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A formal analysis of costs and benefits of interorganizational systems

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A FORMAL ANALYSIS OF COSTS AND BENEFITS OF INTERORGANIZATIONAL SYSTEMS

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Dedication

Für meine Eltern

Abstract

Since the interchange of information forms the basis of all organizational activity, it is not surprising that automated information systems that connect different organizations have become very important in today's business environment. The literature abounds with anecdotal evidence of how these interorganizational systems (IOS) have had strategic impact. However, there is a clear lack of rigorous assessment of costs and benefits of interorganizational systems.

In contrast to intraorganizational systems, interorganizational systems involve more than one organization, thus raising issues of control and cooperation. This makes industrial organization theory an appropriate reference discipline for an attempt to develop normative models highlighting the economics of IOS. Non-cooperative game theory provides a formalism for analyzing the competitive strategies of participants in IOS.

We focus on three areas:

- Shifts in bargaining positions between a manufacturer and his suppliers are shown to result from the introduction of a vertical IOS. Key determinants are the transaction volume of suppliers and the possibility of credible threats by the manufacturer.

- Competition between proprietary IOS that are already established in a market is analyzed. Switching costs and network externalities induced by IOS result in a stable coexistence of competing systems. A framework of competitive moves provides insight into the competitive use of IOS.

- The problem of competitive advantage vs. strategic necessity in the context of IOS is studied leading to the issue of cooperation among IOS providers.

We use published data on the airline reservation systems industry, automated teller machine networks, and electronic data interchange (EDI) use, to justify the assumptions of the models.

Based on the results of the dissertation, a new framework for the evolution of IOS is introduced by drawing a parallel to the evolution of internal information systems.

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Chapter 1

Introduction

In a 1966 Harvard Business Review article Felix Kaufman elaborated on the vision of extra-corporate data systems made possible by computer time-sharing and networking capabilities (Kaufman 1966). This vision has turned into reality during the last two decades. Orders and receipts are being exchanged between organizations via connected computer systems in retailing and manufacturing. The banking industry is relying extensively on computer networks for electronic fund transfers. Most travel reservations are made through computerized reservation systems. The literature abounds with anecdotal evidence of how information systems connecting organizations have had strategic impact. However, there is a clear lack of rigorous assessments of the costs and benefits of these interorganizational systems (IOS).

We begin this dissertation by presenting the phenomenon of interorganizational systems within the general context of strategic information systems management in the next section. The increasingly important and complex role of information technology in today's business environment makes the task of managing information technology challenging in an operational, strategic, and economic context.

These challenges with regard to interorganizational systems motivate the research problems considered in this dissertation. In section 1.2 we give an overview of the dissertation with an emphasis on the research questions addressed.

1.1 General context of research

1.1.1 Role of information technology in today's business environment

In an increasingly fast changing and complex environment we are faced with important roles for information technology (IT). They include

- automation of clerical tasks,
- internal information gathering and processing,
- support of decision making,
- environmental scanning, and
- communication with customers and suppliers.

In fact, with steadily increasing capabilities of IT, more and more tasks in an organization can be supported by IT. Along with this increasing use of IT comes an increase in complexity in the management of IT as a resource.

Current problems in the management of IT start with a focus on the technology and its implementation:

- What IT is available and what IT is appropriate for a given environment?
- When does new technology call for introduction and old technology for replacement? What are the 'life-spans' of different information technologies?
- Which architecture provides the best integrability and connectability of the different IT resources?
- How can internal systems share information with external systems?
- How can the reliability and maintainability of IT be guaranteed?

- How can IT resources be expanded and integrated?

These problems, however, tend to be less and less answerable without reference to the given business context. In fact, the competitive environment of a company provides a higher level perspective of IT as a resource that may be used not only in support of the business purpose but as a source of competitive advantage. Questions at this level go beyond the realm of technical system managers into the responsibility of general managers at a senior level.

- What business purpose is the IT supposed to support? How can IT be used for supporting that purpose effectively and efficiently?
- Which role does IT play in a company and the respective industry sector? How important is the movement of data within a company? How big is the 'information content' in a company's products?
- What role does time play in a given business? How critical is time in determining business relationships with customers and suppliers? What is the importance of 'information float', the gap between the generation of a piece of information and the processing of that information by a decision maker?

This increasing importance of the business context in the management of IT has led to a shift in perspectives on IT. The management of IT has become a major interest within the area of strategic management research. This trend is also reflected in the business world. According to Peter Keen (1988) telecommunications, and we might add IT in general, started out as a part of operations management. With increasing importance of IT, the perception of IT as an internal utility took over. Today, IT needs to be regarded as a "coordinated business resource" (Keen 1988). This evolution can be traced in organization charts where today many major corporations have functions like 'vice president of IS' or 'chief information officer (CIO)' that are responsible for an information service function which integrates telecommunications and information systems.

The discussion concerning the sustainability of competitive advantage leads to a third level of questions imposed by the use of IT.

- Once competitive advantage is gained, how can it be maintained over time? How can a first-mover advantage be sustained against countermoves by competitors?
- When does the innovator face a disadvantage compared to imitators?
- What is the aggregate utility of *all* participants in the competitive game? When are socially inefficient choices likely?
- When is coordination preferable to competition? What are appropriate coordinating mechanisms for the introduction and use of IT?

These questions aim at more long-term solutions which lay traditionally within the realm of economists.

In summary, IT in today's business environment has to be analyzed and managed at three levels: the technical and operational level, the strategic level, and the economic level.

1.1.2 The management of interorganizational systems

Interorganizational systems are information systems that cross company boundaries. They provide prominent examples of all three levels of IT management mentioned above.

At the technical level we have witnessed the emergence of telecommunication networks providing the infrastructure for connecting information systems across organizational boundaries. Technological changes that support the development of interorganizational systems are the advent of better hardware, better communication software and the establishment of standards of protocols (Suomi 1988). Moreover, with costs of telecommunications decreasing, interorganizational systems are increasingly within the reach of most companies.

The strategic potential of interorganizational systems can be deduced from many anecdotes where interorganizational systems have led to business success. American Airlines' reservation system, Foremost-McKesson's and American Hospital Supply's order entry systems are among the most famous and often cited success stories. There is a growing awareness that interorganizational systems are an important 'resource' of a company despite the fact that the links between information systems of different companies tend not to be under the control of one company.

There has been a focus in many articles on how to achieve competitive advantage with interorganizational systems. Cost reductions, product differentiation, and the creation of high switching costs are mostly cited as the goal of strategic IOS.

However, one may also look at the potential of interorganizational systems in supporting strategic cooperations: "Yet a great deal of important strategic improvement in competitiveness may be taking place in coalitions – rather than "inside" the "boundaries" of one organization" (Kanter 1989, p. 160). Economic and organizational factors contribute to the strategic potential of IOS for cooperation among companies. From an economic point of view, the value of information in companies tends to increase steadily due to shifts in international competition, shrinking geographic separation, and deregulation with more open competition. (Suomi 1988, p. 106) Due to the importance of timeliness of information, interorganizational systems play an increasingly important role in the information exchange between cooperating organizations. From an organizational point of view, there is a growing need for interorganizational contacts in order to increase coordination among companies and achieve synergies. As many opportunities for synergy rely on information sharing, interorganizational systems achieve an important role in realizing these opportunities. This is part of a more general answer to the strategic challenge of 'doing more with less' according to Kanter. Kanter emphasizes that companies can improve their ability to compete without adding internal capacity by stretching in three ways: "They can *pool* resources with other, *ally* to exploit an opportunity, or *link* systems in a partnership" (Kanter 1989, p. 118).

At the third level many economic implications of interorganizational systems call for attention. Although the virtues of IOS for achieving competitive advantage had been emphasized by many articles, many competitors found it difficult to repeat the success stories of the innovators. In fact, the repetition of the success stories was often impossible because the innovating IOS had changed the industry structure. For example, airline reservation systems have redefined the industry structure and the basis for competition in the airline industry. These systems have even become the object of court battles and the motivation behind carrier mergers and acquisitions. In many retailing industries electronic customer channels have become the preferred way to do business (Silverman 1990, Keen 1980). Moreover, new opportunities have opened up for third-party providers to provide bridges between supply and demand. These changes call for further theoretical analysis.

