

# Inter-Organization Computer Networks: Indications of Shifts in Interdependence\*

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## Abstract

As firms increasingly adopt inter-organization computer networks (IONs) to improve coordination, researchers must be concerned about the long term impact of IONs on organizational relationships. This paper reports on an exploratory study of the use of IONs in design and manufacturing activities in the semiconductor industry. We identify the potential interactions between firms that can be facilitated by IONs, and focus on the implications for customer and producer interdependence. Our analysis suggests that the long term impacts of IONs are not technologically determined, and that their use ought to be regarded differently than those of other media.

## 1 Introduction

This research addresses the use of inter-organization networks (IONs) to facilitate the exchange of information between firms involved in design and manufacturing activities in the semiconductor industry. These firms are highly information intensive and have only recently begun to adopt computer networks to facilitate the exchange of large databases. Our work is an exploratory investigation of the early adoption of a technology with the potential for widespread diffusion in the future.

We have reported our findings on the use of IONs among select firms elsewhere (in Estrin and Hart, 1989). Here we want to focus on an important implication of ION implementation and use, that is, the potential for shifts in interdependence between adopting firms. We found that for each opportunity that motivates ION adoption, there is a corresponding vulnerability associated with the need to use computing resources or retrieve information in another organization. Each opportunity-vulnerability dyad represents a potential shift in interdependence between customer and vendor firms.

In general, among the firms that comprise the sample for our study, we found that only a few ION applications are used in a routine way. However, based on current as well as anticipated ION use, the interview data collected provided some understanding of how ION implementation can contribute to a variety of benefits. These benefits are associated with increased coordination resulting in shorter product turn-around time. They range from the more obvious ability to transfer large databases between geographically distant sites quickly, to greater capability for monitoring product flow, and the elimination of redundant and time consuming tasks.

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## 2 Communication and Computing Innovations in Organizations

### 2.1 Three Assumptions

Our research is based on three assumptions related to the nature of organizations, the effect of information technologies on organizations, and the motivation to adopt these technologies by organizations.

First, organizations can be described as information processing systems. Galbraith (1977) maintains that effective structures are those that reduce uncertainty by allowing the required amount of information to be exchanged between organization units to ensure optimum coordination. We assume that what is true of intra-organization units is also true of inter-organization units. Namely, that relationships between firms will reflect attempts to ensure optimum coordination in the pursuit of mutually dependent activities.

Second, if an organization adopts a technological innovation that changes the conventional way information is processed, the innovation will affect the structure of the organization. The relationship between information technology and organization change has not been empirically tested in a reliable way (Markus and Robey, 1988). Nevertheless, theoretical development (Tushman and Nadler, 1978; Olson and Lucas, 1982; Rice 1987), and some case studies (Hart, 1987; Aydin, 1989) support the integrity of this proposition.

Third, an innovation changes the conventional way information is processed because it serves a previously unmet demand (Estrin, 1987). An innovation, for example, that improves the speed of information transfer will be adopted by a firm in an industry with pressures to shorten product turnaround time. The implication of this assumption is that the effect of the technology is not deterministic, but rather defined by an existing context. Organization contexts have certain economic, as well as political (Kling and Scacchi, 1982) attributes, and they define the demand that is met by the technical attributes of the innovation. Thus, while there is a relationship between the technical attributes and the type of intra-organization changes (or inter-organization relations) that result when particular innovations are adopted (Rice, 1984), these changes are moderated by organizational contexts.

The technical attributes of IONs, described in detail by Estrin (1987), include a wide range of capabilities (i.e., electronic mail, file transfer, database transactions, and remote log in), increased speed in transferring information, automatic response in person-to-computer or computer-to-computer transactions, higher fixed-entry but lower incremental cost than comparable functions and speeds using conventional media, access to internal facilities of other organizations, and standard communication protocol and application procedure requirements to facilitate interchange among multiple partners.

### 2.2 Three Perspectives

This research is an extension of three areas of current theoretical concern.

First, our research is an extension of the work done on electronic data interchange (EDI) for business related applications (Ponting, 1988). This literature focuses on the strategic use of IONs for linking suppliers and customers in specific industries such as the hospital supply and airline industries (Benjamin, Rockart, Morton, and Wyman, 1984; Porter and Millar, 1985; Cash, 1985; Meyer and Boone, 1987; Benjamin, DeLong, and Morton, 1988; Malone, Yates, and Benjamin, 1989). We focus primarily on the use of IONs to support design and manufacturing applications.

