
\]

where,

\[
X_i (\text{ith automaker}) = [x_{i1}, x_{i2}, ..., x_{i,72}]
\]

\[
X_j (\text{jth automaker}) = [x_{j1}, x_{j2}, ..., x_{j,72}]
\]

\( i \neq j; i = 1, 2, ..., 9; j = 1, 2, ..., 9 \)

Thirty-six similarity scores between pairs of the nine automakers are obtained. Table 6.11 gives these scores.

(1) The shortest distance exists both between Volkswagen-Mazda and between Volkswagen-Nissan, indicating relatively similar action patterns undertaken by those automakers in 2003.

(2) DaimlerChrysler has the longest distance with both Volkswagen and BMW, indicating that DaimlerChrysler took quite different actions from those of Volkswagen and BMW in 2003.

| Table 6.11 Action pattern similarity between the nine automakers in 2003 |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | BMW             | DaimlerChrysler | Ford            | GM              | Mazda           | Mitsubishi      | Nissan           | Toyota           | Volkswagen       |
| BMW             | 1.886           |                 |                 |                 |                 |                 |                 |                 |                 |
| DaimlerChrysler | 1.364           | 1.624           |                 |                 |                 |                 |                 |                 |                 |
| Ford            | 1.149           | 1.586           | 1.514           |                 |                 |                 |                 |                 |                 |
| GM              | 0.913           | 1.675           | 1.424           | 1.196           |                 |                 |                 |                 |                 |
| Mazda           | 0.755           | 1.704           | 1.339           | 1.130           | 0.825           |                 |                 |                 |                 |
| Mitsubishi     | 0.764           | 1.803           | 1.546           | 1.149           | 0.816           | 0.890           |                 |                 |                 |
| Nissan          | 1.130           | 1.563           | 1.333           | 1.161           | 1.130           | 1.061           | 0.882           |                 |                 |
| Toyota          | 0.745           | 1.886           | 1.424           | 1.173           | 0.667           | 0.697           | 0.667           | 1.027           |                 |
| Volkswagen      |                 |                 |                 |                 |                 |                 |                 |                 | 0.882           |

Figure 6.2 depicts the action patterns undertaken at BMW, DaimlerChrysler, Mazda, Nissan, and Volkswagen in 2003.
Volkswagen vs. Mazda, Nissan

(a) Volkswagen’s actions vs. actions of Mazda and Nissan

(b) DaimlerChrysler’s actions vs. actions of BMW and Volkswagen

Figure 6.2 A comparison of automakers’ action patterns in 2003

Action Volume

Action volume is calculated as the total number of actions initiated by an automaker during time \( t \) (Chen and Hambrick 1995). Table 6.12 gives the action volume of the nine automakers in 2003.

Table 6.12 Action volume of the nine automakers in 2003

<table>
<thead>
<tr>
<th>Automaker</th>
<th>Action Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>16</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>81</td>
</tr>
<tr>
<td>Ford</td>
<td>61</td>
</tr>
<tr>
<td>GM</td>
<td>43</td>
</tr>
<tr>
<td>Mazda</td>
<td>19</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>23</td>
</tr>
<tr>
<td>Nissan</td>
<td>16</td>
</tr>
<tr>
<td>Toyota</td>
<td>38</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>8</td>
</tr>
</tbody>
</table>
As indicated in Table 6.12, DaimlerChrysler initiated the largest number of actions in 2003, followed by Ford and GM. Volkswagen took the fewest actions of the nine automakers.

**Complexity of Action Repertoire**

Complexity of action repertoire is calculated using Shannon’s estimate (E2) and inverse Simpson’s estimate (E3), by omitting higher order terms of $O(n^{-2})$. $O(n^{-1})$ are still considered, given the small sample sizes ranging from 8 (for Volkswagen) to 81 (for DaimlerChrysler).

\[
\text{Adj. Shannon's Complexity of Action Repertoire} = -\sum_{i=1}^{s} p_i \ln(p_i) - \frac{s-1}{2n}
\]

\[
\text{Adj. Simpson's Complexity of Action Repertoire} = 1 - \left( \sum_{i=1}^{s} p_i^2 + \frac{1 - \sum_{i=1}^{s} p_i^2}{n} \right),
\]

where,

- $n$ denotes an automaker’s action volume in 2003;
- $s = 6$, which denotes 6 action categories in the action repertoire, including procurement, product development, production, logistics, marketing & sales, and service;
- $p_i$ denotes the degree of concentration of action category $i$ ($i = 1, 2, 3, \ldots, 6$).

Table 6.13 gives the action complexity scores of the nine automakers. Of all the automakers, Mazda presents the lowest complexity of actions in 2003, while Ford, DaimlerChrysler, and Nissan are three firms that initiated the largest variety of actions.

**Table 6.13 Complexity of action repertoire for the nine automakers in 2003**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>16</td>
<td>0.063</td>
<td>0.625</td>
<td>0.000</td>
<td>0.000</td>
<td>0.313</td>
<td>0.000</td>
<td>0.476</td>
<td>0.674</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>81</td>
<td>0.037</td>
<td>0.222</td>
<td>0.025</td>
<td>0.000</td>
<td>0.556</td>
<td>0.160</td>
<td>0.607</td>
<td>1.137</td>
</tr>
<tr>
<td>Ford</td>
<td>61</td>
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<tr>
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<td>0.000</td>
<td>0.651</td>
<td>0.070</td>
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<td>0.063</td>
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<td>0.625</td>
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Using E4, the differences between two automakers’ action complexity is further evaluated as,

\[
\text{Simpson's Dissimilarity} = \frac{1}{2} \sum_{i=1}^{k} (p_a - p_b)^2
\]

\[
\text{Shannon's Dissimilarity} = \left\{-\sum_{i=1}^{k} (\frac{p_a + p_b}{2}) \ln(\frac{p_a + p_b}{2}) \right\} - \frac{1}{2} \left\{ \sum_{i=1}^{k} p_a \ln(p_a) + \sum_{i=1}^{k} p_b \ln(p_b) \right\}
\]

where,

- \(k = 6\), which denotes the 6 action categories;
- \(n\) denotes action volume;
- \(p_i = n_i / n\), denotes the degree of concentration of actions in action category \(i\);
- \(s \neq t; s = 1, 2, ..., 9; t = 1, 2, ..., 9\).

Table 6.14 Differences of action complexity between the nine automakers in 2003

<table>
<thead>
<tr>
<th>SIMPSON’S DISSIMILARITY OF ACTION COMPLEXITY</th>
<th>BMW</th>
<th>DaimlerChrysler</th>
<th>Ford</th>
<th>GM</th>
<th>Mazda</th>
<th>Mitsubishi</th>
<th>Nissan</th>
<th>Toyota</th>
<th>Volkswagen</th>
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<td>0.046</td>
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<td></td>
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<tr>
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<td>0.038</td>
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</tr>
<tr>
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<td>0.013</td>
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<th>GM</th>
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<th>Mitsubishi</th>
<th>Nissan</th>
<th>Toyota</th>
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Table 6.14 gives both Simpson’s and Shannon’s estimates of action complexity differences to quantitatively describe how much two automakers differ in their initiated set of action repertoire in 2003. BMW-Mazda display the largest difference in their action repertoire,
while Mitsubishi-Toyota present the least difference (or highest similarity) in their action complexity.

Figure 6.3 graphically depicts the differences of action complexity between BMW-Mazda and Mitsubishi-Toyota.

(1) **BMW-Mazda.** BMW put a heavy focus on actions for developing cars, whereas Mazda more concentrated on taking actions for selling cars.

(2) **Mitsubishi-Toyota.** Mitsubishi and Toyota tended to follow each other closely in launching actions in a diversified manner.

### Figure 6.3 A comparison of automakers’ action complexity in 2003

**Action Heterogeneity**

*Action heterogeneity* is computed based on the similarity measure (E1). It measures how an automaker’s actions deviate from the industry norm during time $t$ (Miller and Chen 1994): in a repeated manner comparable to others, or in an innovative way by bringing surprise and change.
from time to time. The time scale can be taken as broad as three-year, five-year, or ten-year, to
give a stereotypic idea of how an automaker’s actions deviate from the average competitors. The
time scale can also be fine-tuned to as short as a year, a month, or even a day, to give a close
examination of the fluctuations in an automaker’s actions. Here, automakers’ actions are
examined on a monthly scale.

In the automotive industry, DOT (Department of Transportation) and NHTSA (National
Highway Transportation Safety Administration) publish regulations that always take effect or
start to phase-in on September 1st, so most automakers start to produce next year's model at the
beginning of September of the current year. In order to sell out old car models and boost sales
for new models, automakers tend to initiate marketing & sales campaigns and offer big
incentives starting in the summer through to the year end. Additionally, in each year, auto shows
roll out regularly in certain months (e.g., Detroit Auto Show and Los Angeles Auto Show in Jan.,
Chicago Auto Show in Feb., Geneva Motor Show in March, New York Auto Show in April,
Frankfurt Motor Show in Sept., Tokyo Motor Show in Oct., and Special Equipment Market
Association Show in Nov.). As such, in the automotive industry, the industry norm defines a
relatively stable or predictable action pattern in which certain action events (such as new model
production, marketing campaigns, sales promotions, and auto shows) are repeated at certain
times of each year.

Consider the action heterogeneity of an automaker in 2003, each automaker is regarded
as an observation with 72 dimensions. Each dimension corresponds to action category s in
month t of 2003, where \( s = 1, 2, \ldots, 6; \ t = 1, 2, \ldots, 12 \).

The mean scores, which represent the industry norm of actions taken in each month of
2003, are calculated by taking the average of the nine automakers’ actions. Action heterogeneity
\( S_3 \) is then calculated as,

\[
S_3(X_i, \bar{X}) = \sqrt{\frac{(x_{i1} - \bar{x}_1)^2 + (x_{i2} - \bar{x}_2)^2 + \ldots + (x_{i72} - \bar{x}_{72})^2}{72}}
\]

where,

\[
X_i = [x_{i1}, x_{i2}, \ldots, x_{i,72}]' \\
\bar{X} = \frac{1}{9} \sum_{i=1}^{9} X_i = [\bar{x}_1, \bar{x}_2, \ldots, \bar{x}_{72}]' \\
i = 1, 2, \ldots, 9
\]
Table 6.15 gives partial data of the monthly actions initiated by the nine automakers between August-December, 2003 and mean scores in those months.

<table>
<thead>
<tr>
<th>Action Timing</th>
<th>Action Category</th>
<th>BMW</th>
<th>DaimlerChrysler</th>
<th>Ford</th>
<th>GM</th>
<th>Mazda</th>
<th>Mitsubishi</th>
<th>Nissan</th>
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Table 6.16 gives action heterogeneity scores of the nine automakers. As indicated in Table 6.16, DaimlerChrysler stands out among the nine automakers by undertaking actions in a highly distinct pattern from the other automakers in 2003.

<table>
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<tr>
<th>BMW</th>
<th>DaimlerChrysler</th>
<th>Ford</th>
<th>GM</th>
<th>Mazda</th>
<th>Mitsubishi</th>
<th>Nissan</th>
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Table 6.17 summarizes the variable constructs and their measures used in this study.

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<tr>
<td><strong>Network Structure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural similarity</td>
<td>( S(X_i, X_j) = \frac{1}{n} \sum_{i=1}^{n} \frac{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 + \ldots + (x_{in} - x_{jn})^2}{n} )</td>
<td>Rice &amp; Aydin 1991; Johnson &amp; Wichern 1998</td>
</tr>
<tr>
<td>Degree centrality</td>
<td>( C_{B}(p_k) = \frac{\sum_{i=1}^{n} b_j(p_k)}{C_{\text{max}}} )</td>
<td>Freeman 1979; Borgatti et al. 2002</td>
</tr>
<tr>
<td><strong>IOS Use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IOS reach</td>
<td>The total number of different types of partners that are linked via IOS.</td>
<td>Keen 1991</td>
</tr>
<tr>
<td>IOS range</td>
<td>The total number of technological functionalities and services provided by IOS.</td>
<td>Keen 1991; Weill et al. 2002; Chi &amp; Holsapple 2005</td>
</tr>
<tr>
<td>Diversity of IOS use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj. Shannon’s Diversity of IOS Use</td>
<td>( = -\sum_{i=1}^{s} p_i \ln(p_i) - \frac{s-1}{2n} )</td>
<td>Shannon 1948; Simpson 1949; Good 1953; Greenberg 1956; Berger &amp; Parker 1970; Pielou 1975; Baczkowski et al. 1997; 1998</td>
</tr>
<tr>
<td>Adj. Simpson’s Diversity of IOS Use</td>
<td>( = 1 - \left( \sum_{i=1}^{s} p_i^2 + \frac{1}{n} \sum_{i=1}^{s} p_i^2 \right) )</td>
<td></td>
</tr>
<tr>
<td><strong>Competitive Action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action volume</td>
<td>The total number of actions initiated by an automaker at time ( t ).</td>
<td>Chen &amp; Hambrick 1995</td>
</tr>
<tr>
<td>Complexity of Action Repertoire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj. Shannon’s Complexity of Action Repertoire</td>
<td>( = -\sum_{i=1}^{s} p_i \ln(p_i) - \frac{s-1}{2n} )</td>
<td>Shannon 1948; Simpson 1949; Good 1953; Greenberg 1956; Berger &amp; Parker 1970; Pielou 1975; Baczkowski et al. 1997; 1998</td>
</tr>
<tr>
<td>Adj. Simpson’s Complexity of Action Repertoire</td>
<td>( = 1 - \left( \sum_{i=1}^{s} p_i^2 + \frac{1}{n} \sum_{i=1}^{s} p_i^2 \right) )</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action heterogeneity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( S_h(X_i, \bar{X}) = \sqrt{(x_{i1} - \bar{x}<em>{1})^2 + (x</em>{i2} - \bar{x}<em>{2})^2 + \ldots + (x</em>{i,n} - \bar{x}_{n})^2} / 72 )</td>
<td>Miller &amp; Chen 1994; Johnson &amp; Wichern 1998</td>
<td></td>
</tr>
</tbody>
</table>

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Chapter 7 Data Analysis Methods and Results

This Chapter discusses methods for data analysis and presents data analysis results for hypothesis testing.