1.2 Problem statement and overview of dissertation

This research aims at a more formal understanding of the benefits and costs of IOS at the operational, strategic and economic levels. Despite the large number of articles in IT research emphasizing the importance of IOS, little progress has been made in developing models for analyzing the costs and benefits of interorganizational systems. The aim is a theoretical foundation for the discussion of IOS. In a young area such as MIS, the need for a theoretical foundations has elicited more calls for it than responses. The goal of this dissertation is to help build a better foundation for MIS as a discipline by taking a formal modeling approach. Thus, the main contribution of this dissertation is conceptual. There also is a more practical aspiration of the research that is connected to the theoretical thrust of this dissertation. There is an increasing need for a well-founded understanding of information technology (IT) by senior managers as "technical risk becomes business

risk, and vice versa" (Keen 1988, p. 5). This research provides a basis for such a better understanding of interorganizational systems by presenting formal models and frameworks that form a conceptual bridge between the strategic management issues and the technological opportunities and restraints.

The focus of this research is on costs and benefits of participants in interorganizational systems. Pricing issues are not of primary concern. However, although not directly addressed, effects of market structure and social welfare considerations are commented upon throughout the dissertation where appropriate. Support for our focus on costs and efficiency benefits can be derived from Williamson's analysis of the tradeoff between efficiency benefits and market power effects in mergers (Williamson 1968). As allocative effects are shown to be often dominated by efficiency benefits rather than market structure effects, a cost-based focus is not as limited as may seem at first glance.

In chapter 2 definitions and taxonomies regarding interorganizational systems are presented. A variety of possible perspectives on IOS illustrates the complexity of the phenomenon. The literature review in section 2.2 groups relevant research into four groups that are ordered according to their theoretical rigor: case studies, strategic impact research, transaction cost economics, and formal modeling in industrial organization theory. This dissertation uses industrial organization theory as a reference discipline. Methodological considerations are added in section 2.3 that justify the use of mathematical modeling and point at inherent limits of the approach.

Chapter 3 focuses on the introduction of a vertical IOS between a manufacturer and his suppliers. Questions in the adoption of such an IOS center on the benefits derived from the system and the bargaining power of the participants.

- When can a manufacturer and system provider threaten a supplier into joining the system?
- What role does transaction volume play in the adoption decision?
- What are factors that enhance the bargaining position of suppliers?

In chapter 3 a new normative model is introduced to analyze the introduction of a vertical IOS. The impact of the introduction of the IOS on the existing relationship between a manufacturer and his suppliers is studied. Key determinants are the importance of transaction volume of the suppliers and the possibility of credible threats by the manufacturer to substitute a supplier.

In chapters 4 and 5 we focus on the competition between proprietary IOS that are already established in a limited market. Many questions are open here:

- Can the strategic advantages of IOS be measured in terms of greater market shares, improved profit margins, or other economic factors?
- How do the economics of IOS affect the behavior of users of the system? Under what conditions will they select one system over another?
- How will IOS affect the competitive moves of firms within an industry? Under what conditions will these firms develop an IOS? How should a firm respond to the introduction of such a system by a competitor?

In chapter 4 a new normative model explains the coexistence of multiple IOS in terms of network externalities and switching costs. A list of generic competitive moves by system providers is derived and analyzed. This provides further insights into the strategic management of IOS.

Chapter 5 uses non-cooperative game theory to formalize scenarios of competition between IOS providers. This analysis suggests that competitive advantage based on IOS may be less likely than is usually claimed. A more detailed analysis

of the airline reservation systems case in section 5.3 provides further insight into this set of problems and gives credibility to the assumptions underlying the model.

Chapter 6 broadens the scope of our analysis one step further by addressing the problem of when and why competitive advantage turns into strategic necessity. Particular questions raised here are:

- Under what conditions will an IOS be beneficial to an industry as a whole?
- Do all of the firms benefit from IOS, or just a few?
- When would we expect standards to be adopted in an industry?
- What are chances and risks of coordinated IOS development among competitors?

The Prisoner's Dilemma from game theory is identified as an appropriate paradigm for this analysis. Two possible ways to seek competitive advantage with IOS are discussed. In the first case, providers compete on user benefits. In the second case, providers try to establish proprietary standards. As interorganizational systems involve providers and users of the system, one has to distinguish between two perspectives regarding the quest for competitive advantage through the use of an IOS. This analysis leads to normative implications for cooperation in the context of IOS, in particular the management of IOS standardization. The case of ATM networks is reviewed in section 6.6.

The last chapter points at opportunities for further applying and validating the results of this dissertation. Promising extensions of the approach taken in this dissertation are discussed. Finally, based on the understanding gained in this dissertation, we venture to predict the evolution of interorganizational systems in section 7.3. A parallel drawn to the evolution of internal information systems suggests a rich agenda for further research.

Chapter 2

Literature review and methodological considerations

2.1 Definitions and taxonomies

2.1.1 General definition

The most general definition of interorganizational systems (IOS) is probably Cash and Konsynski's definition "as automated information systems shared by two or more companies" (Cash and Konsynski 1985, p. 134). Thus, IOS have to be distinguished from intraorganizational information systems that most information system research has focused upon. In contrast to traditional distributed data processing (DDP), IOS cross company boundaries, so that the system is not under the control of a single company. In fact, we shall assume that a participant in an IOS has some control over the degree of participation in the IOS. In this strict sense, we do not subsume the use of an automated information system for the coordination of regional activities within one corporation under the definition. For example, the production of the Wall Street Journal with its decentralized printing facilities linked via satellite to the central editor's office is not part of our analysis.

The sharing of resources between companies is made possible by a computer and communication infrastructure. The resources to be shared can be applications, such as reservation systems or programs for supply ordering. Bakos has stressed this aspect by defining IOS as "systems based on information technology that cross

organizational boundaries and whose purpose is the exchange of information-based products or services" (Bakos 1987, p. 44). Other labels for the same concept include Barrett and Konsynski's (1982, p. 94) acronym "IS*" for interorganizational information sharing system, and Choudhury's (1988, p. 44) acronym "IOIS" for inter-organizational information system.

In order to relate our results to articles in the business press, we want to clarify the relationship between our understanding of an IOS and the notions EDI, VANs, and POS.

- "Electronic data interchange (EDI) is the intercompany, computer-to-computer exchange of business documents in standard formats" (Hinge 1988, p. 9). Thus, EDI systems are a clear subset of IOS.

  However, some authors use a less restrictive definition of EDI that also encompasses electronic document interchange between geographically different locations of the same company. Those systems still qualify as intraorganizational systems and are not part of this research. An even more encompassing definition has been used by consultants: EDI is "a general approach for a company to do business electronically" (Silverman 1990). In fact, this definition is useful for alerting managers to the potential importance of EDI, but it is hard to base a more formal analysis of EDI on it.

- "Point of sale (POS) is the capture of data at the time and place of sale" (Freedman 1989, Document #2426). Usually POS systems are part of an intraorganizational system. However, they may be an important system extension of an IOS, as can be seen by retailers that use POS registers to collect information, then convert it to marketing and reordering data, and use an IOS to transmit the data to their suppliers (Davis 1989, p. 53). We consider POS to be a possible functionality rather than a conceptual attribute of an IOS in our analysis.

- "A value-added network [VAN] is a communication network that provides services beyond normal transmission, such as automatic error detection and correction, protocol conversion and message storing & forwarding" (Freedman 1989, Document #3296). The emphasis of the definition is on the distinction between value-added systems and pure transmission systems. The perspective is technology oriented. In contrast, the concept of IOS is business oriented. Thus, a VAN may form the technological basis for an IOS, but neither does every VAN have to cross company boundaries nor does the technology of every IOS have to go beyond a transmission system. In principle, one may even cite the traditional telephone system as an IOS, although we shall focus on IOS based on computer communication. In fact, the distinctions between pure transmission systems and value-added systems are becoming increasingly blurred with the new possibilities opened up by ISDN.

2.1.2 The Barrett-Konsynski classification of IOS

The above definitions are so general that they comprise many different types of interorganizational systems, including reservation systems, electronic supplier-manufacturer links or electronic markets to name just a few examples. Thus, it is helpful to have a more detailed taxonomy of IOS. Barrett and Konsynski (1982) have provided a classification scheme that identifies important characteristics of different types of IOS. The classification scheme defines five levels of participation that increase "in degree of participant responsibility, cost commitment, and complexity of the operating environment" (Barrett and Konsynski 1982, p. 95).

1. *Remote I/O Node*

   The lowest level of participation is the use of remote I/O functions without independent processing within an application system supplied by higher level participants. Procedures and protocols for participation are provided by

higher levels. The use of airline reservation systems by travel agents constitutes a classic example.