Second, this study is an extension of the literature that has developed around the use of computer-mediated communication. Most of this research focuses on the use of electronic mail or file transfer systems to facilitate intra-organization communication (e.g., Fulk, Schmitz, Ryu, and Steinfield, 1989; Rice and Shook, 1988; Eveland and Bikson, 1988; Valle, 1984; Rice and Case, 1983). The exception is the work on computer-conferencing (Hiltz and Turoff, 1978; Rice, 1982; and Kerr and Hiltz, 1982), but the units of analysis in these studies are primarily the individuals in different organizations rather than the different organizations themselves. We focus on inter-organization exchange of electronic databases, containing

technical data, that range tremendously in size (up to 150 MB and larger) for the purpose of improving coordination between organizations.

Third, this research should be of interest to those concerned about task interdependence between organizational units, as well as the development of inter-organization relationships. First, task interdependence literature focuses on tasks performed within organizations (e.g., Kiggundu, 1981). This research involves complementary tasks performed in different organizations. Second, resource dependence literature focuses on the role of linkages with other organizations to ensure the flow of resources necessary for the growth of the organization (e.g., Pfeffer and Salancik, 1978; Aldrich, 1979). Organization resources are typically defined as elements with conventionally tangible properties (i.e., money, clients, materials, and so on), and information as the exchange necessary to ensure the flow of these resources (Levine and White, 1961; Van de Ven, 1976). In this research information is regarded as a resource in itself (e.g., a circuit design database), and we are interested in the effect of the exchange of information via IONs on organization relationships.

### 3 Methodology

Eighty-two interviews were conducted in twelve organizations, seven semiconductor firms and five merchant photomask shops during an 18 month period, from January, 1988 to July, 1989. The purpose of the open-ended interviews was to understand how circuits are designed, semiconductors are manufactured, and the occasions when information must be exchanged between firms. Interviewees provided descriptions about present and anticipated use of computer networks, both of which were incorporated into our analysis.

### 4 Circuit Design and Semiconductor Production

Interactions between firms during the production phase are similar for all types of semiconductor products. However, interactions between firms during the design phase vary by product. Application specific integrated circuits (ASICs), a major subset of logic devices, are semicustom or custom products in contrast to memory, microdevices, and linear devices, which are standard products sold off-the-shelf. This implies a range of possible interactions between engineers in the customer firm and design engineers in the semiconductor firm during the design process. The number and type of interactions between customers and producers is determined by whether the customer develops the circuit design in-house or contracts with the semiconductor firm to do the design. Part 1 of Figure 1 briefly summarizes the interactions between ASIC customers and producers that can be facilitated by IONs during the design process.

Part 2 indicates the interactions between semiconductor producers and photomask shops. Photomasks are the "hardcopy" of CAD circuit designs required to reproduce circuit designs onto silicon wafers. The masks, as they are called, are glass plates containing geometric design patterns, and are produced by a sophisticated photolithography technique which currently employs electron beam technology. On average, 10 to 12 masks are required to reproduce each integrated circuit design onto a silicon wafer. Photomasks are produced by either merchant or captive mask shops. The latter are owned and operated by the semiconductor producing firms. In either case, the interactions between the firm or the department ordering the photomask and the photomask shop are similar.

After the photomask is produced, it is shipped to the semiconductor producer and used in wafer fabrication – a process similar to mask production insofar as a lithographic process is used to delineate patterns on a coated substrate, in this case silicon. After the wafer is processed, each die on the wafer (e.g., over 300 to 800) must be sawed, tested, sorted, then assembled, packaged and then tested again. The important interactions between the semiconductor producer and customer during this phase of production

## 1. Design of ASIC Devices

- (a) Design tool exchange.\*\* Downloading design tool software and updates to the customer site.
- (b) Design support. Responding to customer design tool or other design related inquiries.
- (c) Design convergence. Merging design database files of individuals performing complementary design tasks.
- (d) Design verification. Transferring design files to vendor sites for simulation tests requiring major computing resources and downloading results back to the customer firm.