7.1 Data Analysis Methodology

Based on the coding categories and variable measures developed in Chapters 5-6, raw data obtained from various data sources are categorized, coded, and calculated. Table 7.1 gives descriptive statistics of these data and their corresponding data sources. These data are then analyzed for hypothesis testing.

Due to a small data set (of the nine automakers), Pearson product-moment correlation is calculated to test the hypotheses. The significance level for each correlation characterizes the correlation reliability and indicates the linear relationship between two variables. But Pearson correlation is based on the normality assumption and measures a relation between two variables only to the extent that it is linear. In the case of a strong correlation but nonlinearity, if the curve is monotonic (i.e., continuously decreasing or increasing), nonparametric correlation (such as Spearman’s $R$, Kendall’s $tao$) would work better than Pearson correlation. Nonparametric correlation is sensitive only to the ordinal arrangement of values, and thus ignores the monotonic curvilinearity. In addition, nonparametric correlation does not require a normality assumption. Therefore, in this study, Spearman’s $R$ and Kendall’s $Tao$ statistics are also calculated to supplement Pearson correlation.

Spearman’s $R$ can be thought of as the regular Pearson product-moment correlation coefficient (Pearson’s $r$); i.e., in terms of the proportion of variability accounted for, except that Spearman’s $R$ is computed from ranks. Spearman’s $R$ assumes that the variables under consideration are measured on at least an ordinal (rank order) scale (i.e., the individual observations (cases) can be ranked into ordered series). Kendall’s $tau$ is equivalent to the Spearman’s $R$ statistic with regard to the underlying assumptions. It is also comparable in terms of its statistical power. However, Spearman’s $R$ and Kendall’s $tau$ usually are not identical in magnitude because their underlying logic and computational formulas are very different.

More importantly, Kendall’s $tau$ and Spearman’s $R$ imply different interpretations: While Spearman’s $R$ can be thought of as the regular Pearson product-moment correlation
coefficient as computed from ranks, Kendall’s *tau* rather represents a *probability*. Specifically, it is the difference between the probability that the observed data are in the same order for the two variables versus the probability that the observed data are in different orders for the two variables (Kendall 1949; Gibbons 1985; Siegel and Castellan 1988).

The Pearson’s *r*, Spearman’s *R*, and Kendall’s *tau* results are presented in Tables 7.2-7.6. As indicated in these tables, most of the significance levels for Pearson’s *r*, Spearman’s *R*, and Kendall’s *tau* are consistent, providing additional support for those data results. But there are some inconsistent results, which may be due to the small data set. Both Spearman’s correlation and Kendall’s correlation tend to work better for large data sets. So when Pearson correlation is significant, it is interpreted, while in the case of inconsistent results between Pearson correlation and nonparametric correlation (e.g., Pearson’s *r* is not significant, but Spearman’s *R* and Kendall’s *tau* are significant), all correlations are considered and interpreted. Interpretations are given in Chapters 8-11.
### 7.2 Data Analysis Results

**Table 7.1 Data descriptions**

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Pattern Similarity</td>
<td>36</td>
<td>1.211</td>
<td>0.366</td>
<td>Competitive action data (F &amp; S Predicast’s Index, major trade publications)</td>
</tr>
<tr>
<td>Structural Similarity</td>
<td>36</td>
<td>1.170</td>
<td>0.264</td>
<td>Network structure data (SDC database)</td>
</tr>
<tr>
<td>IOS Reach Similarity</td>
<td>36</td>
<td>5.235</td>
<td>3.781</td>
<td>IOS use data (Computerworld.com, corporate Web sites)</td>
</tr>
<tr>
<td>IOS Range Similarity</td>
<td>36</td>
<td>5.459</td>
<td>3.863</td>
<td>IOS use data (Computerworld.com, corporate Web sites)</td>
</tr>
<tr>
<td>Diversity of IOS Use Similarity</td>
<td>36</td>
<td>5.073</td>
<td>3.390</td>
<td>IOS use data (Computerworld.com, corporate Web sites)</td>
</tr>
<tr>
<td>Adj. Simpson’s Diversity of IOS Use</td>
<td>9</td>
<td>0.694</td>
<td>0.079</td>
<td>IOS use data (Computerworld.com, corporate Web sites)</td>
</tr>
<tr>
<td>Adj. Shannon’s Diversity of IOS Use</td>
<td>9</td>
<td>1.291</td>
<td>0.309</td>
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<tr>
<td>IOS Reach</td>
<td>9</td>
<td>26.889</td>
<td>26.615</td>
<td>IOS use data (Computerworld.com, corporate Web sites)</td>
</tr>
<tr>
<td>IOS Range</td>
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<td>95.222</td>
<td>77.068</td>
<td>IOS use data (Computerworld.com, corporate Web sites)</td>
</tr>
<tr>
<td>Degree Centrality</td>
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<td>185.222</td>
<td>112.278</td>
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</tr>
<tr>
<td>Betweenness Centrality</td>
<td>9</td>
<td>18.012</td>
<td>11.863</td>
<td>Network structure data (SDC database)</td>
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<td>Action heterogeneity</td>
<td>9</td>
<td>0.805</td>
<td>0.264</td>
<td>Competitive action data (F &amp; S Predicast’s Index, major trade publications)</td>
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<tr>
<td>Action Volume</td>
<td>9</td>
<td>33.889</td>
<td>24.251</td>
<td>Competitive action data (F &amp; S Predicast’s Index, major trade publications)</td>
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<td>0.121</td>
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<tr>
<td>Adj. Shannon’s Complexity of Action Repertoire</td>
<td>9</td>
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<td>0.272</td>
<td>Competitive action data (F &amp; S Predicast’s Index, major trade publications)</td>
</tr>
<tr>
<td></td>
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<td>Structural Similarity</td>
<td>IOS Reach Similarity</td>
<td>IOS Range Similarity</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------</td>
<td>-----------------------</td>
<td>----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td><strong>Action Pattern Similarity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation Sig. (2-tailed)</td>
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<td>.781(**)</td>
<td>.592(**)</td>
<td>.585(**)</td>
</tr>
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<td>Structural Similarity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.781(**)</td>
<td>1</td>
<td>.544(**)</td>
<td>.504(**)</td>
</tr>
<tr>
<td>IOS Reach Similarity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.592(**)</td>
<td>.544(**)</td>
<td>1</td>
<td>.976(**)</td>
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<tr>
<td>IOS Range Similarity</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.585(**)</td>
<td>.504(**)</td>
<td>.976(**)</td>
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</tr>
<tr>
<td>Diversity of IOS Use Similarity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.578(**)</td>
<td>.510(**)</td>
<td>.977(**)</td>
<td>.984(**)</td>
</tr>
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</table>

** Correlation is significant at the 0.01 level (2-tailed).
Table 7.3 Correlations for H1 and H4: non-parametric correlations

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<th>Action Pattern Similarity</th>
<th>Structural Similarity</th>
<th>IOS Reach Similarity</th>
<th>IOS Range Similarity</th>
<th>Diversity of IOS Use Similarity</th>
</tr>
</thead>
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<td><strong>Action Pattern</strong></td>
<td><strong>Kendall’s tau_b</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
<tr>
<td><strong>Similarity</strong></td>
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<td>.594(**)</td>
<td>.478(**)</td>
<td>.385(**)</td>
</tr>
<tr>
<td></td>
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<td><strong>.000</strong></td>
<td><strong>.001</strong></td>
<td><strong>.002</strong></td>
</tr>
<tr>
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<td><strong>Kendall’s tau_b</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
<tr>
<td><strong>Similarity</strong></td>
<td></td>
<td>.594(**)</td>
<td>1.000</td>
<td>.374(**)</td>
<td>.262(*)</td>
</tr>
<tr>
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<td><strong>.000</strong></td>
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<td><strong>Kendall’s tau_b</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
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<td><strong>Similarity</strong></td>
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<td>.374(**)</td>
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</tr>
<tr>
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<td><strong>Kendall’s tau_b</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
<tr>
<td><strong>Similarity</strong></td>
<td></td>
<td>.385(**)</td>
<td>.262(*)</td>
<td>.789(**)</td>
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</tr>
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<td><strong>.025</strong></td>
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</tr>
<tr>
<td><strong>Diversity of</strong></td>
<td><strong>Kendall’s tau_b</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td></td>
</tr>
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<td><strong>Similarity</strong></td>
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<td>.777(**)</td>
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<td><strong>.000</strong></td>
<td><strong>1.000</strong></td>
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<td><strong>Action Pattern</strong></td>
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<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
<tr>
<td><strong>Similarity</strong></td>
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<td>.781(**)</td>
<td>.660(**)</td>
<td>.601(**)</td>
</tr>
<tr>
<td></td>
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<td><strong>.000</strong></td>
<td><strong>.000</strong></td>
<td><strong>.000</strong></td>
</tr>
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<td><strong>Spearman's R</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
<tr>
<td><strong>Similarity</strong></td>
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<td>.781(**)</td>
<td>1.000</td>
<td>.568(**)</td>
<td>.441(**)</td>
</tr>
<tr>
<td></td>
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<td><strong>.000</strong></td>
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<td><strong>.007</strong></td>
</tr>
<tr>
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<td><strong>Spearman's R</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
<tr>
<td><strong>Similarity</strong></td>
<td></td>
<td>.660(**)</td>
<td>.568(**)</td>
<td>1.000</td>
<td>.930(**)</td>
</tr>
<tr>
<td></td>
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<td><strong>.000</strong></td>
<td><strong>.000</strong></td>
<td><strong>.000</strong></td>
<td><strong>.000</strong></td>
</tr>
<tr>
<td><strong>IOS Range</strong></td>
<td><strong>Spearman's R</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
</tr>
<tr>
<td><strong>Similarity</strong></td>
<td></td>
<td>.601(**)</td>
<td>.441(**)</td>
<td>.930(**)</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
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<td><strong>Spearman's R</strong></td>
<td><strong>Correlation</strong></td>
<td><strong>Sig. (2-tailed)</strong></td>
<td><strong>Correlation</strong></td>
<td></td>
</tr>
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<td><strong>IOS Use</strong></td>
<td><strong>Similarity</strong></td>
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<td>.403(*)</td>
<td>.913(**)</td>
<td>.919(**)</td>
</tr>
<tr>
<td></td>
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<td><strong>.015</strong></td>
<td><strong>.000</strong></td>
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</tr>
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</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Table 7.4 Correlations for H2-H3, H5-H9: Pearson correlation

<table>
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<th></th>
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<th></th>
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<tbody>
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<td>Adj. Simpson's Diversity of IOS Use</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>1</td>
<td>.993(**)</td>
<td>.683(*)</td>
<td>.751(*)</td>
<td>.536</td>
<td>.611</td>
<td>.584</td>
<td>.580</td>
</tr>
<tr>
<td>Adj. Shannon's Diversity of IOS Use</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.993(**)</td>
<td>1</td>
<td>.652</td>
<td>.716(*)</td>
<td>.501</td>
<td>.575</td>
<td>.531</td>
<td>.518</td>
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<td>IOS Reach</td>
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<td>.683(*)</td>
<td>.652</td>
<td>1</td>
<td>.991(**)</td>
<td>.696(*)</td>
<td>.745(*)</td>
<td>.756(*)</td>
<td>.802(**)</td>
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<td>IOS Range</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.751(*)</td>
<td>.716(*)</td>
<td>.991(**)</td>
<td>1</td>
<td>.677(*)</td>
<td>.738(*)</td>
<td>.786(*)</td>
<td>.811(**)</td>
</tr>
<tr>
<td>Degree Centrality</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.536</td>
<td>.501</td>
<td>.696(*)</td>
<td>.677(*)</td>
<td>1</td>
<td>.986(**)</td>
<td>.627</td>
<td>.768(*)</td>
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<td>Betweenness Centrality</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.137</td>
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<td>.575</td>
<td>.745(*)</td>
<td>.738(*)</td>
<td>.986(**)</td>
<td>1</td>
<td>.669(*)</td>
<td>.774(*)</td>
</tr>
<tr>
<td>Action Volume</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.081</td>
<td>.106</td>
<td>.021</td>
<td>.023</td>
<td>.000</td>
<td>.049</td>
<td>.014</td>
<td>.123</td>
</tr>
<tr>
<td>Adj. Simpson's Complexity of Action Repertoire</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.594</td>
<td>.531</td>
<td>.756(*)</td>
<td>.786(*)</td>
<td>.627</td>
<td>.669(*)</td>
<td>1</td>
<td>.955(**)</td>
</tr>
<tr>
<td>Adj. Shannon's Complexity of Action Repertoire</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.092</td>
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<td>Action Volume</td>
<td>Pearson Correlation Sig. (2-tailed)</td>
<td>.580</td>
<td>.518</td>
<td>.802(**)</td>
<td>.811(**)</td>
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** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Table 7.5 Correlations for H2-H3, H5-H9: Kendall's \( \tau_b \) non-parametric correlation

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** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Table 7.6 Correlations for H2-H3, H5-H9: Spearman’s $R$ non-parametric correlation

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** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

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Chapter 8 Data Analysis Results: An Overview

This chapter presents an overview of the data analysis results. With a majority of the hypotheses supported, the data results provide strong evidence to indicate that in the automotive industry, electronic networks are rapidly evolving and spanning across an increasing number of firms. These electronic networks have become the loci of resources. An automaker’s IOS use and structural position in these networks influence the automaker’s resource acquisition and subsequent actions taken to improve performance. Detailed discussions of the data results are given in Chapters 9-11.