2. *Application Processing Node*

   Level 2 participants have the responsibility of developing and maintaining a single application which is shared with level 1 participants. Good examples for level 1 and level 2 interactions can be found in retailing with supply ordering systems, such as ASAP by American Hospital Supply.

3. *Multi-participant Exchange Node*

   The characteristic feature of level 3 participation is the idea of a network interlinking the level 3 participant to any number of lower level participants. Thus, lower level participants may communicate among each other via the level 3 node. An example is American Durable Manufacturers providing daily sales summaries, electronic mail, parts ordering, warranty claims, parts credit, distributed accounting, invoicing, and installment payment computation to its nationwide independent dealers.

4. *Network Control Node*

   Level 4 participants develop and share more than one application allowing different types of lower level participants to use the system. A level 4 participant does not have to have a direct non-information product/market relationship with any of the lower level participant classes. A possible use of a network control node is the linking of different networks. Barrett and Konsynski (1982, p. 98) cite automated clearing houses for financial transactions or insurance claims as examples because they tend to be both processing centers and company-to-company communication facilitators.

5. *Integrating Network Node*

   A level 5 is defined as "a data communication/data processing utility which integrates any number of lower level participants and applications in realtime"

(Barrett and Konsynski 1982, p. 98). The emphasis is on a more complex operating environment compared to level 4, as there is simultaneous execution of applications at multiple participant sites. Barrett and Konsynski (1982, p. 101) cite again an automated clearing house where simultaneous, transparent links are provided between sellers and credit service firms.

Although responsibilities increase with level, it would be wrong to conclude that the decision for low level participation is easier to make. Even the costs facing a level 1 participant may still be formidable depending on the level of changes in manual procedures required. With higher levels of participation a trend towards information services as a product in itself becomes clear raising opportunities for third-party providers.

2.1.3 The Cash-Konsynski taxonomy

Another classification of participation has been proposed by Cash and Konsynski (1985, p. 140). They derive three levels according to the influence a participant exerts over access and design of the IOS.

1. *Information entry and receipt*

   This level corresponds to the first level in the Barrett-Konsynski taxonomy with participants having no control over applications and standards.

2. *Software development and maintenance*

   At level 2 we find companies that develop and maintain software used by other IOS participants. American Airlines and United Airlines are famous examples with their SABRE and APOLLO reservation systems, respectively.

3. *Network and processing management*

   This level represents a utility function where the participant owns and manages all network and computer processing resources. Public information networks, such as CompuServe, may be taken as an example.

In fact, these participation roles are neither mutually exclusive nor completely exhaustive. Thus, they have a rather exemplary character without meeting the criteria of a classification.

2.1.4 Bakos' functional characterization of IOS

Bakos (1987, p. 50–52) classifies IOS according to the functional role of their participants with the help of three generic vertical stages: supplier, market intermediary, and customer. Depending on the number of actual and potential participants at each of the three stages, the distinction between competitive markets and unilateral or bilateral monopolies and oligopolies can be represented. Bakos defines four generic types of IOS structures:

- *Type 1* denotes $1-1$ relationships between one supplier, an optional intermediary, and one customer.
- *Type 2* denotes $1-n$ relationships between either one customer and n suppliers, or one supplier and n customers. The single customer or supplier may be replaced by an intermediary.
- *Type 3* is similar to *Type 2* except that the intermediary is included explicitly as a link leading to a $1-1-n$ relationship.
- *Type 4*, finally, is the most general type in that one intermediary provides the link between n customers and n suppliers.

These types are shown graphically in figure 2.1 and figure 2.2.

In addition to the functional structure, the control over the value added at each link of the IOS has to be described as a basis for analyzing bargaining leverage and distribution of system payoffs.

Type 1: One supplier, one intermediary, one customer.
Type 1A: No intermediary.

Type 2A: One customer/intermediary, many suppliers.
Type 2B: One supplier/intermediary, many customers.

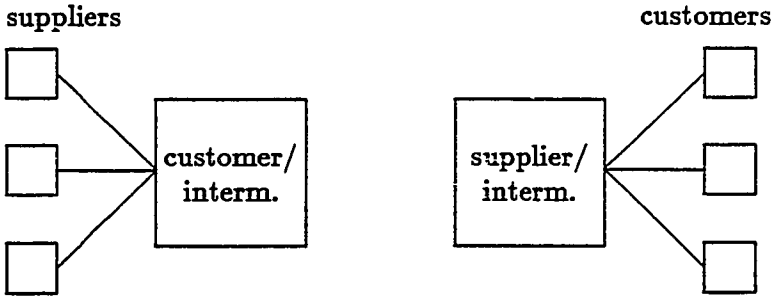
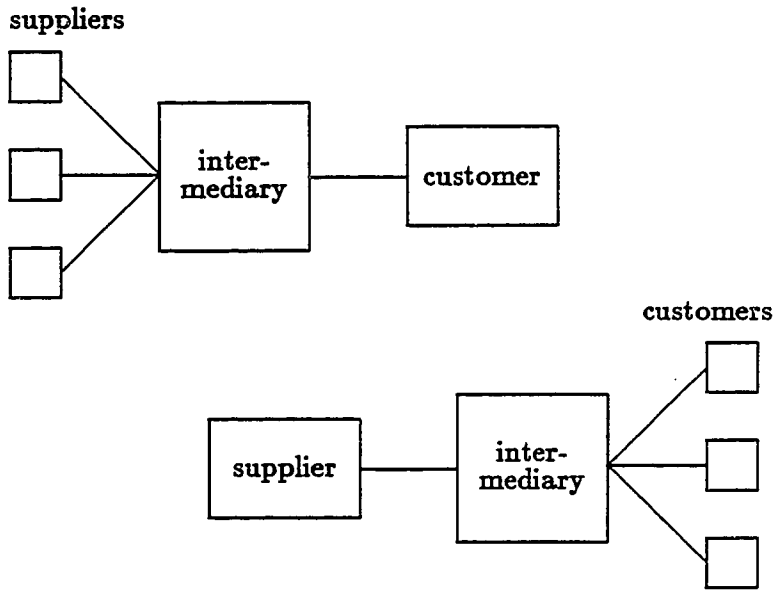


Figure 2.1 Generic, functional types of IOS (part 1)

Type 3A: Like type 2A, except customer and intermediary are distinct.
Type 3B: Like type 2B, except supplier and intermediary are distinct.



Type 4: Many suppliers, an intermediary, many customers.

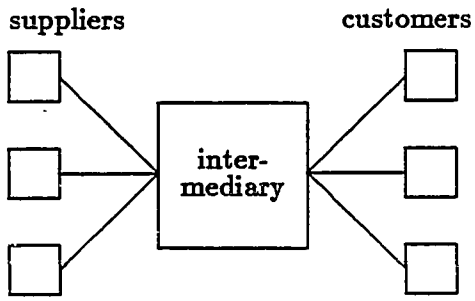


Figure 2.2 Generic functional types of IOS (part 2)

2.1.5 Possible dimensions for taxonomies

The drawback of the classification by Barrett and Konsynski is that the derivation is based mainly on architectural and complexity aspects of IOS. Cash and Konsynski's taxonomy is based on technological participation in an IOS, focusing on different roles related to development, administration and use of an IOS. This limits the usefulness of these taxonomies for economic analysis of IOS. The structural focus of Bakos helps in getting the necessary degree of abstraction for economic modeling. However, he ignores technological issues are. Thus, one has to emphasize that the above taxonomies each provide a valid perspective on IOS. However, they are hard to compare because they blend more than one dimensions into their classification scheme leading to some overlap and unclear comparative delineation. The following list identifies different dimensions of IOS.

- *Topology*

  An IOS is per definition based on a communication network. The topology of a network allows a classification of the connectivity of the participants. A graph can be used to describe the topology formally.

- *Architecture*

  This dimension describes the technological implementation of the abstract topology.

- *Market Structures*

  This dimension aims at the competitive structures, from monopoly to pure competition, that each group of participants represents.

- *Value Chain*

  Porter's concept[1] allows description of the productive function of an IOS in terms of value added by its use (Porter 1986). Following Bakos, the issue of control over an IOS functionality belongs to this dimension.

[1] A more detailed description of this concept follows in section 2.2.2.