## 2. Manufacturing

- (a) Photomask production.
  - i. Placing mask order.
  - ii. Transferring technical instructions indicating how the mask is to be written.
  - iii. Transferring circuit design database.
  - iv. Verifying design database after data is formatted for photolithography process.
  - v. Checking status of mask order.
  - vi. Transferring quality inspection data.
- (b) Production control. Providing customers with status reports on chip orders.
- (c) Quality control. Transferring reliability data to the chip customer.

\*\*Design tool exchange is an interaction that can be facilitated by IONs. We found that semiconductor firms are currently transferring software to their customers by magnetic tape, however several indicated that they anticipated using IONs for this purpose in the future. One important reason for not using IONs at the present time is lack of adequate bandwidth.

Figure 1: Interactions Between Semiconductor Customers and Producers Requiring the Exchange of Technical Information That Can be Facilitated by IONs.

involve transferring the test results (i.e., quality assurance and reliability information) to the customer along with the finished product. The interactions between firms involving semiconductor production that can be facilitated by IONs are also indicated in Figure 1.

The interactions described focus on two sets of firms: (1) semiconductor customers and semiconductor producers, and (2) semiconductor producers and merchant photomask shops.

## 5 Interdependence and Circuit Design

The shifts in interdependence related to both design and production are summarized in Figure 2.

In general, it is cost-effective to invest in computing systems that support in-house circuit design if a firm develops more than two or three circuits. As ASIC customers increasingly invest in these facilities, ASIC producers have developed proprietary design tools (Figure 1, 1(A)). These tools specify design parameters determined by fabrication requirements specific to the semiconductor firm and are, therefore, an important interface between design and manufacturing processes. Proprietary tools, in contrast to generic tools, prevent interchangeability of the physical design database (i.e., restrict the exchange of design data from one semiconductor firm to another after the design has been completed). Moreover, these

software design tools comprise libraries of pre-defined structures, such as basic gates or standard cells. Knowledge of these libraries is associated with a learning curve which means that there are advantages in using the same tools over time.

On the one hand, the ability to purchase or license design tools provides greater customer control over circuit design development (Figure 2, (1a)). On the other hand, the proprietary design tools represent an important strategy employed by semiconductor producers to "lock in" ASIC customers (Figure 2, (1b)).

## 6 Interdependence and Semiconductor Production

Even when ASIC circuits are designed in-house by semiconductor producers, the design data must be transferred to the producer site for final database preparation before it is transferred to the photomask shop. Thus, all interactions involving photomask vendors are with semiconductor producers.

### 6.1 Database Preparation and Verification

Before the photomask is written a software program called a job deck must be created that will drive the photolithography equipment. The program applies technical specifications supplied by the customer (Figure 1, 2(A)(ii)). Since the job deck is a set of instructions on how the mask is to be written, once the instructions are implemented the database must be inspected to verify that the design conforms to the expectations of the customer (Figure 1, 2(A)(iv)).

The job deck is typically created at the photomask shop. However, some customers have begun to create their own job decks and transfer them over IONs to photomask shops. On the one hand, the customer created job deck provides certain opportunities for streamlining the internal flow of information within the customer firm, while allowing design engineers to verify the design prior to transferring the database to the mask shop (Figure 2, (4a)). On the other hand, the shift in division of labor increases the vendor's dependence on the customer. Customer generation of the job deck means that an outside party is supplying the software program that will run a core resource in the photomask shop. The amount of time it takes to write a mask (from 30 to 45 minutes up to 12 hours) varies by mask type and complexity of the circuit design. The vendor becomes dependent on the customer's program to maximize the efficiency of an expensive and scarce internal resource (Figure 2, (4b)).

In lieu of customer job deck creation one photomask shop is beginning to allow customers online access to their design databases after the job deck has been written to verify circuit designs. This practice could contribute to shortening product turn around time by allowing design engineers to identify and correct errors more quickly. Online verification could, in some cases, eliminate the need for delivering "set qualifiers" (i.e., the initial mask layers) required for testing at the customer site before the complete mask set is produced (Figure 2, (5a)).

At the same time, allowing customer access to internal databases raises potential security concerns. Vendors are more vulnerable when proprietary resources are potentially accessible to outside parties (Figure 2, (5b)). This type of vulnerability may lead vendors to develop arrangements that make it more difficult for outside parties to access vendor databases, which would restrict the degree of network use. Or, they may allow only select customers (i.e., customers that place large orders) access to their databases.