8.1 The Automotive Industry: Evolving Electronic Networks as Loci of Resources

Since the mid-1980s, there has been unprecedented growth in corporate partnering and reliance on various forms of external collaboration in the automotive industry. Innovations are increasingly found at the intersections between automakers, suppliers, and customers. Automakers used to do all the design and engineering, and then have suppliers build to specifications. Now more and more of that design and engineering involve the participation of suppliers and customers.

Automakers also enter into collaboration among themselves for reducing costs and sharing risks, while they compete fiercely against each other for selling more cars at a higher profit margin. As indicated in Table 8.1, during 1985-2003, Ford has engaged in 18 contractual collaborative arrangements with each of GM, DaimlerChrysler, and Mazda. DaimlerChrysler has 17 formal collaborative arrangements with Mitsubishi Motors, 4 with BMW, and 3 with Volkswagen. Toyota has 10 formal collaboration with GM, 6 with Ford, and 5 with Nissan. Collaboration between automakers spans nearly every step in business operations, including procurement, product development, production, logistics, marketing & sales, and service.
Table 8.1 Collaboration between the nine automakers in 1985-2003

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(Data source: SDC database)

In the last decade, rapid advancements in digital technology have enabled many innovative IOS, escalating the collaboration between automakers and their partners. Some major automakers (such as the Big-Three, Toyota, BMW, and Volkswagen) are trying to follow Dell’s build-to-order model. They have implemented Web-based systems for linking the automakers to their suppliers and dealers. For example, using the Web-based build-to-order system, Toyota has launched an ambitious effort, the “five-day car,” to reduce the production cycle from six weeks to five days (counting the days from receiving an order to delivering the custom-built car to the dealership) (*Computerworld* August 30, 1999).

The Big-Three have gone even further in using IOS to support their business operations. In early 1999, Ford first bought into Microsoft Corp.'s CarPoint Web site for providing custom-built car services. GM followed by cutting a deal with NetZero Inc., a provider of free Internet access. Ford then joined with Yahoo Inc. to provide customized Web services for Ford car owners. GM also entered into a joint service arrangement with America Online Inc. In late 1999, Ford created AutoXchange, an online procurement system, with Oracle Corp. Hours later, GM announced teaming-up with Commerce One Inc. to create a similar system, TradeXchange. Months later, Ford and GM announced plans to shut down their trade exchanges respectively. The battle between Ford and GM to dominate online purchasing morphed into a collaboration between the two automakers. DaimlerChrysler also joined forces with Ford and GM, together, to form a common Internet automotive trade exchange that intended to offer procurement transactions for the Big-Three, other automakers, and their extensive supply chain partners (including Tier 1 and Tier 2 suppliers) (*Computerworld* March 6 and 13, 2000). In December 2000, the Big-Three automakers teamed up on a second B2B portal: this time to develop a
common Internet-based exchange platform through which their dealers would be able to sell repair parts to body shops and other customers (Computerworld December 7, 2000). Recently, the Big-Three have launched the “Digital Factory” initiatives. They are trying to embed digital technology into virtually every core business process, linking the automakers to their suppliers, logistics parties, assembly plants, dealers, and customers on common computing platforms.

According to a 2001 survey of 30 Tier 1 automotive suppliers in North America (multiple responses allowed) (Computerworld December 17, 2001), there is a rapidly growing use of IOS in the automotive industry, and some IOS are becoming fundamental in their daily business operations. For example,

(a) e-mail systems: 97% of suppliers had used them in 2001 and 100% would in 2003;
(b) extranets: 60% of suppliers had used them in 2001 and 77% would in 2003;
(c) Internet-based EDI: 57% of suppliers had used this in 2001 and 77% would in 2003;
(d) Covisint: 50% of suppliers had used this in 2001 and 77% would in 2003;
(e) public exchange hubs: 17% of suppliers had used them in 2001 and 33% would in 2003.

As more and more IOS links have been established between automakers and their partners, electronic networks have become the loci of resources. An automaker’s survival and performance are increasingly dependent on its linkages to these networks.

8.2 Hypothesis Testing Results

The increasing phenomena of IOS use and “co-opetition” in the automotive industry provide an excellent testing-bed for the research model introduced in Chapter 4. This research model focuses on three paired relationships of network structure-IOS use, network structure-competitive action, and IOS use-competitive action. It contends that in a network of electronically interconnected relations, network structure and IOS use co-evolve and influence competitive behavior.

Using the data collected from the automotive industry, this study examines a dynamic process of how nine sports car makers structure and restructure their network positions, deploy and redeploy their IOS to achieve competitiveness through initiating patterned actions.

Table 8.2 presents the hypothesis testing results in terms of supported and non-supported hypotheses. As indicated in Table 8.2, a majority of the hypotheses are supported. The
exceptions are a few hypotheses related to diversity of IOS use and complexity of action repertoire. The data results provide strong evidence to indicate that an automaker’s IOS use and structural position in an electronic network can significantly impact the automaker’s resource acquisition and actions that are subsequently taken to improve performance. Chapters 9-11 discuss these hypothesis testing results in terms of each paired relationship of network structure-IOS use, network structure-competitive action, and IOS use-competitive action.

Table 8.2 Hypothesis testing results: an overview

<table>
<thead>
<tr>
<th></th>
<th>HYPOTHESIS</th>
<th>SUPPORTED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Network-IOS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1:</td>
<td>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.</td>
<td>1(a) 1(b) 1(c)</td>
</tr>
<tr>
<td>H2:</td>
<td>All else being equal, degree centrality is positively related to (a) IOS reach, (b) IOS range, and (c) diversity of IOS use.</td>
<td>2(a) 2(b)</td>
</tr>
<tr>
<td>H3:</td>
<td>All else being equal, betweenness centrality is positively related to (a) IOS reach, (b) IOS range, and (c) diversity of IOS use.</td>
<td>3(a) 3(b)</td>
</tr>
<tr>
<td><strong>Network-Action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H4:</td>
<td>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.</td>
<td>4</td>
</tr>
<tr>
<td>H5:</td>
<td>All else being equal, degree centrality is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.</td>
<td>5(a) 5(b)</td>
</tr>
<tr>
<td>H6:</td>
<td>All else being equal, betweenness centrality is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.</td>
<td>6(a) 6(b)</td>
</tr>
<tr>
<td><strong>IOS-Action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H7:</td>
<td>All else being equal, IOS reach is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.</td>
<td>7(a) 7(b)</td>
</tr>
<tr>
<td>H8:</td>
<td>All else being equal, IOS range is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.</td>
<td>8(a) 8(b)</td>
</tr>
<tr>
<td>H9:</td>
<td>All else being equal, diversity of IOS use is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.</td>
<td>9(b) 9(c)</td>
</tr>
</tbody>
</table>

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Chapter 9 The Relationship between Network Structure and IOS Use

This chapter discusses data analysis results concerned with the relationship between network structure and IOS use. Results from the empirical testing of H1-H3 indicate that IOS reach and range are positively related to network centrality and are therefore two important dimensions of IOS use. However, diversity of IOS use does not relate to network centrality. In general, the argument that network structure and IOS use co-evolve is supported.

9.1 Hypothesis Testing Results

Table 9.1 presents hypothesis testing results regarding the relationship between network structure and IOS use.
Table 9.1  Hypothesis testing results regarding the relationship between network structure and IOS use

<table>
<thead>
<tr>
<th>HYPOTHESES</th>
<th>SUPPORTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: 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.</td>
<td>1(a) 1(b) 1(c)</td>
</tr>
<tr>
<td>H2: All else being equal, degree centrality is positively related to (a) IOS reach, (b) IOS range, and (c) diversity of IOS use.</td>
<td>2(a) 2(b)</td>
</tr>
<tr>
<td>H3: All else being equal, betweenness centrality is positively related to (a) IOS reach, (b) IOS range, and (c) diversity of IOS use.</td>
<td>3(a) 3(b)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(HYPOTHESIS) VARIABLE</th>
<th>CORRELATION</th>
<th>(a) IOS Reach Similarity</th>
<th>(b) IOS Range Similarity</th>
<th>(c) Diversity of IOS Use Similarity</th>
<th>(a) IOS Reach</th>
<th>(b) IOS Range</th>
<th>(c) Adj. Simpson's Diversity of IOS Use</th>
<th>(c) Adj. Shannon's Diversity of IOS Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>(H1) Structural Similarity</td>
<td>Pearson Correlation</td>
<td>.544(**).001</td>
<td>.504(**).002</td>
<td>.510(**).001</td>
<td>.696(*)</td>
<td>.677(*)</td>
<td>.536</td>
<td>.501</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td>.037</td>
<td>.045</td>
<td>.137</td>
<td>.170</td>
</tr>
<tr>
<td></td>
<td>Kendall's tau_b Correlation</td>
<td>.374(**)</td>
<td>.262(*)</td>
<td>.212</td>
<td>.479</td>
<td>.333</td>
<td>.254</td>
<td>.167</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.001</td>
<td>.025</td>
<td>.070</td>
<td>.075</td>
<td>.211</td>
<td>.345</td>
<td>.532</td>
</tr>
<tr>
<td></td>
<td>Spearman Correlation</td>
<td>.568(**)</td>
<td>.441(**)</td>
<td>.403(*)</td>
<td>.703(*)</td>
<td>.550</td>
<td>.402</td>
<td>.367</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.007</td>
<td>.015</td>
<td>.035</td>
<td>.125</td>
<td>.284</td>
<td>.332</td>
</tr>
<tr>
<td>(H2) Degree Centrality</td>
<td>Pearson Correlation</td>
<td></td>
<td></td>
<td></td>
<td>.745(*)</td>
<td>.738(*)</td>
<td>.611</td>
<td>.575</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td>.021</td>
<td>.023</td>
<td>.081</td>
<td>.106</td>
</tr>
<tr>
<td></td>
<td>Kendall's tau_b Correlation</td>
<td></td>
<td></td>
<td></td>
<td>.479</td>
<td>.556(*)</td>
<td>.479</td>
<td>.389</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td>.075</td>
<td>.037</td>
<td>.075</td>
<td>.144</td>
</tr>
<tr>
<td></td>
<td>Spearman Correlation</td>
<td></td>
<td></td>
<td></td>
<td>.728(*)</td>
<td>.717(*)</td>
<td>.611</td>
<td>.583</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td>.026</td>
<td>.030</td>
<td>.081</td>
<td>.099</td>
</tr>
</tbody>
</table>

N (structural similarity, IOS reach similarity, IOS range similarity) = 36, N (other variables) = 9
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Hypothesis 1(a) (supported): the Pearson correlation between structural similarity and IOS reach similarity is positive and significant (Pearson’s r = 0.544, p < .01). This result supports the hypothesis that structural similarity between a pair of competing firms in an electronic network is positively related to their similarity in IOS reach.

Hypothesis 1(b) (supported): the Pearson correlation between structural similarity and IOS range similarity is positive and significant (Pearson’s r = 0.504, p < .01). This result
supports the hypothesis that structural similarity between a pair of competing firms in an electronic network is positively related to their similarity in IOS range.

Hypothesis 1(c) (supported): the Pearson correlation between structural similarity and diversity of IOS use similarity is positive and significant (Pearson’s r = 0.510, p < .01). This result supports the hypothesis that structural similarity between a pair of competing firms in an electronic network is positively related to their similarity in diversity of IOS use.

Hypothesis 2(a) (supported): the Pearson correlation between degree centrality and IOS reach is positive and significant (Pearson’s r = 0.696, p < .05). This result supports the hypothesis that degree centrality is positively related to IOS reach.

Hypothesis 2(b) (supported): the Pearson correlation between degree centrality and IOS range is positive and significant (Pearson’s r = 0.677, p < .05). This result supports the hypothesis that degree centrality is positively related to IOS range.

Hypothesis 2(c) (not supported): neither the Pearson correlation nor the nonparametric correlations between degree centrality and diversity of IOS use are significant (degree centrality – adj. Simpson’s diversity: Pearson’s r = 0.536, ns, Kendall’s tau_b = 0.254, ns, Spearman’s R = 0.402, ns; degree centrality – adj. Shannon’s diversity: Pearson’s r = 0.501, ns, Kendall’s tau_b = 0.167, ns, Spearman’s R = 0.367, ns). This result fails to support the hypothesis that degree centrality is positively related to diversity of IOS use.

Hypothesis 3(a) (supported): the Pearson correlation between betweenness centrality and IOS reach is positive and significant (Pearson’s r = 0.745, p < .05). This result supports that betweenness centrality is positively related to IOS reach.

Hypothesis 3(b) (supported): the Pearson correlation between betweenness centrality and IOS range is positive and significant (Pearson’s r = 0.738, p < .05). This result supports that betweenness centrality is positively related to IOS range.