- *Participation Roles*

  This dimension distinguishes different roles that can be played by an IOS participant. Potential roles are:

  1. development roles
  2. maintenance
  3. administration
  4. ownership of the IOS
  5. use of the IOS without ownership

  Participation roles 1, 2 and 3 can be fulfilled by third-party firms not involved in the actual use of the system. Thus, it is important to describe the business purpose of each participant, i.e., whether the participation is primary business function, e.g., CompuServe, or auxiliary to another business function, e.g., automatic inventory control programs.

- *Strategic Purpose*

  An IOS may be used for cooperative or competitive purposes.

This list helps in understanding how various classifications complement and depend on each other. An integrative and exhaustive taxonomy of IOS would have to take account of each of these dimensions.

2.2 Literature review

In the literature review we look at four relevant research perspectives that are ordered according to their theoretical rigor. While case studies contain only anecdotal evidence, strategic impact research tries to identify more general patterns that can provide the basis for guidelines for managers. Transaction cost analysis is an important contribution to a more explanatory organizational theory. Finally, formal

modeling in industrial organization theory goes one step further towards quantifiable theories.

2.2.1 Case studies

The difficulty in discerning dependent and independent variables in comparing case studies on IOS makes the value of comparative data from these case studies questionable. However, case studies do help in identifying critical success factors and crucial attributes that may be important in an explanatory theory for the phenomena. In fact, there are only a few well-documented case studies on interorganizational systems and these few are "being used over and over again to proselytize the faithful" (Bakos 1987, p. 15).

Systems in retailing that connect buyers and suppliers are most prominent in the discussion of IOS. Examples include American Hospital Supply (Bakos 1987), Foremost-McKesson ("Foremost-McKesson: The Computer Moves Distribution to Center Stage" 1981, Clemons and Row 1988), Bergen Brunswig, Cotner Dry Goods, and Westinghouse Electric Supply Company. The Tradanet system in Great Britain provides an example of an IOS by a third-party vendor.

General Motors exemplifies an effort by manufacturers to tie production systems with the production system of suppliers. The goal is that a supplier's computer communicates directly via CAD/CAM links with GM's robot-based assembly line. Such an IOS permits flexible manufacturing where order-entry systems are taken one step further. It also reflects a trend towards increased buyer power in industries assembling components. Using automated vendor quotations and bills, sources of materials can be selected optimally. Ford and other automobile manufacturers make similar use of IOS.

Almost two-thirds of all airline reservations are made through two famous IOS: the airline reservation systems by United Airlines and American Airlines, which have changed the industry structure. Today American has a higher return on investment

(ROI) with its reservation system than with its carrier service. Ownership of such a system opens up new marketing opportunities.

We shall reference these and other case studies in the course of the dissertation in more detail to justify the assumptions of our theoretical models.

2.2.2 Strategic impact research

The following list contains frameworks used in MIS and management to evaluate information technology (IT) in a strategic management context. Given the infatuation of the MIS field with frameworks this list is certainly not exhaustive, however, it contains the most widely used and quoted frameworks in the literature.

- *Strategic grid* (Cash, McFarlan and McKenney 1988)
  The concept of the strategic grid allows classification of a firm on the basis of the strategic impact of existing applications and the strategic impact of the current applications under development. Depending on whether the strategic impact of existing and future applications is low or high, the strategic grid contains four quadrants named factory, support, strategic, and turnaround. The strategic grid can be applied to the development of appropriate management control systems. It is also useful in evaluating alternative information system investments. However, no new opportunities for the strategic application of information systems can be deduced from the strategic grid. Although the concept of the strategic grid has been applied mainly to intraorganizational systems, it is sufficiently general to encompass IOS too.

- *Industry and competitor analysis* (Porter 1980)
  Porter's framework for analyzing industries and competitors is based upon the identification of five competitive forces:

  1. bargaining power of suppliers
  2. bargaining power of buyers

3. threat of new entrants
4. threat of substitute products or services
5. rivalry among existing firms

Overall cost leadership, differentiation, and focus are presented as generic strategies. Although not aimed at IT in particular, this framework has proved very useful in understanding the role of IT in a more general business context.

- *Categories of competitive advantage through IT* (Parsons 1983)
  Based on Porter's competitive forces framework six generic categories of opportunities for competitive advantage are identified.

  1. increase customer's switching costs through value-adding IT-based information or service
  2. decrease one's own switching costs against suppliers
  3. use IT to support product innovation for purposes of maintaining one's position or detering potential substitutes
  4. cooperate with selected rivals through shared IT resources
  5. substitute information technology for labor
  6. use information to better segment and satisfy one's customer base

- *IOS application to generic strategies* (Cash and Konsynski 1985)
  Porter's five competitive forces are analyzed in terms of their implications and the potential use of an IOS to combat them. Abstracting from the analysis by Cash and Konsynski of the competitive use of IOS, one can identify the following levers: switching costs on the buyer's or supplier's side, cost effectiveness mainly through economies of scale, product differentiation by redefining products and services, and control of market and distribution channel access.

- *Causal model of competitive advantage* (Bakos and Treacey 1986)

  According to Bakos and Treacey, competitive advantage can be traced back to bargaining power and comparative efficiency. Bargaining power in turn is caused by search-related costs, unique product features, and switching costs, while comparative efficiency is determined by internal and interorganizational efficiency.

- *Customer resource life cycle* (Ives and Learmonth 1984)

  An organization's products or services can be visualized to go through a life cycle from a customer's point of view, during which information technology may provide strategic advantage. The authors define a thirteen-stage customer resource life cycle:

  1. establish requirements
  2. specify attributes of resource
  3. select a source
  4. order
  5. authorize and pay for
  6. acquire
  7. test and accept
  8. integrate into and manage inventory
  9. monitor use and behavior
  10. upgrade if necessary
  11. maintain
  12. transfer or dispose
  13. account for

A deeper penetration into a customer's resource life cycle by a product or service results in higher switching costs away from the product or service for the customer.

- *Value chain* (Porter 1986)

  The concept of the value chain makes it possible to pinpoint not only areas where competitive advantage can be gained but also identify ways to achieve this goal. The value chain is a system of interdependent value added activities, i.e., technologically and economically distinct activities of the business. Through each activity in the value chain, value is added to the product. The difference between the sum of the values added and the costs of performing the activities provides the margin for profit. The value is measured by what the customer is willing to pay for the product. Linkages connect value activities inside a company and also with value activities outside the company.

The cited frameworks are highly normative. However, there is no systematic theoretical or empirical evidence supporting these norms. These frameworks try to help practitioners in making management decisions. They do not allow quantitative predictions; even qualitative predictions tend to be only possible in vague terms, such as high/low impact. The quality of these frameworks stems more from their practical usefulness than from their theoretical foundation. The high level abstraction of these frameworks calls for many steps of refinement before actual competitive advantage is ever achieved, as is attested by the thriving consulting practice on the strategic use of information technology.

2.2.3 Transaction cost economics

Transaction cost economics represents an attempt to give an explanatory theory of the 'economic institutions of capitalism' (Williamson 1985). The goal of this theory is to identify structural features of various forms of organizing ranging from hierarchies to quasi-market forms to perfect markets.

The starting point of transaction cost economics is that transactions are the basic unit of analysis (Coase 1937, Williamson 1975). Economic transactions refer to the transfer of a good or service between individuals or organizations (Williamson 1981). This understanding of transactions has a social dimension in contrast to the use of the term 'transactions' in the computer science context. There transactions denote a computer exchange of data in response to a request by a user. It adds to the relevance of transaction cost theory for the analysis of interorganizational systems that the two concepts can be linked in the case of computer-mediated economic transactions. (Ciborra 1987)

Transactions have associated costs that include the drafting, monitoring, and enforcing of contracts. The costs of transactions in an economic sense are the "economic equivalent of friction in physical systems" (Williamson 1985, p. 19).

The explicit acknowledgment of the existence of transaction costs leads to the need to economize on transaction costs in addition to the traditional economizing on production costs. Transaction cost economies are realized by assigning transactions to governance structures in a discriminating way. In other words, the key idea is to identify defining attributes of transactions and then compare the efficiency of alternative governance mechanisms. Governance mechanisms range from classical market contracting to centralized, hierarchical organizations. It is interesting to note that even hierarchical organizations can be viewed as a form of contracting between the members of the organization. Williamson (1985, p. 41) emphasizes that "any problem that can be posed directly or indirectly as a contracting problem is usefully investigated in transaction cost economizing terms".