### 6.2 Production Control

The benefits derived from the implementation of computer-based production control systems within firms have led some to pursue the opportunities inherent in accessing their vendor's systems (Figure 1, 2(A)(v) and 2(B)). We found that one merchant mask vendor allowed online access to the order status of one

**From The Customer's Perspective:**

<b>Motivation</b>	<b>Dependence</b>
(1a) Greater control over ASIC design through in-house use of design tool software.	(1b) Increased dependence on vendor for providing design related resources.
(2a) More efficient use of scarce resources through more access to detailed scheduling information.	(2b) Increased dependence on vendor for providing access to production control information.
(3a) Streamlining information flows and eliminating redundant inspections and tests.	(3b) Increased dependence on vendor to provide accurate information.

**From the Vendor's Perspective:**

<b>Motivations</b>	<b>Dependence</b>
(4a) Offload data preparation tasks to customer.	(4b) Increased dependence on accurate information from customer.
(5a) Strategic use to attract and retain customers – access to unique, valued resources.	(5b) Increased vulnerability of accessible proprietary resources and customer data.
(6a) Reduced personnel cost in providing timely status information to customer.	(6b) Increased accountability for internal production scheduling.

Figure 2: Motivations and Corresponding Sources of Change in Interdependence Between Firms Exchanging Information Over Inter-Organization Computer Networks

major ASIC customer. And, we found one large semiconductor producer aggressively negotiating with its photomask vendors for online access to their systems. Moreover, that producer's customers were similarly negotiating for access to the producer's system.

While online access to vendor production control systems would improve the ability to control internal scheduling (Figure 2, (2a)), acquisition of information would be contingent on the vendor's permission to access their computing systems. Over a relatively short period of time the customer's improved ability to schedule scarce resources would become routine, reflecting an increase in dependence on the vendor (Figure 2, (2b)).

In addition, another shift in interdependence is associated with vulnerability on the vendor side. On the one hand, online access to production control systems provides customers with the status of orders without costing the vendor customer service personnel (Figure 2, (6a)). On the other hand, online access also increases vendor accountability. If customers observe that their orders have been located in a particular production area for an inordinate amount of time, or that the priority of their orders have been downgraded, vendors may be required to explain unexpected order status (Figure 2, (6b)). Vendor reluctance to allow online access to production control databases is based on the perception and fear that customers do not understand vendor production processes well enough to interpret changes in prioritizing and scheduling.

### 6.3 Quality Assurance and Reliability Data

Inspection and testing data are generated by the computer-based systems that support the inspection and test of photomasks and semiconductors respectively. Photomask inspection data include the results of tests that measure the accuracy and placement of geometric patterns that must fall within a certain range of tolerance, and reports of any defects, such as extra chrome or a gap in a line of chrome, that may have appeared on the mask, as well as a record of attempts to repairs such defects (Figure 1, 2(A)(vi)). Semiconductor test data are associated with the type and rate of change in material properties over time (Figure 1, 2(C)).

We found that two large semiconductor producers currently provide online access to reliability and quality assurance data for standard products, and anticipate providing similar information for ASIC products in the future. One semiconductor producer indicated that when quality assurance and reliability data are obtained directly from the semiconductor producer's database, the qualification cycle for new products at the customer site (which takes from six to nine months or more) can be eliminated. The benefits associated with using IONs for this application also include more convenient access to information which is otherwise retrieved by searching through voluminous technical documents.

One of these semiconductor firms, in turn, has been negotiating with one of its photomask vendors to provide inspection data online. Other semiconductor firms may also be applying pressure on other vendors since at the time the interviews were conducted the three largest merchant photomask shops were at various stages of networking their inspection systems with relational databases. This integration is a requirement for effectively providing inspection data to customers online.

Also, the potential benefit of accessing quality assurance data online for photomask customers is similar to the benefit gained by semiconductor customers. The semiconductor producer driving the photomask vendor to provide select inspection data from integrated inspection systems maintains that online retrieval will contribute to eliminating redundant inspections performed at the producer site, which are both time consuming and expensive.

While IONs can facilitate the exchange of information that contributes to eliminating redundant tasks (Figure 2, (3a)), customer access to this data represents a series of new dependencies on vendors to provide accurate inspection and test data (Figure 2, (3b)).