Hypothesis 3(c) (not supported): neither the Pearson correlation nor the nonparametric correlations between betweenness centrality and diversity of IOS use are significant (betweenness centrality – adj. Simpson’s diversity: Pearson’s r = 0.611, ns, Kendall’s tau_b = 0.479, ns, Spearman’s R = 0.611, ns; betweenness centrality – adj. Shannon’s diversity: Pearson’s r = 0.575, ns, Kendall’s tau_b = 0.389, ns, Spearman’s R = 0.583, ns). This result fails to support that betweenness centrality is positively related to diversity of IOS use.
9.2 Discussions

The support for H1(a)-(c), H2(a)-(b), and H3(a)-(b) is consistent with the contention of co-evolving dynamics between IOS use and network structure. A firm may initiate a collaborative relationship first and then customize its IOS use to support that collaboration. In an automotive network of electronically interconnected relations, structurally similar firms are likely to use IOS in a similar manner, while firms with a similar IOS usage tend to interact with similar others (e.g., those with similar technological capabilities) in that network. Firms with a high centrality, being central for many (significant) relationships, are more likely to observe opportunities and benefits of a greater IOS use than less central competitors, and thus are more likely to have an extensive IOS reach and range. Meanwhile, aggressive IOS users, by extending IOS reach and range to many (significant) partners, are more likely to locate themselves centrally in a network than less aggressive users. As such, a firm’s structural position in a network influences its IOS usage, while the firm’s IOS use can also change its structural position in that network.

Figure 9.1 illustrates a co-evolving pattern between network structure and IOS use in the automotive industry. The recent technology development and increasing IOS use in the automotive industry have enabled many new, significant links (relationships) that would be impossible conventionally. These IOS-enabled new interorganizational links have induced structural changes in the automotive network.

![Figure 9.1 IOS-induced structural changes in the automotive network](image)

**Figure 9.1 IOS-induced structural changes in the automotive network**

*The link between automakers and customers*

Traditionally, it is difficult for automakers to reach and collect information directly from customers, because federal laws inhibit automakers from selling cars directly to individual
customers (including rental car companies, auto repair shops, corporate buyers, and individual car buyers). Dealers must sit in between them. Now an increasing number of automakers, such as Ford, GM, DaimlerChrysler and Volkswagen, have taken the initiative in selling cars online. The Web-based sales are conducted via integrated systems that link the automakers’ back-end systems to those information systems of their customers, dealers, and even banks and other financial institutions. These Web-enabled links not only allow customers to negotiate prices and place orders with dealers directly online and apply for financing and loans in real-time, but also enable automakers to gather information directly from individual buyers and immediately transform that information into factory-floor actions.

A few automakers have even classified customers into fine-tuned segments and customized their IOS links to maximize the reach to those segmented customers. For example, Ford has segmented its customers into dealers, potential car buyers, car owners, car fans, female car buyers, young car buyers, and so forth. To maximize its reach to those customers, Ford has tried many alternative ways. These include DealerConnection portal (for providing details on local inventories and special deals), BuyerConnection portal (for providing local dealer price quotes and insurance applications), OwnerConnection portal (for providing a virtual community of owners and building ongoing customer relationships), community sites (such as iVillage for women, digital entertainment network for young people), as well as CarClub portal (for providing automotive-related products and services) (Computerworld September 22, 1999). In addition, through joint services with Microsoft’s CarPoint automotive portal, Ford lets individual car buyers order custom-built cars directly from Ford’s factory (Computerworld November 15, 1999). Ford also links its corporate site to Priceline.com and lets car buyers bid prices for new cars. Customers who visit the automaker's Web site can click on a button and arrive at Priceline's Web site. Once there, they can submit bids for the cars of their choice. Those bids are then sent to car dealers near the customers, and the dealers can decide whether to accept the offer or not.

Take BMW as another example. BMW is testing a customer innovation lab, an innovative new multimedia Internet tool, for fostering customer community and leveraging creative thinking of customers. The customer innovation lab (www.bmw.com/innovationlab) provides car fans or interested customers a sort of online toolbox to help them shape and develop their own ideas. Depending on the scenario chosen, users can choose from a selection of
appropriate pictures and keywords to help them define their maybe vague ideas with greater precision. For example, to submit a suggestion to the customer innovation lab, the user must first log on by giving a user name and an e-mail address. Then each idea is assigned to a certain scenario: e.g., "vacation," "business trip," "highway," "city driving," etc. Following that rough classification, the creative user can describe the concrete everyday situations in which the new service would be useful, or an idea and its technical implementation if possible. Finally, the best ideas will be selected by the automaker and pursued in collaboration with their originators (news release at www.bmw.com August 21, 2003).

The link between dealers and parts suppliers

Following the initiatives for linking automakers and customers in 1999, some automakers launched Web portals to link dealers and parts suppliers for providing better service to dealers. For example, GM developed a Web portal (www.gmde.com) to offer dealers an easier way to order equipment than faxing or phoning in orders. The Web portal lets dealers read the latest service and equipment news, browse equipment specials, make equipment purchases online, and contact suppliers directly for better information. The portal offers more than 10,000 service equipment items from over 100 suppliers, whose Web sites are hot linked for dealers who need additional information on designed gears. After entering their dealer codes, dealers can order items such as lifts, alignment equipment, wheel balances, and battery chargers (Computerworld November 16, 1998).

The link between automakers and Tier-2 suppliers

Traditionally, many automakers only maintained direct contacts with a selected number of Tier-1 suppliers. Establishing direct ties with Tier-2 suppliers would be costly. The proliferation and growing sophistication of automotive electronic marketplaces have enabled automakers to manage their extended supply chain (including Tier 1 and Tier 2 suppliers) on a common application platform and reap the benefits of economies of scale and scope.

Covisint represents a first joint effort of such an attempt by the Big-Three automakers – GM, Ford, and DaimlerChrysler – to weave together the back-end systems of the automakers and their extended suppliers. Covisint can handle up to $300 billion in automotive business each year. It helps cut time, costs and wastes in both the exchange process and the collaborative engineering and design process (Computerworld December 17, 2001).
Failing to support H2(c) and H3(c) suggests that diversity of IOS use may not relate to network structure (centrality). A possible rationale is that a high centrality may not involve a firm’s direct engagement in diverse business operations and thus its IOS support for diverse operations. Likewise, a diversity of IOS use may not involve a firm’s engagement in a large number of (significant) relationships, and thus may not relate to a high centrality.

9.3 Implications

For IOS researchers, the strong relationship between network structure and IOS use found in the automotive industry suggests that introducing a social network perspective into the IOS study offers a new exciting and necessary research direction. Research in this direction deepens our understanding of IOS’s roles in today’s e-business. This understanding is especially meaningful when IOS-mediated networks are increasingly become the loci of resources.

For IOS users, the evidence of co-evolving dynamics between network structure and IOS use found in the automotive industry suggests that aggressive pursuit of new possibilities for establishing significant relationships via IOS can be an important source of competitive advantage. By doing so, a firm is able to structure in an advantageous resource position in a network and obtains a greater potential for leveraging emergent market opportunities for superior performance.
Chapter 10 The Relationship between Network Structure and Competitive Action

This chapter discusses results concerned with the relationship between network structure and competitive action. Results from the empirical testing of H4-H6 indicate a strong relationship between network structure and competitive action. These results also suggest the importance of structuring an efficient network by linking to diverse significant partners or partners with diverse backgrounds. An efficient network provides rich resources (particularly knowledge) that are additive and non-redundant, and enables a firm to launch actions with speed and surprise.

10.1 Hypothesis Testing Results

Table 10.1 presents hypothesis testing results regarding the relationship between network structure and competitive action.
Table 10.1  Hypothesis testing results regarding the relationship between network structure and action pattern

<table>
<thead>
<tr>
<th>HYPOTHESES</th>
<th>SUPPORTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>H4: 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.</td>
<td>4</td>
</tr>
<tr>
<td>H5: All else being equal, degree centrality is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.</td>
<td>5(a) 5(b)</td>
</tr>
<tr>
<td>H6: All else being equal, betweenness centrality is positively related to (a) action volume, (b) complexity of action repertoire, and (c) action heterogeneity.</td>
<td>6(a) 6(c)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(HYPOTHESIS) VARIABLE</th>
<th>CORRELATION</th>
<th>(H4) Action Pattern Similarity</th>
<th>(a) Action Volume</th>
<th>(b) Adj. Simpson's Complexity of Action Repertoire</th>
<th>(c) Adj. Shannon's Complexity of Action Repertoire</th>
<th>(c) Action Heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(H4) Structural Similarity</td>
<td>Pearson Correlation</td>
<td>.781(**)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kendall's tau_b Correlation</td>
<td>.594(**)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spearman Correlation</td>
<td>.781(**)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(H5) Degree Centrality</td>
<td>Pearson Correlation</td>
<td>.768(*)</td>
<td>.584</td>
<td>.682(*)</td>
<td>.627</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.016</td>
<td>.099</td>
<td>.043</td>
<td>.070</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kendall's tau_b Correlation</td>
<td>.479</td>
<td>.444</td>
<td>.389</td>
<td>.333</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.075</td>
<td>.095</td>
<td>.144</td>
<td>.211</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spearman Correlation</td>
<td>.703(*)</td>
<td>.617</td>
<td>.583</td>
<td>.617</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.035</td>
<td>.077</td>
<td>.099</td>
<td>.077</td>
<td></td>
</tr>
<tr>
<td>(H6) Betweenness Centrality</td>
<td>Pearson Correlation</td>
<td>.774(*)</td>
<td>.553</td>
<td>.609</td>
<td>.669(*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.014</td>
<td>.123</td>
<td>.082</td>
<td>.049</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kendall's tau_b Correlation</td>
<td>.366</td>
<td>.333</td>
<td>.278</td>
<td>.556(*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.173</td>
<td>.211</td>
<td>.297</td>
<td>.037</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spearman Correlation</td>
<td>.586</td>
<td>.517</td>
<td>.500</td>
<td>.750(*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.097</td>
<td>.154</td>
<td>.170</td>
<td>.020</td>
<td></td>
</tr>
</tbody>
</table>

N (structural similarity) = 36, N (other variables) = 9
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Hypothesis 4 (supported): the Pearson correlation between structural similarity and action pattern similarity is positive and significant (Pearson’s r = 0.781, p < .000). This result supports the hypothesis that structural similarity between two competing firms is positively related to their action pattern similarity.

ANOVA tests are conducted to compare the nine automakers’ network structures and action patterns. Table 10.2 presents the test results for network structure. Tukey’s grouping indicates that Toyota, GM, DaimlerChrysler, and Ford possess a similar network structure (with
a degree centrality greater than 200), thus falling into one group. Mitsubishi, Volkswagen, Mazda, and BMW (with a degree centrality less than 100) are not significantly different in their network structures, thus falling into another group. Nissan’s structure (with a degree centrality between 100-200) is in-between the other two groups. It is not significantly different from the structures of Ford and DaimlerChrysler, nor significantly different from those of Mitsubishi, Volkswagen, Mazda, and BMW.

Table 10.2 ANOVA Tukey’s studentized range test for network structure

<table>
<thead>
<tr>
<th>Automaker</th>
<th>Mean</th>
<th>N</th>
<th>Tukey Grouping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toyota</td>
<td>0.410</td>
<td>805</td>
<td>A</td>
</tr>
<tr>
<td>GM</td>
<td>0.373</td>
<td>805</td>
<td>A</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>0.358</td>
<td>805</td>
<td>A B</td>
</tr>
<tr>
<td>Ford</td>
<td>0.337</td>
<td>805</td>
<td>A B</td>
</tr>
<tr>
<td>Nissan</td>
<td>0.217</td>
<td>805</td>
<td>C B</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>0.121</td>
<td>805</td>
<td>C</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0.094</td>
<td>805</td>
<td>C</td>
</tr>
<tr>
<td>Mazda</td>
<td>0.088</td>
<td>805</td>
<td>C</td>
</tr>
<tr>
<td>BMW</td>
<td>0.073</td>
<td>805</td>
<td>C</td>
</tr>
</tbody>
</table>

(Means with the same letter are not significantly different at the 0.05 level.)

Table 10.3 ANOVA Tukey’s studentized range test for competitive action

<table>
<thead>
<tr>
<th>Automaker</th>
<th>Mean</th>
<th>N</th>
<th>Tukey Grouping</th>
</tr>
</thead>
<tbody>
<tr>
<td>DaimlerChrysler</td>
<td>1.139</td>
<td>72</td>
<td>A</td>
</tr>
<tr>
<td>Ford</td>
<td>0.861</td>
<td>72</td>
<td>A B</td>
</tr>
<tr>
<td>GM</td>
<td>0.597</td>
<td>72</td>
<td>C B</td>
</tr>
<tr>
<td>Toyota</td>
<td>0.527</td>
<td>72</td>
<td>C B</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>0.319</td>
<td>72</td>
<td>C</td>
</tr>
<tr>
<td>BMW</td>
<td>0.222</td>
<td>72</td>
<td>C</td>
</tr>
<tr>
<td>Mazda</td>
<td>0.222</td>
<td>72</td>
<td>C</td>
</tr>
<tr>
<td>Nissan</td>
<td>0.222</td>
<td>72</td>
<td>C</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0.111</td>
<td>72</td>
<td>C</td>
</tr>
</tbody>
</table>

(Means with the same letter are not significantly different at the 0.05 level.)

Table 10.3 gives the ANOVA results for competitive action. Tukey’s grouping suggests that automakers’ action patterns follow a similar grouping as the grouping for network structures. Mitsubishi, BMW, Mazda, Nissan, and Volkswagen undertook actions that were similar to each other but were significantly different from those undertaken by DaimlerChrysler and Ford. The action patterns of GM and Toyota fall in-between the other two groups, neither significantly
different from the action patterns of DaimlerChrysler and Ford, nor significantly different from those of Mitsubishi, BMW, Mazda, Nissan, and Volkswagen.