In order to understand the economizing process in transaction cost economics, one has to look at two behavioral assumptions underlying the notion of a contract in this theory. Firstly, transaction cost economics assumes, following Simon, that human agents are subject to bounded rationality. Secondly, human agents are expected to be opportunistic, i.e., they seek their self-interest with guile, which may include cheating and lying. Thus, transaction cost economics aims at a contractual

organization and governance of transactions "so as to economize on bounded rationality while simultaneously safeguarding them against the hazards of opportunism" (Williamson 1985, p. 32).

Before comparing different governance mechanisms in this context, one has to realize that parties engaged in a trade may be supported by nontrivial investments in transaction-specific assets. This asset specificity is a critical dimension of any transaction, as trading partners with high investments specific to their trading effectively operate in a bilateral trading relation (Williamson 1985). The central hypotheses of transaction cost economics now states that with increased asset specificity the transaction cost superiority of the internal organization outweighs the market's advantage in production efficiency. This leads to the notion of "efficient boundaries" of organizations (Williamson 1981). First attempts of empirical validation have supported this hypotheses (Joskow 1988).

The impact of IT on the governance of transactions is twofold. Firstly, IT can increase production process flexibility and change production cost advantages of markets, thus changing the economics of make-buy decisions by shifting efficient boundaries of organizations (Williamson 1981). Secondly, IT can impact transaction costs directly. In particular, externally focused applications tend to aim at reduced customer transaction costs (Clemons 1986). Most external or customer focused systems have relied on customer's switching costs to defend initial gains in the marketplace. Choudhury (1988) states that market share gained before competitors offset the edge may be retained through investments that lead to *nonnegatable asset specificity* in terms of transaction cost theory.

In summary, transaction cost economics provides an intuitively appealing theory of economic institutions. Transaction cost economics does not provide a mathematical formalism that could drive a normative model. A more mathematical approach is central to industrial organization theory, which is discussed in the next section.

2.2.4 Formal modeling in industrial organization theory

Industrial organization theory is a central element of microeconomics, as "to study industrial organization is to study the functioning of markets, the central concept in microeconomics" (Tirole 1988, p. 1). Formal modeling in industrial organization theory is also known as 'normative economic modeling'.

We now give an overview of some models that concentrate on attributes that are also relevant to the study of interorganizational systems. We start by looking at models of efficiency changes through IT. We then mention some seminal models of switching costs and their effect. From the many models of technology adoption, we pick those that can most readily be related to information technology diffusion. With regard to interorganizational systems we are particularly interested in models that model network externalities. Finally, we reference models that look at the effects of IOS on market structure.

Inventory models

Gains from efficiency through IT have mostly been quantified in terms of gains from reduced inventory. Inventory models from the production and operations management literature (e.g., Buffa and Sarin 1987) suggest that increases in certainty of demand and decreases in lead times due to an IOS lead to inventory reductions. Bakos has expanded on these notions by providing a proof based on information theory that information and inventory are substitutes. (Bakos 1987)

Switching cost models

Von Weizsäcker (1984) defines a model of two goods with substitution costs and transportation costs. Using the concept of competitive distances, equilibrium market shares of the two suppliers as a function of their price differences are computed. It is shown that the price sensitivity of users increases with rising switching costs. Klemperer (1987a, 1987b, 1987c) has expanded on these results. He shows that in a

two-period differentiated-products model that prices may be higher in both periods that they would be in a market without switching costs. Thus, the noncooperative equilibrium in an oligopoly with switching costs may be the same as the collusive outcome in an otherwise identical market without switching costs.

Long-term contracts or contracts with penalties for breach are a source of high switching costs for buyers. Aghion and Bolton (1987) have modeled how such contracts can inefficiently deter entry in a market. The model emphasizes that even a buyer's concern for monopolization of the supplier cannot prevent the high degree of market foreclosure.

Adoption of technology models

Fudenberg and Tirole (1985) have modeled the strategic adoption of a technology in a duopoly. Given that information lags are negligible it is shown that firms may want to adopt the technology early in order to delay or prevent adoption by their rivals leading to an equilibrium where the rent from the technology adoption is equal to the cost of adoption. However, when a technology is proprietary it is adopted later because of decreasing costs of adoption. Other references are Jensen (1982), who analyzes the effects of uncertain profitability of a new technology in the adoption process, and Ordover and Willig (1981) who analyze predatory product incompatibility.

When analyzing interorganizational systems, the adoption process has to take account of positive consumption externalities that reflect a dependence of the utility a given user derives from a good or service on the number of other users. These consumption externalities have also been called network externalities (Katz 1985). Consumption externalities give special importance to the users' expectations of a network's size. This notion is the motivation for models by Katz and Shapiro (1985, 1986a, 1986b) that concentrate on the *suppliers'* side by studying fulfilled user expectation equilibria in a static model of a duopoly. The effects of sponsoring of technologies on the pattern of adoption are demonstrated. From a social welfare

point of view it is interesting to note that firms may use product compatibility as a means of reducing competition among themselves.

Farrell and Saloner (1985a) use a game-theoretic model to analyze the adoption of new technologies in the presence of network externalities from the *users'* point of view. It is shown that a 'bandwagon effect' may impede the collective switch to a preferred technology. This phenomenon may take the form of symmetric inertia, where firms are unanimous in their preference for the new technology and yet the change is not made, or asymmetric inertia, where different preferences of firms prevent the bandwagon from starting to roll. Farrell and Saloner (1986) also look at the effects of installed base on the introduction of new technologies in the presence of network externalities. A continuous-time model in which users arrive to the market over time shows that effects of installed base on the utility function of users of a technology result in a disparity between the social incentives or the adoption of the new technology and the private incentives.

These models show that traditional economic models based on convexity and diminishing returns can be misleading when bandwagon effects, windows of opportunity for entry, installed base problems are important (Farrell and Saloner 1985a). Economies of scale on the demand side make standardization an important economic issue. Questions raised include the timing of standardization, the problem of excess inertia and excess momentum, and possible anticompetitive effects of standards.

Market structure models

One of the first models of interorganizational systems is a continuous-linkage, one-commodity model by Balderston (1958) that aims at identifying an optimal structure of a market where suppliers and buyers are connected via communication networks administered by wholesalers. The model suggests that there is an optimum number of wholesalers (and networks by definition of the model) where the wholesalers can reap long-run positive economic profit. Whether the optimum is

reached depends on the relative economic profits reaped by different wholesalers and the conditions for entry into the market of new wholesalers.

A more recent modeling approach by Malone (1987) features four generic coordination structures (product hierarchies, functional hierarchies, centralized markets, and decentralized markets) that are compared with regard to the costs of information processing involved in coordination. The comparison takes account of production costs, coordination costs, and vulnerability costs. Abstracting from this modeling approach Malone et. al. (1987, 1989) argue that by reducing the costs of coordination, information technology will lead to increased use of markets instead of hierarchies to coordinate economic activity. Electronic hierarchies and markets become possible because of technological developments characterized by the electronic communication, brokerage and integration effects.

Bakos (1987) has introduced uncertainty of the value of the new technology in order to analyze the effects of an IOS on market structure. Modeling search costs, he demonstrates that even small search costs for the buyers can enable suppliers to charge prices substantially above marginal costs. This points at a possible shift in profits from suppliers to customers if an IOS, in the form of an electronic marketplace, reduces the search costs.

2.3 Methodological considerations

The scarcity of resources, in particular of time, constitutes the basis of the theoretical perspective on the 'homo oeconomicus' . In fact, the scientist is himself subjected to these constraints leading to a tradeoff between rigor and relevance. This section looks closer at this tradeoff. The purpose of this section is to justify the use of mathematical models in this dissertation and point at limits of the approach.

2.3.1 The tradeoff between rigor and descriptive completeness

A study of an economic phenomenon may aim at high realism by describing a situation with a large number of attributes. There is no limit to the number of attributes, as the scientist can only observe the effects of the inner models of his subjects, not the models themselves. The more attributes[2] the scientist can instantiate in his study the higher the reference with reality. With the increase of attributes increases the complexity of a typology, eventually leading to an emphasis on the characteristics of the single case and away from the determination of patterns out of the empirical diversity. Interpretation of the results in a larger context becomes increasingly difficult in terms of effort as well as from a methodological point of view.