## 6.4 Computing Resources

In addition, each of the motivations listed in Figure 2, along with the incentive to transfer design databases more quickly over geographically distant locations (Figure 1, 2(A)(iii)), creates or increases dependence on the computing resources of the participating organizations. In general, we anticipate that the direction of dependence developed by ION adoption would reflect existing inter-organizational relationships.

There is a tradeoff between the number of online partners an organization can accommodate and system load performance. Computing system capacity must match the capacity required to handle the largest possible number of partners at acceptable performance levels. If the performance level is just acceptable, then additional partners cannot be served without jeopardizing response time. If additional partners are desirable, then the computing system must be upgraded.

It appears that initially vendors will accommodate as many customers as possible and bear the cost of computing upgrades as a cost of doing business. However, it is also assumed that the resources to support upgrades are not infinite. The vendor must tradeoff supporting a larger number of customers and investment in the facilities required to maintain adequate performance.

## 7 Discussion

The following brief discussion focuses on three concerns. The first involves the relationship between the technical attributes of IONs and described shifts in the interdependence between firms. These shifts in inter-organization relations are, in part, a function of the technical attributes of IONs which were described earlier. As Estrin (1987) has argued, these attributes affect certain changes in communication patterns. ION use can increase the intensity (i.e., frequency) and scope (i.e., breadth of application) of communication between organizations. But they affect inter-organization penetration (i.e., direct access to another firm's computing and information resources) and segmentation (non-universal access to these resources) as well. The extent to which firms use IONs to fill previously unmet demands, resulting in communications of greater intensity and scope, reflects the contribution that IONs make to improving inter-organization coordination. But the extent to which ION use results in penetration and segmentation reflects certain opportunities and corresponding vulnerabilities associated with inter-organization interdependence. This paper provides evidence of shifts in interdependence: each of the six dyads in Figure 2 are linked to shifts in communication patterns associated with either penetration (2ab,3ab,4ab,5ab,6ab) or segmentation (1ab).

The second concern involves the requirement of internal computing integration as a function of effective ION use. The extent of internal integration defines what information can be accessible via IONs: the greater the internal integration, the greater the opportunity for accessing specific information that can facilitate inter-organization coordination. Furthermore, the implementation of internal integration introduces the need to reassess the amount and type of information processed within and between organizations. In theory, this reassessment should result in greater streamlining of information flows between organizations. However, the vulnerabilities that accompany ION use will moderate the pure efficiencies that might otherwise accompany their implementation. This suggests that the impacts of ION adoption are not technologically determined, and deserve careful attention over time by managers and researchers alike.

Third, the improvements in inter-firm coordination based on ION use ought to reduce the transaction costs inherent in market structures as described by Williamson (1975, 1985). The dimensions of these costs, which define their value, include frequency, uncertainty, and asset specificity. Asset specificity refers to durable investments that are transaction specific. To the extent that IONs reinforce market segmentation (i.e., non-universal access) as in the case of ION supported exchanges of organization specific design tools, they increase the investment required to maintain specific contracts, and thereby contribute to increasing

transaction costs. Moreover, we would argue that the vulnerabilities associated with either allowing other organizations access to internal databases, or developing increasing dependence on information generated by computing systems in other organizations, also increase transaction costs. This type of vulnerability does not easily fit into the typology of transaction dimensions as outlined by Williamson. And, this reinforces our own conviction that the use and impact of inter-organization networks ought to be viewed differently than the use and impact of other media.