**Hypothesis 5(a) (supported):** the Pearson correlation between degree centrality and action volume is positive and significant (Pearson’s $r = 0.768$, $p < .05$). This result supports the hypothesis that degree centrality is positively related to action volume.

**Hypothesis 5(b) (supported):** the Pearson correlation between degree centrality and complexity of action repertoire (adj. Shannon’s complexity) is positive and significant ($Pearson’s r = 0.682$, $p < .05$). This result supports the hypothesis that degree centrality is positively related to complexity of action repertoire.

**Hypothesis 5(c) (not supported):** neither the Pearson correlation nor the nonparametric correlations between degree centrality and action heterogeneity are significant ($Pearson’s r = 0.627$, $ns$, Kendall’s $tau _b = 0.333$, $ns$, Spearman’s $R = 0.617$, $ns$). This result fails to support the hypothesis that degree centrality is positively related to action heterogeneity.

**Hypothesis 6(a) (supported):** the Pearson correlation between betweenness centrality and action volume is positive and significant ($Pearson’s r = 0.774$, $p < .05$). This result supports the hypothesis that betweenness centrality is positively related to action volume.

**Hypothesis 6(b) (not supported):** neither the Pearson correlation nor nonparametric correlations between betweenness centrality and complexity of action repertoire are significant (betweenness centrality – adj. Simpson’s complexity: $Pearson’s r = 0.553$, $ns$, Kendall’s $tau _b = 0.333$, $ns$, Spearman’s $R = 0.517$, $ns$; betweenness centrality – adj. Shannon’s complexity: $Pearson’s r = 0.609$, $ns$, Kendall’s $tau _b = 0.278$, $ns$, Spearman’s $R = 0.5$, $ns$). This result fails to support the hypothesis that betweenness centrality is positively related to complexity of action repertoire.

**Hypothesis 6(c) (supported):** the Pearson correlation between betweenness centrality and action heterogeneity is positive and significant ($Pearson’s r = 0.669$, $p < .05$). This result supports the hypothesis that betweenness centrality is positively related to action heterogeneity.

10.2 Discussions

The support for H4, H5(a), and H6(a) and the ANOVA results are consistent with the argument that in a network of electronically interconnected relations, a firm’s structural position in the network shapes the firm’s acquisition of external resources (assets, knowledge, and status),
its awareness of market opportunities and ability to respond to the competitive context, and thus the firm’s subsequent actions taken against competitors. Firms with similar structural positions are likely to undertake similar actions. While firms that position in the center of a network, being at the confluence of resource flows, are likely to launch a greater number of actions than less central competitors.

**The support for H5(b) but not for H6(b)** invites further scrutiny of the relationship between network centrality and action complexity. Action complexity denotes the extent to which a given series of actions consists of a diversified set of action categories. To undertake a broad range of actions requires a firm to manage interdependencies with partners among diverse business operations (e.g., task coordination in procurement, logistics and production, collaborative construction in product design, relationship management in marketing & sales and service).

Degree centrality, defined as the number of direct partnerships, reflects a firm’s *direct* engagement in various collaborative operations and access to external assets of connected partners, such as technology, money, and managerial skills. As such, a firm with a high degree centrality is likely to accumulate experiences through direct engagement in joint task performance of many operations. Experiences in joint task performance enhance the firm’s ability to undertake a diversified set of actions. Thus, a high degree centrality is likely related to a high action complexity.

On the other hand, betweenness centrality, by denoting a firm’s probability of falling on the shortest paths of other network participants, reflects a firm’s *relative* position in acquiring knowledge and power in relation to its partners. A high betweenness centrality does not indicate a firm’s direct engagement in collaborative ventures, and thus may not directly enhance a firm’s ability to manage interdependencies among various business operations. As such, a high betweenness centrality and information (control) advantage may not directly relate to a high action complexity.

**The support for H6(c) but not for H5(c)** highlights the difference between degree centrality and betweenness centrality. Betweenness centrality reflects a firm’s relative position in spanning the sparse regions, which is vividly described by Burt (1992) as “structural holes” in a network. “A hole is a buffer, like an insulator in an electric circuit” (Burt 1997 pp. 341). A structural hole between two clusters in a network need not mean that participants in the two
clusters are unaware of one another. It simply means that they are so focused on their own activities that they have paid little attention to activities in the other cluster. A structural hole indicates that firms on either side of the hole operate with different flows of knowledge. A firm that spans the structural hole, by having strong relations with contacts on both sides of the hole, has access to both knowledge flows. The more holes spanned, the richer the knowledge benefits of the network (Burt 1997 pp. 341). As such, a firm with a high betweenness centrality is likely to obtain rich knowledge that is non-redundant but additive.

However, unlike betweenness centrality which indicates the degree of non-redundant knowledge benefits, degree centrality does not have such a direct indication. By directly linking to many partners, a firm possesses a high degree centrality. But a high degree centrality does not necessarily imply the occurrence of non-redundant knowledge. It is likely that the contacts who link to the focal firm also link to the same third parties, and thus have the same knowledge sources and redundant knowledge. Therefore, a firm with a high betweenness centrality, rather than a high degree centrality, is likely to obtain knowledge advantage that increases the firm’s awareness of external opportunities and competitive context, and thus is better able to position itself to launch actions that are distinct from those of its competitors.

A close examination of the automakers’ network structures and action patterns further support the above rationale.

(1) Toyota’s network structure is the densest of all nine automakers, with many contacts having ties linked to each other. This network structure explains why Toyota has the highest degree centrality of all nine automakers (330), but Toyota has a lower betweenness centrality (31.33) than that of GM (31.57), and a lower action heterogeneity (0.72) than that of GM (0.85).

(2) Although Mazda has a higher degree centrality (71) than that of BMW (59), its betweenness centrality (4.66) is much lower than that of BMW (6.62), and its action heterogeneity (0.65) is also lower than that of BMW (0.68).

(3) Mitsubishi has a much higher degree centrality (97) than that of Volkswagen (76) and that of BMW (59), but its betweenness centrality (5.58) is much lower than that of both Volkswagen (9.47) and BMW (6.62). Mitsubishi’s action heterogeneity (0.6) is also lower than that of both Volkswagen (0.63) and BMW (0.68).
10.3 Implications

For researchers, the strong relationship between network structure and competitive action found in the automotive industry adds an in-depth understanding of the competitive dynamics in e-business. Although the relationship between network structure and competitive action has captured an increasing research interest, no empirical studies so far have been conducted to validate this relationship. As such, this study enriches research on competitive dynamics and social networks by empirically validating the relationship between network structure and competitive action.

For IOS users, the hypothesis testing results from this study suggest the importance of structuring an efficient network by linking to many, significant partners or partners with diverse backgrounds (e.g., different knowledge, experiences, or industry activities) (Beckman and Haunschild 2002; Rodan and Galunic 2004). An efficient network provides rich resources (particularly knowledge) that are additive and non-redundant, and enables a firm to launch actions with speed and surprise. Heterogeneous actions need not to be complex, even a simple one would be able to differentiate a firm from its competitors and disrupt the advantages of market leaders.
Chapter 11 The Relationship between IOS Use and Competitive Action

This chapter discusses results concerned with the relationship between IOS use and competitive action. Results from the empirical testing of H7-H9 suggest important roles of IOS in influencing firm behavior. They also provide the promise of developing an IT value measure that supplements the traditional measures by addressing the limitations of those measures.

11.1 Hypothesis Testing Results

Table 11.1 presents the hypothesis testing results regarding the relationship between IOS use and competitive action.
Table 11.1  Hypothesis testing results regarding the relationship between IOS use and competitive action

<table>
<thead>
<tr>
<th>(HYPOTHESIS) VARIABLE</th>
<th>CORRELATION</th>
<th>(a) Action Volume</th>
<th>(b) Adj. Simpson’s Complexity of Action Repertoire</th>
<th>(b) Adj. Shannon’s Complexity of Action Repertoire</th>
<th>(c) Action Heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>(H7) IOS Reach</td>
<td>Pearson Correlation</td>
<td>.802(**)</td>
<td>.370</td>
<td>.394</td>
<td>.756(*)</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.009</td>
<td>.327</td>
<td>.294</td>
<td>.018</td>
</tr>
<tr>
<td></td>
<td>Kendall’s tau_b Correlation</td>
<td>.629(*)</td>
<td>.423</td>
<td>.366</td>
<td>.535(*)</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.020</td>
<td>.116</td>
<td>.173</td>
<td>.046</td>
</tr>
<tr>
<td></td>
<td>Spearman Correlation</td>
<td>.811(**)</td>
<td>.527</td>
<td>.393</td>
<td>.711(*)</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.008</td>
<td>.145</td>
<td>.295</td>
<td>.032</td>
</tr>
<tr>
<td>(H8) IOS Range</td>
<td>Pearson Correlation</td>
<td>.811(**)</td>
<td>.385</td>
<td>.381</td>
<td>.786(*)</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.008</td>
<td>.306</td>
<td>.312</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td>Kendall’s tau_b Correlation</td>
<td>.423</td>
<td>.222</td>
<td>.167</td>
<td>.556(*)</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.116</td>
<td>.404</td>
<td>.532</td>
<td>.037</td>
</tr>
<tr>
<td></td>
<td>Spearman Correlation</td>
<td>.603</td>
<td>.350</td>
<td>.233</td>
<td>.700(*)</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.086</td>
<td>.356</td>
<td>.546</td>
<td>.036</td>
</tr>
<tr>
<td>(H9) Diversity of IOS Use</td>
<td>Pearson Correlation</td>
<td>.580</td>
<td>**.699(*)</td>
<td>.594</td>
<td>.092</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.102</td>
<td>.036</td>
<td>.016</td>
<td>.016</td>
</tr>
<tr>
<td></td>
<td>Kendall’s tau_b Correlation</td>
<td>.514</td>
<td>.197</td>
<td>.648(*)</td>
<td>.016</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.058</td>
<td>.463</td>
<td>.762(*)</td>
<td>.017</td>
</tr>
<tr>
<td></td>
<td>Spearman Correlation</td>
<td>.609</td>
<td>.276</td>
<td>.767(*)</td>
<td>.016</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.082</td>
<td>.472</td>
<td>.017</td>
<td>.017</td>
</tr>
</tbody>
</table>

N = 9
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Hypothesis 7(a) (supported): the Pearson correlation between IOS reach and action volume is positive and significant ($Pearson’s \ r = 0.802, p < .01$). This result supports the hypothesis that IOS reach is positively related to action volume.

Hypothesis 7(b) (not supported): neither the Pearson correlation nor the nonparametric correlations between IOS reach and complexity of action repertoire are significant (IOS reach – adj. Simpson’s complexity: $Pearson’s \ r = 0.37, ns, Kendall’s \ tau_b = 0.423, ns, Spearman’s \ R = 0.527, ns$; IOS reach – adj. Shannon’s complexity: $Pearson’s \ r = 0.394, ns, Kendall’s \ tau_b = 0.366, ns, Spearman’s \ R = 0.393, ns$). This result fails to support the hypothesis that IOS reach is positively related to complexity of action repertoire.

Hypothesis 7(c) (supported): the Pearson correlation between IOS reach and action heterogeneity is positive and significant ($Pearson’s \ r = 0.756, p < .05$). This result supports the hypothesis that IOS reach is positively related to heterogeneity.

Hypothesis 8(a) (supported): the Pearson correlation between IOS range and action volume is positive and significant ($Pearson’s \ r = 0.811, p < .01$). This result supports the hypothesis that IOS range is positively related to action volume.

Hypothesis 8(b) (not supported): neither the Pearson correlation nor the nonparametric correlations between IOS range and complexity of action repertoire are significant (IOS range – adj. Simpson’s complexity: $Pearson’s \ r = 0.385, ns, Kendall’s \ tau_b = 0.222, ns, Spearman’s \ R = 0.350, ns$; IOS range – adj. Shannon’s complexity: $Pearson’s \ r = 0.381, ns, Kendall’s \ tau_b = 0.167, ns, Spearman’s \ R = 0.233, ns$). This result supports that IOS range is positively related to complexity of action repertoire.

Hypothesis 8(c) (supported): the Pearson correlation between IOS range and action heterogeneity is positive and significant ($Pearson’s \ r = 0.786, p < .05$). This result supports the hypothesis that IOS range is positively related to action heterogeneity.

Hypothesis 9(a) (not supported): neither the Pearson correlation nor the nonparametric correlations between diversity of IOS use and action volume are significant (adj. Simpson’s diversity – action volume: $Pearson’s \ r = 0.58, ns, Kendall’s \ tau_b = 0.514, ns, Spearman’s \ R = 0.609, ns$; adj. Shannon’s diversity – action volume: $Pearson’s \ r = 0.518, ns, Kendall’s \ tau_b = 0.479, ns, Spearman’s \ R = 0.603, ns$). This result fails to support that diversity of IOS use is positively related to action volume.
Hypothesis 9(b) (supported): the Pearson correlation between diversity of IOS use and complexity of action repertoire (adj. Simpson’s diversity) is positive and significant (Pearson’s $r = 0.699$, $p < .05$). This result supports the hypothesis that diversity of IOS use is positively related to complexity of action repertoire.

Hypothesis 9(c) (supported): although the Pearson correlation between diversity of IOS use and action heterogeneity is not significant, the nonparametric correlation is positive and significant (adj. Simpson’s diversity – action heterogeneity: Pearson’s $r = 0.594$, ns, Kendall’s tau_b = 0.648, $p < .05$, Spearman’s $R = 0.611$, $p < .05$; adj. Shannon’s diversity – action heterogeneity: Pearson’s $r = 0.531$, ns, Kendall’s tau_b = 0.611, $p < .05$, Spearman’s $R = 0.767$, $p < .05$). This result supports the hypothesis that diversity of IOS use is positively related to action heterogeneity. But a nonlinear relationship may exist between diversity of IOS use and action heterogeneity.