The alternative is to restrict oneself to a limited morphology of the constellations in question and to postulate only few attributes as existing, or rather, important. Given this axiomatic reference with reality the emphasis is on rigor, the consistent interpretation of the axiomatic description of the phenomenon. Because of the low complexity of the description the number of possible interpretations to be considered tends to be finite and manageable. Such an approach has been compared to an hourglass (Slatkin 1980): The problem at hand is broad and important. By means of approximation, symmetrization, and aggregation the problem is reduced to a manageable model in the hope that the essence of the problem has been captured. This corresponds to Occam's razor and the *ceteris paribus* assumption of most kinds of scientific analysis. Finally, one tries to expand the results from the model again so that they apply to the original problem again. This validation may lead towards modifications of the premises and another iteration of the process.

Macneil (1980) has highlighted the tradeoff between the two fundamental line-break methodological perspectives. Whichever perspective the scientist takes, he

[2]We assume that the attributes are not perfectly correlated.

faces opportunity costs either with regard to relevance or with regard to the generalization and consistency because of the limited nature of time for an individual. The consequences of the scientist's choice are important with regard to practical application and communication of the results. The scientist aiming at high empirical reference tends to lack the methodological tools for reducing his results to elegant key propositions that meet the 'critical-rational' criteria of science legitimization. His discourse has to be based on circumstantial arguments. The scientist emphasizing rigor, on the other hand, takes the risk of missing important aspects of the phenomenon in reducing reality to his elegant axioms. Thus, he faces additional effort to justify and explain his reductions in order to meet the reference-consistency-expectations of his readers.

Aware of this tradeoff, this study consciously emphasizes the consistency pole in analyzing the economics of interorganizational systems.

2.3.2 Inherent limits of a mathematical approach

The benefits from the mathematical approach come at a price. That's why it is insufficient to use mathematics without delineating principal limits of the approach.

The fundamental limits of the axiomatic method should be clear. Our formal models are basically implications: Given certain axioms a set of propositions is only true in a formal sense. A principal limit arises from the attempt to map a non-formal system to a formal system. Mathematics or rather mathematical logic is a formal system that makes no statement about reality. When we use mathematics as a method to analyze a phenomenon in the social sciences, we automatically do *normative* research, because we interpret formal axioms in a non-formal real-life situation. Not only is this mapping between a formal and a non-formal system normative, it is also incomplete no matter how many variables the formal system may contain. Otherwise real life could be described as a formal system. However, an attempt to describe reality exhaustively as a formal system is doomed not only

due to complexity, but first of all due to ontological reasons as has been shown for the case of evolutionary structures. (e.g., Blaseio 1986). Thus, the problem of external validation goes beyond the mere problem of limited time to be spend on a particular research question. The mathematical formalism implicitly limits our ability to describe a real-life phenomenon.

> Die Grenzen meiner Sprache bedeuten die Grenzen meiner Welt.[3]
> (Wittgenstein 1963, Tractatus 5.6)

What constitutes an ontological limit of the mathematical approach, the incomplete mapping of reality, provides on the other hand the basis for trying to develop a theory of a real-life phenomenon in the first place. The goal of the approach is the discovery and approximation of symmetries in the real world. Formalizing those symmetries allows us to avoid redundancy in the description. Eventually, the quality of a theory depends very much on whether it is a minimal description.

The mathematical process of abstraction leads to another inherent limitation of the approach. The mathematical formalisms underlying neoclassical economics and industrial organization theory in particular all rely on the existence of units of analysis that do not change autonomously. In other words, the construction of models always starts out with complete information in the sense that all present and future possibilities are contained in the model.[4] (Blaseio 1986) This implies that given a certain level of aggregation for our units of analysis, we cannot take account of autonomous internal changes underneath this level of aggregation. In particular, a choice of the firm as unit of analysis makes it impossible to model changes within the firm in beliefs and attitudes. Thus, the postulate of the invariance of the elementary units of analysis makes it crucial to find the highest level of aggregation that does not ignore relevant details for the respective research question.

[3] "The limits of my language define the limits of my world." (my translation)

[4] This does not imply that players in a model need to have complete information at all times. The requirement to list all potential states of a model only implies complete information on the side of the researcher constructing models.

2.3.3 Value of approach

Even before empirical validation, there is a major value in the development of new models: A new theoretical framework allows avoiding the 'curse of singularity' and guidance of empirical research. In other words, the development of a theory constitutes a first step in the attempt to explain reality. Or as Coase has put it:

> My impression is that [...] quantitative studies are almost invariably guided by a theory and that they may most aptly be described as explorations with the aid of a theory. In almost all cases, the theory exists before the statistical investigation is made and is not derived from the investigation. (Coase 1982, p. 15)

Thus, I feel justified in not attempting to formally validate the models developed in this thesis within the scope of the thesis. However, examples dispersed throughout the text shall lend credibility to the assumptions and the results. To quote Coase again:

> Testable predictions are not all that matters. And realism in our assumptions is needed if our theories are ever to help us understand why the system works in the way it does (Coase 1982, p. 13).

Eventually, the worth of a theory "is to be judged by the precision, scope, and conformity with experience of the predictions it yields. [...] The ultimate goal of a positive science is the development of a 'theory' or 'hypothesis' that yields valid and meaningful [...] predictions about phenomena not yet observed" (Friedman 1953, p. 3, 4, 7).

In summary, this dissertation aims at a better theoretical understanding of interorganizational systems. The formal modeling approach constitutes a step towards a more comprehensive and predictive theory of IOS.

Chapter 3

Introducing a vertical IOS

3.1 Introduction

In this chapter we shall look at the impact of interorganizational systems on the vertical relationship between firms by looking at the introduction of electronic data interchange (EDI) links. In particular we analyze the introduction of EDI links between a manufacturer and suppliers of goods to the manufacturer. The research focuses on the analysis of the relative bargaining power of the provider and user of the system where the system facilitates the exchange of a good. Thus, the goal is to understand not only the introduction of a new technology, but also the constraints imposed by the already existing business relationship between the manufacturer and the suppliers.

Let us set the stage by quoting examples of vertical interorganizational systems from the business press.

- Westinghouse Electric Supply Co. (WESCO) intends to drop suppliers that cannot send invoices and receive purchases orders via EDI. 20 of the 400 leading suppliers of WESCO have EDI links already and receive about 45% of purchasing (Iida 1989, p. 17).

- At Ford an EDI system is part of a plan to cut auto design and manufacturing time from four years to two-and-a-half years. The goal of shortening the product life-cycle so radically implies major changes of internal processes in

addition to the introduction of the interorganizational system (Caldwell, Iida and Von Simson 1988, p. 12).

Similar efforts are made by GM ("The Rise of 'Cooperative Systems" 1987). In Europe GM now requires its suppliers to be capable of doing EDI with GM (Fallon, 1988).

- Levi Strauss and Co. has installed LeviLink with its retailers to speed up processing of orders and to be able to respond quickly to changing consumer tastes. LeviLink goes beyond linking retailers with the apparel manufacturer electronically. In fact, LeviLink is part of an effort to computerize the entire manufacturing and marketing cycle of Levi Strauss. The system's functionality includes inventory management, management and reconciliation of purchase orders, order tracking, processing and payment of invoices, capturing of point-of-sale information, and analysis of market trends. ("The Strategic Value of EDI," 1989)

  Despite the companies tremendous investment Levi Strauss does not charge retailers for linking into the network: retailers only pay for the initial software. This reflects an effort at sponsoring a system towards wider usage. (Sehr 1989)

We are faced with a number of interesting research questions:

- What factors determine a strategy to introduce an EDI system from a manufacturers point of view?
- What are key determinants of a decision to use an EDI system from the suppliers' point of view?
- If a manufacturer introduces an EDI system, what are the effects of the introduction on the relationship with his suppliers?

In this chapter we define a normative model that provides further insight into this set of problems in a context where competing suppliers with different transaction

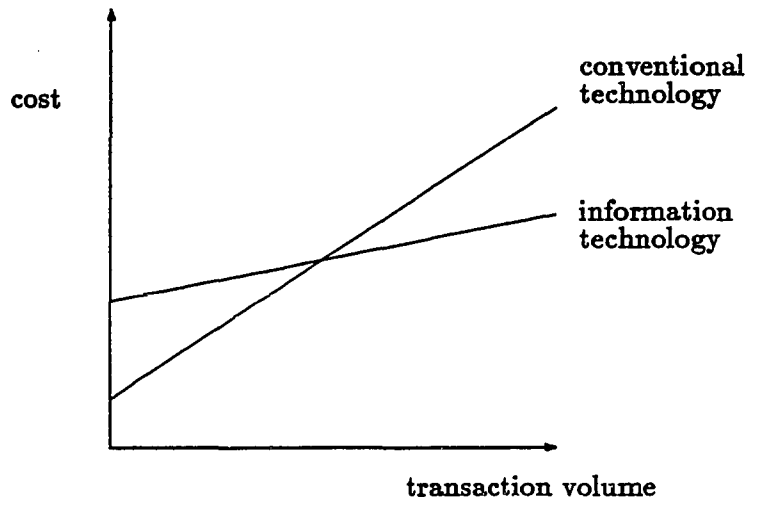


Figure 3.1 Information technology vs. conventional technology

volume provide the same part to a manufacturer. Although this model concentrates on the relationship between a manufacturer (or a retailer) and suppliers, it may also be applied *mutatis mutandis* to a vendor with multiple customers.