## 8 References

1. Aldrich, H.E. (1979). *Organizations and environments*. Englewood Cliffs, NJ: Prentice-Hall.
2. Aydin, C.E. (1989). Occupational adaptation to computerized medical information systems. *Journal of Health and Social Behavior*, 30, 163-179.
3. Benjamin, R.I., Rockart, J.F., Morton, M.S.S., & Wyman, J. (1984). Information technology: A strategic opportunity. *Sloan Management Review*, 25(3), 3-10.
4. Benjamin, R.I., DeLong, D.W., & Morton, M.S.S. (1988). The realities of electronic data interchange: How much competitive advantage? M.I.T. Management of the 1990s, CISR WP No.166.
5. Cash, J.I. (1985). Inter-organizational systems: An Information society opportunity or threat? *The Information Society*, 3, 199-228.
6. Estrin, D. (1987). Interconnection of private networks. *Telecommunications Policy*, (September), 247-258.
7. Estrin, D. & Hart, P. (1989). Inter-organization computer networks in the design and manufacturing of semiconductors: Final report of a two year study. Technical Report TR-89-13. Computer Science Department, University of Southern California, Los Angeles.
8. Eveland, J.D. & Bikson, T.K. (1988). Work group structures and computer support: A field experiment. *ACM Transactions on Office Information Systems*, 6, 354-379.
9. Fulk, J., Schmitz, J., Ryu, D., & Steinfield. (1987). Communication in R&D via Electronic Mail III: Final report. Technical Report No.3. Annenberg School of Communications, University of Southern California, Los Angeles.
10. Galbraith, J.R. (1977). *Organization design*. Reading, MA: Addison-Wesley.
11. Hart, P. (1987). The use and role of commercial online databases in four organizations. Doctoral dissertation, University of Southern California, Los Angeles.
12. Hiltz, R.H. & Turoff, M. (1978). *The network nation*. Reading, MA: Addison-Wesley.
13. Hirschheim, R. & Klein, H.K. (1989). Four paradigms of information systems development. *Communications of the ACM*, 32, 1199-1216.
14. Kerr, E.B. & Hiltz, S.R. (1982). *Computer-mediated communication systems*. New York: Academic Press.
15. Kiggundu, M. (1981). Task interdependence and the theory of job design. *Academy of Management*, 6, 499-508.
16. Kling, R., & Scacchi, W. (1982). The web of computing: Computing technology as social organization. In M.C. Yovits (Ed.), *Advances in computers* (Vol. 21) (1-90). New York, NY: Academic Press.

17. Levine, S. & White, P.E. (1961). Exchange as a conceptual framework for the study of interorganizational relationships. *Administrative Science Quarterly*, 5, 583-601.
18. Malone, T.W., Yates, J., & Benjamin, R.I. (1989). The logic of electronic markets. *Harvard Business Reviews*, (May-June), 166-170.
19. Markus, M.L. & Robey, D. (1988). Information technology and organizational change: Causal structure in theory and research. *Management Science*, 34, 583-598.
20. Meyer, N.D. & Boone, M.E. (1987). *The information edge*. New York, NY: McGraw-Hill.
21. Olson, M.H. & Lucas, H.C. (1982). The impact of office automation on the organization: Some implications for research and practice. *Communications of the ACM*, 25, 838-847.
22. Pfeffer, J. & Salancik, G.R. (1978). *The external control of organizations*. New York, NY: Harper and Row.
23. Ponting, B. (1988). EDI's next frontier: Sending designs and graphics along with the forms. *Data Communications*, (May), 55-60.
24. Porter, M.E., & Millar, V.E. (1985). How information gives you competitive advantage. *Harvard Business Review*, (July-August), 149-160.
25. Rice, R.E. (1982). Communication networking in computer conferencing systems: A longitudinal study of group roles and system structure. In M. Burgoon (Ed.), *Communication Yearbook (Volume 6)* (pp. 925-944). Beverly Hills: Sage.
26. Rice, R.E. (1984). Evaluating new media systems. In J. Johnston (Ed.), *New directions for program evaluation: Evaluating the new information technologies (Vol. 23)* (pp. 53-71).
27. Rice, R.E. (1987). Computer-mediated communication and organizational innovation. *Journal of Communication*, 37 (4), 65-94.
28. Rice, R.E. & Case, D. (1983). Computer-based messaging in the university: A description of use and utility. *Journal of Communication*, 33(1), 131-152.
29. Rice, R.E. & Shook, D.E. (1988). Access to, usage of, and outcomes from an electronic messaging system. *ACM Transactions on Office Information Systems*, 6, 255-276.
30. Tushman, L.T., & Nadler, D.A. (1978). Information processing as an integrating concept in organizational design. *Academy of Management Review*, 3, 613-624.
31. Valle, J. (1984). *Computer message systems*. New York: McGraw-Hill.
32. Van de Ven, A. (1976). Information processing as an integrative concept in organizational design. *Academy of Management Review*, 1, 24-36.
33. Williamson, O. (1975). *Markets and hierarchies: Analysis and antitrust implications*. New York: Free Press.
34. Williamson, O. (1985). *The economic institutions of capitalism: Firms, markets, relational contracting*. York New: Free Press.