11.2 Discussions

The support for H7(a) and H7(c) is consistent with the argument that by extending a firm’s reach to diverse parties, IOS allow the firm to leverage heterogeneous resources of its partners (such as shared IT assets and capabilities, knowledge, and market influence of well-recognized firms), enhance the firm’s internal efficiency (such as enable “just-in-time” delivery, encourage standardization of data representation, capture data more quickly and precisely, shorten response time) and also the interorganizational efficiency between the firm and its partners (such as tighten integration, increase control and coordination, enable build-to-order, extend market reach to customers who could not be economically served by conventional field sales calls). This extended reach through IOS can result in fast and timely actions in a manner that deviates from the industry norm, and thus can be a source of competitive advantage.

DaimlerChrysler presents an excellent example in support of the above statements. DaimlerChrysler has been aggressive in extending its IOS links to diverse partners, including parts suppliers, assembly plants (outsourcers), financial service providers, external design partners, third-party logistics partners, customers (including dealers, retailers, auto repair shops, corporate buyers, individual consumers), and even competitors (other automakers). Aggressively extended IOS links have enabled DaimlerChrysler to launch fast and heterogeneous actions. In 2003, DaimlerChrysler undertook the largest number of actions of all
nine automakers (81). Its action heterogeneity was also the highest (1.39) of all automakers under study.

**Linking to parts suppliers, assembly plants, and other automakers**

DaimlerChrysler is an initiator and participant of Covisint – a B2B procurement exchange that links automotive parts suppliers and other automakers (*Computerworld* December 7, 2000). DaimlerChrysler also participates in ANX (the Automotive Network Exchange) (*Computerworld* July 7, 1997) and ENX (the European Network Exchange) (*Computerworld* April 12, 1999) for supporting computer-aided design, engineering and manufacturing collaboration between the automaker, its suppliers, and other partners around the world.

In addition, DaimlerChrysler uses a Lotus Notes-based material cost management system to link 54 component teams for sharing ideas about how best to streamline the number of common parts used among different vehicle lines. The system has helped conceive an average of 570 weekly “idea changes” and cut the number of fog lamps used in various vehicles, saving $7 million (*Computerworld* November 20, 2002).

Web-based "Do All" system is a corporate intranet, which is used by DaimlerChrysler for publishing real-time manufacturing data. The “Do All” system integrates 21 separate mainframe-based databases worldwide and lets selected parts suppliers and assembly plants view everything from vehicle ID numbers and parts lists to quality and warranty data. In the event of a shortage of a certain kind of brake rotor, for example, a scheduling manager could check the system to see how and where the company's assembly plants would be affected, and then change production schedules accordingly (*Computerworld* July 13, 1998).

DaimlerChrysler also gives its suppliers online access to their performance scorecards and the performance data on competing suppliers. The scorecards rank each supplier in terms of quality, systems cost, technology and the ability to deliver parts (*Computerworld* October 23, 2002).

Aggressive pursuit of joint performance improvement with suppliers and other parties via IOS has greatly enhanced DaimlerChrysler’s ability to launch fast moves innovatively (e.g., new production process, new car models, as well as competitive pricing resulted from lowered production costs and improved vehicle quality).
**Linking to financial service providers**

DaimlerChrysler uses RouteOne system, a Web-based credit application management system, to link automobile dealers, banks, and financial companies for exchanging data about customer loan applications. Direct links to financial institutions and other service providers (such as insurance companies) enhance efficiency and innovation in customer service.

For instance, by allowing customers to apply for financing and car loans directly online, an average car sale, which used to involve a salesperson, a sales manager, and a finance and insurance staffer, and would take 4 hours and 55 minutes at a typical dealership, now can be handled within an hour with one person (Computerworld February 19, 1996).

**Linking to external design partners**

DaimlerChrysler has integrated CATIA, the computer-aided design and manufacturing software, into its worldwide design and manufacturing processes. The software is used as the basis for integration and collaboration with external design partners in designing a vehicle's surface, such as the body panels, doors, and hoods, as well as internal mechanisms like brake calipers and steering columns (Computerworld March 11, 2002).

DaimlerChrysler also uses EBOK (the Engineering Book of Knowledge), a collaborative knowledge management system, for linking diverse automobile engineering parties worldwide. The system provides "best practice" knowledge on car design and building processes, ranging from door panels to tail lamps to engine parts. The idea of EBOK is to get subject matter experts to enter best-practice descriptions into a central database in a Lotus Notes system. The automaker then uses Grapevine, the software that builds on Notes' basic communication capabilities to prune data to users' tastes and deliver it to their doorsteps. Grapevine first requires that users create their own interest profile. It then tracks multiple Notes databases, finds entries related to a user's interests and notifies the user via an e-mail message. The relevant document will show up as a hypertext link in the message (Computerworld December 8, 1997).

Through joint efforts of various design parties linked via collaborative design systems, DaimlerChrysler is able to cut the vehicle development time from 5 years down to 12-18 months (Computerworld August 12, 2002), and is also able to produce more new vehicle models at a lower cost.
**Linking to third-party logistics partners**

DaimlerChrysler implemented a case-based knowledge management system for customer support. Using a Web-based interface, the automaker offers its system to dealers and franchisees, as well as third-party logistics firms such as FedEx Corp. The system has helped speed up diagnosing and troubleshooting problems in the field that are not so concrete (e.g., vehicles running hot or driving tough) (*Computerworld* October 21, 2002).

**Linking to customers**

DaimlerChrysler initiated and participates in a B2B repair parts portal that links to other automakers, dealers and body shops for aftermarket parts procurement (*Computerworld* December 7, 2000).

The automakers also uses ESS, an electronic sales system, to provide dealers online access to everything from vehicle availability to sales incentives in an effort to phase out the inexact process of checking physical manuals and querying management, centralizing information and speeding up sales process. ESS also provides functions that aren’t supported on the automaker’s consumer Web site, including checking for current factory incentives, scanning the inventory of other dealers, handling trade-ins, ordering vehicles and discussing service contracts (*Computerworld* February 15, 1999).

Furthermore, DaimlerChrysler uses E.piphany's CRM (customer relationship management) package to help integrate multiple databases in marketing, vehicle service and warranty, and call center. E.piphany’s CRM also helps provide such functionalities as cross-selling and outbound sales campaigns from the call center, automatic routing of the top customers to the best agents for the best possible service, integration of additional channels such as cell phones, chat and e-mail, incorporating useful Web links onto screens to point callers to additional information in real time, as well as personal Web pages tailored with individual customer information (*Computerworld* December 7, 1998).

Direct links to customers have enabled DaimlerChrysler to segment its customers into fine-tuned categories of bought new, bought used, bought new/still own, and bought used/still own, and to launch targeted actions speedily and innovatively.

The support for H8(a) and H8(c) is consistent with the argument that a wide range of IOS functionalities can broaden the range of action repertoire by bringing forth unique and
innovative actions to the product-market space. Many examples of IOS applications at the nine automakers further explain these correlations.

**IOS support for procurement and production initiatives**

Take Covisint as an example. Covisint (as a B2B procurement exchange linking automakers and their extended supply chains) supports many initiatives in procurement, production, and even product development. Covisint’s integrated functionalities and services include (*Computerworld* July 2, 2001):

(a) supply chain execution software (e.g., direct material and parts procurement) from SupplySolution;

(b) advanced product quality planning, a process that addresses parts changes during the design and manufacturing process from Powerway;

(c) collaborative product design and project management from MatrixOne;

(d) product visualization tools from Engineering Animation Inc.;

(e) online auction services (quote-and-auction services and technology) from CommerceOne;

(f) Internet-based EDI transactions;

(g) ebXML data translation capability.

A wide range of functionalities provided by Covisint expand boundary transactions between participants to include more integrated core business processes, such as joint forecasting, replenishment, and capacity planning, competitive bidding, e-auction and pricing, change order management, and product data management.

**IOS support for marketing & sales initiatives**

Take Mercedes-Benz’s multimedia Web sites as an example. Mercedes-Benz leverages the Internet as an important building block in its integrated brand communication. For each new model, Mercedes-Benz presents an interactive, multimedia-edited Web special. In September, 2003, for instance, Mercedes-Benz launched its marketing initiative in “trilogy” format with racy driving scenes, a multimedia-edited history and a prize activity, in which participants could win an exclusive test drive online in the new "Silver Arrow" of the 21st century (www.mercedes-benz.com/slr-unlimited). Mercedes-Benz used the multimedia Web site to put sports car fans in exactly the right mood for the world premiere of the Mercedes-Benz SLR McLaren. Mercedes-
Benz also used the multimedia Web site to present the first interactive film on the Web, "7 years later." Via numerous decision options, the online visitor could arrange the individual action sequences of the film at www.mercedes-benz.com/7yearslater and could consequently create their own story. The users would then be invited to draft their own individual interpretation of the film. The best storyboard was awarded a prize and a prize was also raffled among all the storywriters. Meanwhile, Mercedes-Benz offered a foretaste of the world’s biggest automobile trade fair at www.mercedes-benz.com/iaa in its own Web special for the IAA 2003. Online visitors could win interesting prizes in the IAA quiz. In addition to all these, a multimedia technology lexicon ranging from "active body control" to "pre-safe" through to "sensotronic brake control" was started in mid-September (news release at www.daimlerchrysler.com August 22, 2003).

Take Ford’s Web sales system as another example. Ford implemented FordDirect.com to support its Web-based car sales initiative. FordDirect.com offers car shoppers an "e-price" on vehicles. The "e-price" falls somewhere between the manufacturer's suggested retail price and its invoice price. Since August 2000, the automaker has been experimenting with the "e-price" concept. Two new pilot projects jointly developed by the automaker and Trilogy Software Inc. have been made to offer more accurate pricing data and allow consumers to configure vehicles online. In both online programs, the Windows NT-based online ordering system was connected to the automaker's back-end vehicle scheduling system, allowing customers to place orders directly with the automaker. The online ordering system also allowed dealers to set up pricing formulas for individual customers, who were prompted with the negotiated price as they configured their vehicles online (Computerworld August 21, 2000).

Both examples of Mercedes-Benz and Ford clearly illustrate that sophisticated Web systems (which provide such functionalities as broadband and multimedia) enable innovative Web-based marketing & sales campaigns and can help support a broad range of marketing & sales initiatives (e.g., enabling e-price, reverse auction, and unique product features, making product easier or less expensive to select, order, handle, or track, enhancing product image via multimedia and broadband, providing immediate feedback on product availability and price).

**IOS support for product development initiative**

Take Ford’s collaborative design system as an example. Ford uses C3P (Computer-Aided Design, Manufacturing and Engineering and Product Information Management system) to
support its worldwide initiative in joint product development. C3P allows engineers at different design centers to participate in online videoconferences from their desktops. These design centers are linked to the automaker's advanced engineering center via T1 lines, satellites, and ATM networks. In addition to videoconferencing, these design centers also use Silicon Graphics Inc.'s Z-Mail and Annotator e-mail programs to send video clips and 3-D images over Ford's intranet. Using these technologies, design engineers who are several time zones apart are able to collaborate asynchronously. Engineers are also able to do collaborative crash and flow analysis, simulations and other electronic work from networked workstations in real-time. Additionally, C3P supports Ford’s collaborative design and engineering process with its suppliers (Computerworld September 30, 1996).

As one engineer puts it, "the collaborative design system is widely used at Ford. Ford’s external suppliers are required to use the same or compatible CAD tools and system as Ford does, such as IDEAS, C3P. Once the supplier's design is made available, it is input into Ford system in a systematic way and kept updated. Even though there exist many versions of a design at working status, once released there will be a single source for information including 3-D graphic drawings which are compatible with CAM. We also use videoconference rooms but not too often. While people still prefer face to face meetings and one on one conversation through telephones, some important regular meetings are set up in videoconference rooms with a call-in number published. If you can not attend the meeting as you are on travel or for whatever reason, you can dial the number, listen to others talking in the meeting and request to be allowed to say something. In a previous program I worked, there was a weekly meeting like that. If both ends are videoconference rooms, we do see each other. We use this way for technical exchange meetings with our counterparts in Ford European operation and Mazda in Japan because we have to see each other's presentations. At Ford product development center, normally large conference rooms (for 20 people and more) are equipped with tele/video-conferencing equipment" (excerpted from the author’s interview with a Ford’s engineer on August 18, 2004).

C3P, by providing a series of sophisticated functionalities like support for collaborative construction and decision making, has helped Ford reduce vehicle development time from 60 months in 1986 to 32 months in 1996 and further down to 22 months in 2002 (for the 2005 Ford GT project). C3P has also helped cut prototype costs by 50%, improve investment efficiencies by 20%-30%, and eliminate half of Ford’s costly late development changes. All these benefits
reaped from C3P have enhanced Ford’s ability to launch agile moves like competitive pricing and new product introduction.

**The support for H9(c) but not for H9(a)** suggests that the use of IOS to support diversified business functions may induce innovative, heterogeneous actions but may not necessarily increase the action volume. A possible rationale is that although the use of IOS in diverse business functions increases operational efficiency, it also increases complexity in coordinating different activities. And, it is likely that the benefits resulting from increased efficiency may not be able to compensate for the retardedness brought about by the increased complication involved in managing a diversified set of business operations. As such, a diversified IOS use may not lead to an increased response ability and a large number of actions subsequently taken.