3.2 Factors in the introduction of a vertical IOS

In general, information technology can be characterized by large fixed development costs and minimal marginal costs for transmission and processing of each additional unit of information. Figure 3.1 illustrates this tradeoff between 'conventional' and information technology.[1] Conventional technology is supposed to be based on mechanical means of transmission, such as the sending of letters by the post service, in contrast to electronic mail on value-added networks.

As a first step we discuss the impact of this characterization on a vertical IOS. We describe factors that influence the introduction of a vertical IOS, in particular,

[1] adapted from Bakos 1987, p. 74

an EDI-link between a manufacturer and his suppliers. The factors are deduced from an analysis of the returns of manufacturer and suppliers before and after the EDI system introduction.

3.2.1 Efficiency benefits

As an electronic data interchange provides faster and more accurate communication between manufacturer and suppliers, we can expect a number of efficiency benefits: Elimination of paper, postage premiums for fast delivery, and data entry personnel will result in savings on both the manufacturer's and the suppliers' side. It is obvious that a purchase order that is keyed into one computer need not be re-entered into another computer once EDI provides a link between the computers. Thus, EDI helps save labor costs and reduce or eliminate re-keying errors. Additional savings stem from higher accuracy of the electronic communication, which facilitates, for example, reconciliation of payment.

The crucial point for our model is that the direct benefits are proportional to the volume of the transactions between manufacturer and supplier. In other words, a 'big' supplier with thousands of transactions per period gets higher absolute benefits from joining the EDI system than a 'small' supplier with only dozens of orders.

One also has to realize that the time of an electronic transmission is by orders of magnitude less than postal service or even overnight express delivery services.[2] A theoretical result pertaining to efficiency benefits in this context is the conclusion by Bakos (1987) that exchange of information in vertical markets and inventories are economic substitutes: By increasing the response time and capacity of the communication link between a supplier and a manufacturer, inventory costs can be decreased. In fact, the time savings through EDI clearly go beyond lower inventory

[2]In principle, EDI may be implemented by physically exchanging data storage media such as micro floppy disks. However, with communication and transmission technology advancing rapidly we feel that we can ignore this type of EDI implementation for our analysis and concentrate on computer-to-computer linkages.

costs. Silverman (1990) gives the following list of potential benefits that can be derived from the reduction in time for the interchange of information.

- lower inventory costs
- potential for higher prices for 'instant products'
- improved new product flow
- higher product quality through shorter information flow cycles
- increased product variety and improved fit with market needs
- faster information on buying patterns, sales reports, pricing patterns

It is clear that most of these benefits cannot be harnessed by merely introducing EDI with other companies and making the external link more efficient. Major changes in the way a company organizes its internal processes are necessary. Thus, one needs to evaluate EDI in a more strategic context.

3.2.2 Process benefits

We claim that one has to take account of changes in effectiveness due to the EDI system. An increase in effectiveness is due to changes in processes made necessary and possible by the system. We call those benefits 'process benefits'. An EDI system tends to allow process changes within a larger strategic context. The idea is that EDI is an essential part of an effort of automating a company's entire operation. This idea has been described in the *I/S Analyzer*:

> The phrase "EDI changes the way companies do business" is defined as a situation where an incoming electronic purchase order automatically causes changes to order entry systems, sales tracking systems, inventory management systems, manufacturing systems and so forth, throughout the company. In such a system, paper order processing has been

> replaced and all systems are linked together, facilitating the organizational changes that make the company more productive and profitable ("The Strategic Value of EDI" 1989, p. 10).

The concept can be further specified in the context of manufacturing philosophies. Introduction of EDI links with suppliers can support an attempt by a manufacturer to switch to just in time manufacturing. Aiming for the complete elimination of inter-process inventories and better timeliness in response to market demands, just in time manufacturing is driven by the vertical flow of information about demand at each stage of production. The literature on just in time implementations shows that the success of this manufacturing philosophy depends also on short set-up times for machinery (e.g., Hay 1988). The point is that the benefits associated with timely market response and zero-inventories are due to an overall change in manufacturing philosophy and changes in processes by the manufacturer.[3] The overall change requires suppliers to 'fit' into the new manufacturing philosophy. This implies that a manufacturer has a strong interest to have all suppliers use the EDI system. If all suppliers use EDI, organizational provisions for dealing manually with orders can be eliminated. An order processing department and the respective overhead can be largely reduced, for example.

These benefits accrue primarily to the initiator of the IOS. In fact, organizations reacting to an IOS may also harness benefits from changing their internal processes. However, it is safe to assume that there is a lag between the times that process benefits accrue to the initiating and reacting organization. This is justified by the observation that today most suppliers that connect to a manufacturer's EDI system

[3]This assessment of just in time manufacturing does not contradict the above result from Bakos that inventories and the vertical information are substitutes. Bakos' results are based on the assumption that "orders are assumed to be filled immediately, *so the only significant delay in the system is the time it takes the downstream firm to place an order*" (Bakos 1987, p. 78–79). Again, without accompanying reductions in set-up times for machinery it is not possible to obtain the full benefits of a just in time manufacturing system. The efficiency benefits of an IOS alone provide only an incomplete description of the benefits of a demand driven resource allocation which is part of the reason for the introduction of the IOS.

do not yet integrate their respective suppliers via EDI. The assumption is also in line with the observation that it takes time to establish an EDI system, so that a supplier's own attempt at integrating its respective suppliers will lag behind the original EDI system of the manufacturer. In this context it is elucidating to cite the observation by Cash and Konsynski (1985, p. 140) that the order of impacts of an IOS depends on whether an organization is joining an IOS implemented by another company or whether it is the initiator of the system. If an organization reacts to an IOS, internal changes take the following order according to Cash and Konsynski (1985):

1. changes in business process (first-order impact)
2. changes in skills and staff requirements (second-order impact)
3. changes in organization structure and business strategy (third-order impacts)

Because of planning for the introduction, the order of changes is reversed when an organization is the initiator of the IOS.

In our modeling approach in section 3.3 we shall at first simplify the representation of these process benefits by postulating that the manufacturer has a constant benefit increase once all suppliers use EDI. The assumption of constant process benefits does not take account of the option of a manufacturer to keep inventories of a few goods and process the corresponding orders manually. In this case there would still be major savings from reducing the size of the order processing department. However, taking account of economies of scale and the cost of overhead in the order processing department, we contend that a manufacturer's interest in maintaining manual facilities decreases at a growing rate if the number of suppliers using EDI is increasing. Thus, we generalize the representation of the process benefits in section 3.4 by assuming that process benefits are increasing at least proportionally to the number of suppliers on the system.

3.2.3 Characterization of suppliers

An important factor in analyzing the introduction of an IOS is the relative bargaining power of manufacturer and suppliers.

From the suppliers' point of view the bargaining power is reflected in the profits of the suppliers. The more suppliers there are in the market and the higher the total output for a given good, the lower the price the manufacturer has to pay for the good. We assume that each supplier has a nonnegative profit, $\Pi_{old} \geq 0$, before the introduction of the EDI system.[4] Thus, we do not adopt the model of pure competition among suppliers.

From the manufacturer's point of view the suppliers can be characterized by the size of substitution costs, that the manufacturer has to bear, if he wants to replace a supplier. This characterization of the suppliers from the manufacturer's point of view is based on the following reasoning: Visualize the suppliers to be distributed over a sphere. The manufacturer shall also be denoted by a fixed point on the surface of the sphere. Let all points, i.e., suppliers and manufacturer, on the sphere be evenly distributed. Now the distance between two points can be used as a model for the costs of substituting one supplier with another. The further apart the suppliers the more costs arise for the manufacturer from switching to another supplier. It follows that the cost of substituting a supplier decreases with the number of suppliers in the market, as the density of suppliers per surface segment decreases with the number of suppliers. Using a finite surface, such as the sphere, implies that there is a limit to the cost of substitution. In fact, this reasoning implies that the cost of substitution is limited by half the circumference of the sphere, as a monopolist supplier will be situated right opposite the manufacturer on the sphere due to the even distribution constraint on all points on the sphere. This theoretical limit makes sense in reality, as there always is the option for a manufacturer to internalize a supplier.