On the other hand, using IOS in diverse business functions may allow firms to learn to manage interdependencies between different business activities and to generate innovations from cross-functional settings. Some examples of innovations generated in various business settings include e-auction and joint inventory management in procurement, Web conferencing and collaborative construction in product development, “just-in-sequence” manufacturing (in which components are immediately sent from a supplier to the manufacturer when an order is placed through linked information systems) in production, Web hosting and reverse auctions in marketing & sales, and wireless order tracking in customer service. Thus, firms with a diversified IOS use are likely to initiate actions heterogeneous from their competitors.

**The support for H9(b) but not for H7(b), H8(b)** suggests that complexity of action repertoire is more related to diversity of IOS use than to IOS reach and range. A possible rationale is that a diversified IOS use supports a firm’s initiatives involved in different business operations, which are subsequently transformed into a diversified set of actions launched in the product-market space. While an extensive IOS reach and range may not necessarily involve a firm’s direct participation in diverse business operations that support a firm’s initiatives in launching diversified actions. As such, an extensive IOS reach and range may not relate to a high complexity of action repertoire.
11.3 Implications

For IOS researchers, the strong relationship between IOS use and competitive action found in the automotive industry suggests a potentially meaningful research direction. Research in this direction can provide an in-depth understanding of IOS’s roles in influencing firm behavior and achieving firm competitiveness in e-business. Moreover, this research, 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 beyond the limitations of traditional measures.

Traditional IT value measures involve three major types: IT productivity, IT profits, and consumer surplus (Hitt and Brynjolfsson 1996).

Based on Hitt and Brynjolfsson (1996), IT productivity (the most commonly used measure) provides an estimate of the gross marginal product of IT (which can be interpreted as a rate of return before costs of investment are subtracted). It is calculated as the output elasticity and the marginal products of inputs:

\[
\text{IT productivity} = \frac{\beta_1}{C/V} \]

where,

\[
V \text{ (the firm value added) is calculated using the Cobb-Douglas production function of total IT stock (C), non-computer capital (K) and labor (L),}
\]

\[
V = \exp \left( \sum_t D_t + \sum_{j-1} D_j \right) C^{\beta_1} K^{\beta_2} L^{\beta_3}.
\]

\(D_t\) and \(D_j\) are two dummy variables that are used to control the observation year and industry or sector of the economy in which a firm operates.

\(\beta_1\) represents the output elasticity of IT stock, which indicates the percentage increase in output provided by a one-percent increase in IT stock. \(\beta_1\) is obtained by taking the logarithms and adding an error term to the production function,

\[
\log V = \sum_t D_t + \sum_{j-1} D_j + \beta_1 \log C + \beta_2 \log K + \beta_3 \log L + \varepsilon .
\]

IT profits can be calculated in three ways: (1) ROA (Return on Assets), which measures how effectively a firm has utilized its existing physical capital to earn income; (2) ROE (Return on Equity), which provides an alternative measure of how effectively a firm has utilized its financial capital and is algebraically related to “Economic Value Added;” (3) Total Shareholder
Return, which theoretically furnishes the discounted value of future profits (Hitt and Brynjolfsson 1996).

*Consumer surplus* is calculated based on the general utility function. The increase in consumer surplus between two periods $(t, t+1)$ is suggested as a function of the ratio of IT Stock to Value Added $(s)$, the Price of IT Stock $(p)$, and Value Added $(V)$ in the reference year (Hitt and Brynjolfsson 1996),

$$(\text{Consumer Surplus})_{t+1} = \frac{1}{2} (s_{t+1} + s_t) \times \log \left( \frac{p_t}{p_{t+1}} \right) \times V.$$ 

*IT productivity, IT profits, and consumer surplus* provide a limited view of IT investments. First, *IT productivity, IT profits, and consumer surplus* provide aggregate-level measures of IT investments and cannot be obtained until after a certain period of time has elapsed. This is because a typical IT investment (e.g., implementation of a customized supply chain system) normally takes at least 1-2 years before reaping its benefits. Second, gains from an IT investment sometimes may be transformed into such soft gains as innovation, responsiveness, or market influence rather than less soft gains like profits, productivity, or consumer surplus. As such, using *IT productivity, IT profits, and consumer surplus* may not be able to capture a complete view of IT investment returns. As in the automotive industry, when asked where they saw IT investment gains, many of the automotive suppliers cited “improved communications” – an intangible that is hard to quantify – rather than more concrete metrics such as higher inventory turns or higher revenue (Computerworld January 12, 2004).

On the other hand, as firms increasingly digitize their business processes and rely on IT-mediated interfirm relationships to develop and deploy capabilities (Subramani 2004), firm behavior becomes increasingly inseparable from IT, either IT-induced or IT-enabled. 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 (e.g., IT-improved communications may be displayed as a larger action volume or faster action pace during a given time period). In this regard, competitive action provides a different view of IT investment returns that may not be captured by the traditional measures. Additionally, competitive action can be observed within any length of time window. The length of the time window can be 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 investment returns.
As such, competitive action provides the promise of serving as an additional measure of IT value. Competitive action supplements *IT productivity, IT profits,* and *consumer surplus*, allowing for a more complete view of IT value.

*For IOS users,* results from the empirical testing of H7-H9 suggest important roles of IOS in influencing firm behavior and the resultant firm performance. An effective use of IOS (by extending reach, range, and diversity of use) broadens the range of action repertoire. It also enables speedy and innovative actions that can bring differential advantages to a firm over its competitors. Thus, results from this study can guide IOS users to focus on aggressive pursuit of new possibilities for joint performance improvement via IOS. This aggressive IOS use can become an important source of sustainable advantage that far exceeds the impact of initial processing of boundary transactions.

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Chapter 12 Conclusion

Integrating prior IOS studies and empirical results obtained from this study, this chapter introduces a framework characterizing IOS’s roles in achieving competitiveness. It then builds on the IOS use framework and develops a roadmap for identifying IOS opportunities. Finally, this chapter discusses research contributions and limitations, and outlines future research directions.

12.1 A Framework of IOS’s Roles in Achieving Firm Competitiveness

This study collects second-hand data to empirically investigate the relationships between IOS use-network structure, IOS use-competitive action, and network structure-competitive action. Empirical results from this study suggest important roles of IOS in influencing firm behavior and network structure that have not heretofore been established.

(1) Direct influence. IOS increase a firm’s ability to act and react to its competitive environment. They increase action speed and also enable innovative actions. Thus, IOS use has direct impacts on firm behavior.

(2) Indirect influence. IOS increase a firm’s ability to reach and manage those significant partnerships that would not be affordable conventionally. This extended reach via IOS induces changes in a firm’s network position, its resource acquisition, and subsequent actions undertaken. Thus, IOS use also has indirect impacts on firm behavior.

Building on the data results from this study and integrating prior IOS studies, a framework characterizing IOS’s roles in achieving firm competitiveness is forged. Figure 12.1 illustrates this framework.
Figure 12.1 A framework of IOS’s roles in achieving firm competitiveness

As illustrated in Figure 12.1, IOS can be used in three major ways: innovation, exploration, and exploitation. They generate two levels of influence on firm performance: first-order influence (which is displayed as patterned competitive actions), and second-order influence (which can be gauged in levels of firm competitiveness).

**IOS innovation** involves both the use of innovative IOS that are afforded by rapid technology advancements (e.g., the Big-Three automakers are using wireless technologies for tracking vehicles across dealers, suppliers and assembly plants; BMW is integrating fuzzy logic into its Web-based build-to-order system to help optimize production and delivery processes) and the innovative use of IOS by applying IOS to new business contexts (e.g., Toyota is using instant messaging for supporting customer service on its help desk and in the sales sections of its dealerships' sites). **IOS innovation** suggests a way of launching innovative actions via aggressive pursuit of opportunities for using emerging IOS or of new ways to use IOS (Copeland and McKenney 1988; Sambamurthy et al. 2003) (e.g., Mercedes-Benz launched Web-based marketing campaigns via interactive, multimedia and broadband technologies; Saturn initiated vehicle inspection services for used-car auctions at eBay).

**IOS exploration** describes a way of extending IOS links to reach new, significant partners and influencing firm actions through structuring in an advantageous network (resource) position.

**IOS exploitation** involves exploiting the existing relationships and structuring the interfirm interactions though IOS. This exploitation process includes exploiting shared functionalities and services afforded by IOS to develop relationship-specific assets (such as proprietary or customized software and hardware), co-specialized business processes (such as joint procedures in procurement, product development, and manufacturing), and co-specialized expertise (such as jointly developed IT capabilities, exchange of unstructured knowledge like

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new product ideas) (Christiaanse and Venkatraman 2002; Subramani 2004), and influencing firm actions through exploiting IOS-mediated relationships.

**IOS innovation, exploration, and exploitation** help (a) achieve efficiency, (b) induce novelty through enabling new relationships, new product features, new transaction structures and content, (c) increase lock-in effects by offsetting power asymmetry and fostering trust in the exchange, and (d) develop complementarities via interfirm interactions. Efficiency, novelty, lock-in and complementarities are four sources of value creation in e-business (Amit and Zott 2001).

Therefore, during the process of **IOS innovation, exploration, and exploitation**, value is created. Meanwhile, **IOS innovation, exploration, and exploitation** enhance a firm’s ability to launch actions with speed and surprise. Over time, actions are patterned and subsequently generate market influence; meanwhile, value is accumulated. Patterned actions and accumulated value can create differential advantages for a firm over its competitors. Firm competitiveness can be gauged in terms of $P^2AIR$, where $P^2$ stands for profits and productivity, $A$ for agility (or alertness and responsiveness), $I$ for innovation, $R$ for reputation (or market influence) (Holsapple and Singh 2001).

### 12.2 A Roadmap for Identifying IOS Opportunities

Built on the above framework characterizing IOS’s roles, a roadmap for systematically identifying IOS opportunities is suggested in this section. Figure 12.2 illustrates this roadmap. To identify appropriate use of an IOS, first, the business purposes of why to use the IOS needs to be addressed. Then, who will be connected through the IOS and what business activities will be supported by the IOS need to be clarified. Upon recognition of business purposes, desired partners, and supported activities of an IOS, how to use the IOS can be formulated. Appropriate IOS technologies can then be evaluated and selected based on the three IOS measures (including IOS reach, range, and diversity of use) introduced earlier in this dissertation.
Why to use the IOS? (Business purposes)
- To initiate a new action (in terms of action type)
- To produce series of patterned actions (in terms of action frequency, heterogeneity, complexity)

Who to link to through the IOS? (IOS partners)
- Customers
- Suppliers
- (Financial) service providers
- external design partners
- logistics partners
- dealers
- competitors

What business activities will the IOS support? (Business activities)
- Procurement
- Product development
- Production
- Logistics
- Marketing & sales
- Customer service

How to use the IOS? (Roles of IOS)
Roles of IOS:
- Innovation (to apply IOS to new business settings, to use emerging technologies to interfirm settings)
- Exploration (to establish new, significant relationships)
- Exploitation (to develop co-specialized business process, knowledge, and expertise)

Metrics for evaluating IOS candidate technologies:
- IOS reach
- IOS range
- Diversity of IOS use

Figure 12.2 A roadmap for identifying IOS opportunities
**Why to use the IOS?** An IOS can be used for two generally purposes: (1) to initiate a new competitive move (e.g., a Web-based marketing campaign, or a Web/wireless-enabled tracking service), and (2) to produce series of patterned competitive actions (e.g., fast moves enabled by the use of shared repositories or electronic marketplaces, or heterogeneous moves generated by the innovations brought forth by using instant messaging in the interfim settings or using RFID in manufacturing and logistics activities).

**Who to link to through the IOS?** IOS partners may be categorized in many ways based on different business needs. This dissertation classifies IOS partners into six categories: customers, suppliers, (financial) service providers, external design partners, dealers, logistics partners, and competitors. For different partners, different IOS technologies may be used. For example, the Internet and B2B exchanges provide open, flexible platforms. They are efficient for linking to potential customers, suppliers, and competitors. Groupware systems facilitate unstructured knowledge exchange and provide an effective means for linking to suppliers and external design partners.

**What business activities will be supported by the IOS?** IOS can be used to support a wide range of activities, such as procurement, product development, production, logistics, marketing & sales, and customer service. Some IOS may provide a common infrastructure for supporting many activities (e.g., the Internet, extranet, and B2B exchanges may support all the activities listed above), while some IOS may provide limited support for certain activities (e.g., sales automation systems are used particularly for supporting marketing & sales activities).

**How to use the IOS?** Roles of IOS can be considered along three ways: innovation, exploration, and exploitation. Specifically, which existing IOS technologies can be used in the current business context? Are there any new applications of the existing technologies that may provide a more efficient support for the current needs (e.g., can EDI systems provide a better solution to support the current product design process than groupware systems)? Are there any emerging technologies that can be applied to meet the current needs (e.g., can wireless supply chain systems be used to improve customer service)? Which IOS technologies can be used to link to the desired partners at a low cost (e.g., can Internet-based EDI provide a low-cost solution for linking to small, significant partners with less sophisticated IT capabilities)? Which IOS technologies provide a greater potential for exploiting the existing partnerships and developing co-specialized business process, knowledge, and expertise (e.g., can EDI systems be
used to develop joint processes of forecasting, store layout, pricing, purchasing, and payment with a particular partner beyond the simple boundary transactions and information transfer)?

Along the line, a list of IOS candidate technologies can be identified. Using the three IOS measures (IOS reach, range, and diversity of use), identified candidate technologies can be further evaluated and compared systematically. Those candidates, which provide the optimal combination of IOS reach, range, and diversity of use, will be selected for use.

In order to understand strategic opportunities for the use of IOS, it is helpful to develop a roadmap that can guide a systematic thinking in identifying IOS opportunities (Johnston and Vitale 1988). Although there may be many ways to categorize and identify IOS opportunities, the value of the roadmap introduced here arises from its utility (1) in structuring the many combinations of possibilities for gaining advantage through the use of an IOS, and (2) in providing evaluation tools that not only allow for a systematic comparison of different combinations of IOS opportunities, but also are easy to use.

The roadmap introduced here may also serve as a useful tool for systematically identifying IOS-based interfirm innovations. Continuous identification and exploitation of IOS innovations may bring about radical and rapid improvements in firm performance, providing a sustainable source for achieving competitiveness. Many powerful innovations may have the potential to diffuse into the wider economy and produce industry-wide or even greater impacts. In addition, such a roadmap would also be instrumental in helping business leaders understand the potential opportunities for using IOS and their benefits and pitfalls before introducing them.

12.3 Contributions

This study empirically investigates competitive dynamics in electronic networks. It adds new depth to our understanding of IOS’s roles in achieving competitiveness in e-business. It contributes to IS/IOS theory, methodology, and practice in multiple ways.

12.3.1 Contribution to Theory

This dissertation empirically investigates the uses of IOS and their impacts on firm performance in e-business. The study provides a unique perspective complementing the existing understanding of IOS’s roles in achieving firm competitiveness. The conceptualization of competitive behavior, as significantly influenced by network structure and IOS use, provides a new theoretical integration of three research streams: interorganizational systems, social
networks, and competitive dynamics. This conceptualization enriches our understanding of how structural embeddedness and IOS use co-evolve and influence competitive behavior, thus leading to differentiated firm performance in e-business. The results from this study deepen our understanding of the changing roles of IOS in e-business. Specifically, this study adds value to the literature of IS/IOS, social networks, and competitive dynamics in the following ways.

First, by introducing a social network perspective into the IOS study, this dissertation examines IOS-intensive networks in multiple levels, including firm-level, pair-level, and network-level. The empirical results from this study have suggested the changing roles of IOS in influencing firm behavior, interfirm relations, and network structure, going beyond the traditional focus of IOS’s roles in increasing efficiency or reinforcing power and control. The empirical investigation of this study has broadened our view of how IOS can be used to achieve firm competitiveness in the e-business context. It contributes to IS research by providing new perspectives and theoretical conceptualizations of IOS’s roles.

Second, this study validates and enriches the D&M IS Success Model (DeLone and McLean 1992; 2003). In 1992, based on theoretical and empirical IS research conducted in the 1970s and 1980s, DeLone and McLean proposed an IS success model (referred to as the “D&M IS Success Model”) as frameworks for conceptualizing and operationalizing information systems success/effectiveness. Since then, the D&M IS Success Model has received wide popularity and made a significant impact on IS research. Nearly 300 articles in refereed journals have referred to, and made use of, this model. In the D&M IS Success Model, DeLone and McLean postulated the use of information systems as a critical dimension of IS success measurement (DeLone and McLean 1992).

Ten years later, integrating the IS research conducted in the 1990s, DeLone and McLean updated the D&M IS Success Model and evaluated its usefulness in light of the dramatic changes in IS practice, especially the advent and explosive growth of e-Commerce. In the updated D&M IS Success Model, DeLone and McLean emphasized the continued importance of system use in understanding IS success/effectiveness. They urged more research to be conducted to refine the multidimensionality of system use, including its nature, extent, quality, and appropriateness (DeLone and McLean 2003).

This dissertation empirically investigates the uses of IOS and their impacts on firm performance in e-business. The empirical results from this study 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/effectiveness. In addition, this study introduces three new measures to describe system use. These measures are *IOS reach, range, and diversity of use*. They enrich the D&M IS Success Model by more fully examining the concept of system use, going beyond the simple *frequency of system use* measure typically used in prior research. Figure 12.3 illustrates this study’s contributions to the updated D&M IS Success Model (DeLone and McLean 2003).

![Diagram](image)

**Notes**
- Bold parts A, B, and C indicate contributions of this study to the D&M IS Success Model.
- A contributes by enriching the measures of system use. In A, three measures of IOS reach, range, and diversity of use are used to describe system use.
- B adds value by highlighting the changing roles of IS in the e-Commerce era. In B, net benefits of IS are examined in two aspects: firm behavior, network structure.
- C validates the D&M IS Success Model by suggesting strong associations between IOS use, firm behavior, and network structure.

**Figure 12.3 Contributions to the D&M IS success model**
(DeLone and McLean 1992; 2003)

Third, through empirical investigation, this study identifies a strong link between IOS use and competitive action. Building upon competitive dynamics research where a robust link between competitive action and firm performance has been well-established, this study makes explicit the *IOS use-competitive action-firm performance* link. The identification of this *IOS use-competitive action-firm performance* link is especially meaningful to IS/IOS research. The link between information systems use and firm performance has been a central focus in the IS/IOS studies. Prior studies have heavily investigated the effects of information systems use on
firm performance in terms of increasing organizational efficiency or managing interfirm relationships (e.g., reinforcing power control, enhancing trust and cooperation). Yet these effects are largely implicit and hard to measure. This study, by establishing the **IOS use-competitive action-firm performance** link, suggests a new, measurable way to examine the effects of information systems use on firm performance, i.e., through specific firm actions launched in the market that are first observed after undertaking a firm’s IT initiatives in achieving competitiveness.

Fourth, this study finds strong associations between **network structure-competitive action** and **IOS use-competitive action**. These results suggest that network structure and IOS use are two important yet unexplored antecedents of competitive action. These findings add value to competitive dynamics research. In competitive dynamics stream, one research focus has been to explore antecedents of competitive action. Three implicit yet essential antecedents: **awareness**, **motivation**, and **ability**, have been identified. Various organizational factors have been widely investigated to explain these three antecedent constructs. For example, the age of a firm, the diversity of markets in which a firm competes, and top management team (TMT) demographics have been used to reflect the level of **awareness**; the past performance and market dependence of a firm have been used to reflect the **motivation** to act; the unabsorbed resource slack required to undertake actions and the TMT demographics have been used to reflect the **ability** to act (Smith et al. 2001). However, all these factors investigated in prior research have focused on the firm-level characteristics and internal resources of a firm. As firms are increasingly relying on external resources from partners and IT-mediated relations to deploy and develop capabilities for undertaking actions, a firm’s position in interfirm networks (i.e., network structure) and its information systems use in interfirm settings (i.e., IOS use) become two key yet unexplored factors in influencing competitive action.

An increasing literature begins to address the importance of network structure in determining firm actions by influencing firm **awareness** and action **ability** through shaping resource flows in the network where a firm is embedded (Gnyawali and Madhavan 2001; Madhavan et al. 2004). The influence of information systems use on competitive action also begins to capture attention in competitive dynamics literature. Some scholars have urged future research to investigate the sequential link between information systems use, competitive action, and firm performance (Ferrier 2001; Ferrier and Lee 2002). The empirical findings from this
study suggest that IOS use not only enhances knowledge processing capability thus increasing firm *awareness*, but also enhances operational efficiency and resource deployment capability thus increasing the *ability* to act. As such, this study enriches competitive dynamics research by empirically investigating two key yet unexplored antecedents of competitive action.

### 12.3.2 Contribution to Methodology

This study collects second-hand data about nine major sports car makers, which represent almost the entire population of the sports car segment. Focusing on one automotive segment allows for an in-depth examination of a relatively complete automotive network and excluding confounding factors related to different industry characteristics.

This study is a pioneering effort at collecting second-hand data about *actual, voluntary* IOS use. *Actual* use refers to the manner in which IOS are implemented and in effect used, rather than intended use (DeLone and McLean 2003) or self-reported use where the same respondents are usually requested to answer questions on their perceptions of the system use and its effectiveness (Devaraj and Kohli 2003). *Voluntary* use refers to the adoption of the system being non-mandatory (DeLone and McLean 2003; Devaraj and Kohli 2003).

Prior empirical studies regarding the *system usage-performance link* largely have relied on self-reported use (Devaraj and Kohli 2003). Self-reported usage measures can provide an important indicator in assessing IS success or effectiveness. But these measures have several limitations. (1) Self-reported usage might induce biases due to obtaining information from a single source or a same respondent, known as common method variance. (2) Some studies have suggested that perceived 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). Possible explanations for the discrepancy between actual usage and perceived usage are subjects’ difficulty in recalling their past usage, exaggeration of the extent of usage to fit in with their superiors’ expectations, attention lapses, and bounded rationality (Devaraj and Kohli 2003). As such, there is an increasing recognition that actual system usage provides better measures than self-reported usage in assessing IS performance impacts (DeLone and McLean 2003, Devaraj and Kohli 2003).

In addition, second-hand data collection involves surveying news articles from multiple information sources, including databases, trade publications, Web sites, and industry indexes. Thus, second-hand data collection provides rich information about actual system use, allowing
for an in-depth data analysis. By obtaining data from multiple information sources, second-hand data collection also increases data reliability.

Furthermore, 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 significant system implementation and usage events, which are generally difficult to obtain in a self-reported manner.

Therefore, second-hand data collection about actual, voluntary IOS use introduces a novel, useful methodology to the field of IS research.

12.3.3 Contribution to Practice

For practitioners, this study has several implications. First, this study provides a better understanding of the relationships between network structure, IOS use, and competitive behavior. It suggests that a good understanding of the nature of electronic partnership (e.g., its structural properties) allows adapting IOS technologies correspondingly, while a good understanding of the IOS capabilities allows a full exploitation of IOS resources for launching targeted actions.

Second, 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.

Third, the roadmap for identifying IOS opportunities can guide a firm’s systematic search for opportunities of wielding IOS as powerful tools for achieving firm competitiveness.

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

12.4 Limitations

First, the field of IOS is changing rapidly. Every month witnesses a variety of new product offerings, upgraded versions of software, and improved hardware and telecommunications networks. Thus, insights on the subject may need frequent updates. In addition, rapid advances in digital technologies render it difficult to conduct a comprehensive classification of IOS technologies.
Second, this study collects one-year data (data about competitive actions initiated in 2003) for the competitive action construct. The data set is relatively small and limited. A longitudinal study across multiple car segments and industries would allow more data to be collected and may provide greater insights about the dynamic roles of IOS in achieving firm competitiveness.

As a third limitation, this study examines only the structural similarity of relationships. Semantics of relationships are not considered. This study uses the Euclidean distance to calculate the structural similarity between two automakers’ network patterns. In this calculation, each relationship between an automaker and its partner is treated equally. In other words, distinctions between different types of relationships are not considered in the calculation. However, it may be that two automakers (e.g., Ford and Toyota), although both collaborating with the same third partner (e.g., Mazda), engage in different collaborative arrangements as illustrated in Table 12.1. Thus, resource flows (i.e., semantics of the relations) between the two automakers and their shared partner may differ.

<table>
<thead>
<tr>
<th>Partner</th>
<th>Collaborative arrangements</th>
<th>Ford</th>
<th>Toyota</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mazda</td>
<td>Procurement</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Product development</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Production</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Logistics</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Marketing &amp; sales</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Service</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 12.4 illustrates a semantic difference between the network structures of Ford and Toyota. This semantic difference in the network structure may be an important factor in inducing differences in firm behavior and IOS use. Future research may need to address this issue and consider the semantic difference in the network structure.
Fourth, high correlations between some variable constructs (e.g., the correlation between degree centrality-action volume, Pearson’s $r = 0.768$, and the correlation betweenness centrality-action volume, Pearson’s $r = 0.774$) may suggest discriminant validity problems. Although degree centrality and betweenness centrality are clearly distinct in concept, there may be some underlying factors that link these two constructs such that they move in unison. Future research is needed to explore this issue.

These four limitations offer additional research opportunities for the future.

12.5 Future Research Directions

Building on the framework of IOS use, future research can be extended along four exciting directions. Figures 12.5(a)-(d) illustrate these four directions.

First, an empirical investigation in a single- or multi-industry context can be conducted to validate and add insights to the relationships between IOS use-network structure-competitive action, as indicated by the bold parts in Figure 12.5(a). Of particular interests are industries that have a widespread use of IOS, such as financial services industry and health-care industry.

Second, additional network properties (such as density, tie strength) and more characteristics of competitive actions (such as action magnitude, action timing) can be examined to provide a fuller understanding of the competitive dynamics in e-business, as indicated by the bold parts in Figure 12.5(b).

Third, this study introduces three measures of IOS use (reach, range, diversity of use) and collects 106 IOS technologies and applications. Future research can collect more real-world IOS technologies and applications to further examine these three measures, as indicated by the
bold parts in Figure 12.5(c). The resultant validation may suggest a systematic way to IOS users for evaluating different IOS technologies and also to IOS vendors for providing innovative IOS solutions.

Fourth, another intriguing research area is to examine how network structure, IOS use, and competitive dynamics co-evolve; how competitors in intertwined electronic networks interact, act and respond to each other; and the nature of co-evolving patterns between the network structure-IOS use-competitive action-firm performance, as indicated by the bold parts in Figure 12.5(d). Feasible research methods may include questionnaire surveys, longitudinal studies through second-hand data collection, and computer-based simulations. Results obtained along this direction may push a step further in developing competitive action as an IT value measure.

(a) Research direction 1

(b) Research direction 2
Managing existing relationships
Co-specializing business processes and expertise
Structuring network position
Establishing new, significant relationships

First-Order Influence
Competitive Action

Value Creation

Second-Order Influence
Firm Competitiveness

Use of innovative IOS
Innovative use of IOS

Exploitation
Innovation
Exploration

 IOS Use

(c) Research direction 3

(d) Research direction 4

Figure 12.5 Four future research directions
References


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