[4]We assume that suppliers employ general and not specific capital.

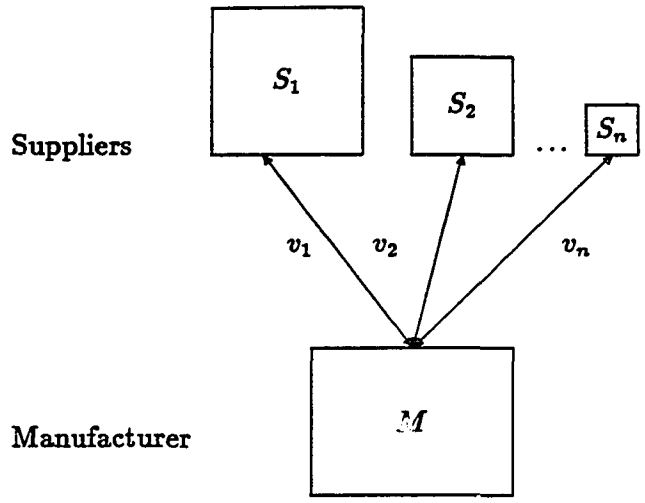


Figure 3.2 The players

At this point it has to be emphasized that an IOS is only a means for facilitating trade. One has to incorporate the notion that the exchange between manufacturer and supplier is not only an information exchange (orders and receipts), but first of all aims at providing parts, raw materials and other resources to the manufacturer. The suppliers' products constitute what we call the 'primary' products.[5]

3.3 The model

The model features one manufacturer and a set of suppliers with different transaction volumes as illustrated in figure 3.2. We assume that all suppliers supply the same part. Commodity-like parts, such as memory chips for computer manufacturers, constitute examples for this setting. The manufacturer has n suppliers, S_i, of transaction volume v_i.

[5]Note that an IOS can turn from a means to facilitate the trade of a primary product to a product itself when a manufacturer and provider of an IOS makes the system available for commercial use. In our terminology the IOS then is the 'secondary' product of the manufacturer-system provider. An example is the move by Sears to make its proprietary EDI system commercially available (Ryan 1989, p. 12).

3.3.1 The manufacturer's perspective

The efficiency benefits for the manufacturer from having supplier S_i on the system, $B_{eff,m}(v_i)$, increase with the transaction volume. The subscript m is used to denote the manufacturer while the subscript s denotes the supplier. Thus,

$$B_{eff,m}(v_i) > B_{eff,m}(v_j) \; \forall \; v_i > v_j. \tag{3.1}$$

The model also incorporates constant process benefits, $B_{process,m}$, for the manufacturer. The set-up cost for the system, C_m, is assumed to be a constant for the manufacturer reflecting the investment for software and hardware that is largely independent of the number of users. By also incorporating the process benefits, $B_{process,m}$, we get the net return of the system to the manufacturer when all suppliers join the system:

$$D_m = \sum_{i=1}^{n} B_{eff,m}(v_i) + B_{process,m} - C_m \tag{3.2}$$

If only a subset of the suppliers joins the system the manufacturer's benefits do not contain the process benefits any more according to our definition of process benefits:

$$D'_m = \sum_{i \in \{k | S_k \text{ on system}\}} B_{eff,m}(v_i) - C_m \tag{3.3}$$

3.3.2 The suppliers' perspective

Similar to the manufacturer, the suppliers have to face constant set-up costs C_s and efficiency benefits proportional to the transaction volume $B_{eff,s}(v_i)$. We make the simplifying assumption that C_s is the same for all suppliers. Although the set-up costs for hardware and software[6] increase with communication needs, it has to be realized that hardware and software components constitute only a part of the set-up

[6]Software pricing is sometimes tiered, with licenses becoming more expensive with CPU-size. One also has to take account of the implementation costs that rise with the size of the installation.

costs. An important factor is the internal adjustment and development necessary for establishing an IOS. These transaction volume independent adjustments include learning costs and possible changes to internal data structures, e.g., article numbering systems. We argue that these adjustment and development costs sufficiently dominate the hardware and software costs to justify our simplifying assumption of neglecting capacity-based set-up costs.

We further assume in the model that there are no process benefits available to the suppliers. This reflects our discussion in section 3.2.2 where we emphasized that the initiator of the IOS is the first to harness process benefits. Thus, the decision of the supplier regarding the manufacturer's EDI system tends not to be able to take account of future potential process benefits. In section 3.4 we discuss the situation if manufacturer and suppliers can harness process benefits simultaneously. Finally, let Π_{old} denote supplier S_i's profit from trading with the manufacturer before the introduction of the IOS. For now we ignore effects of economies of scale on Π_{old} that would result in different profits for different suppliers. In fact, it is hard to describe such effects since suppliers may supply the same part to different manufacturers. In section 3.5 we discuss uncertainty by the manufacturer on Π_{old} and its effect in the basic model as one way to make the model more realistic.

Figure 3.3 illustrates a suppliers' returns after joining the IOS. Note the dependence of the returns on transaction volume: For 'small' suppliers the efficiency benefits do not make up for the set-up costs, while 'big' suppliers can compensate the set-up costs. Thus, the model implies that the inclination of a supplier to join the system increases with the supplier's transaction volume with the manufacturer. In other words, the return function of suppliers is monotonicly increasing in the transaction volume. Linearity of the return function of suppliers is not necessary for our analysis. These assumptions align clearly with figure 3.1.

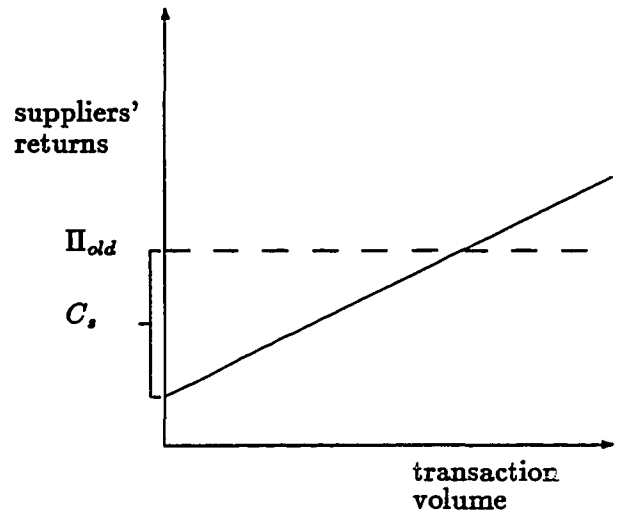


Figure 3.3 Effect of EDI system on suppliers' returns

3.3.3 The players' decision rules

In order to define the decision rule of suppliers we have to look not only at the suppliers' benefits and cost of the system but also at the returns related to the suppliers' primary trading relationship with the manufacturer.

Supplier's decision rule

- First, every supplier S_i with $B_{eff,s}(v_i) > C_s$ will join the system, as S_i increases his absolute returns by joining the system.
- Second, a supplier S_i with $B_{eff,s}(v_i) \leq C_s$ may join the system if the manufacturer makes a credible threat to substitute the supplier with a supplier willing to join the system. The definition of a credible threat is given below. In case of such a credible threat, supplier S_i will join the system, if $\Pi_{old} + B_{eff,s}(v_i) - C_s > 0$, i.e., if the decision to join the system does not make the complete business relationship with the manufacturer unprofitable.

We now order the suppliers according to their transaction volume, starting with the biggest supplier, and depict the cumulative efficiency benefits of the manufacturer

depending on the number of suppliers on the system. Given the ordering of the suppliers and the assumptions on the proportionality to transaction volume, the function $E(j) = \sum_{i=1}^{j} B_{eff,s}(v_i)$ is monotonically increasing in j at a decreasing rate for $j \in \{1...n\}$. This reflects the importance of bigger suppliers.

Let k denote the 'break-even' for suppliers in the sense that the efficiency benefits derived from the system compensate the set-up costs, i.e., let k denote the smallest supplier that joins the system according to the first case in the supplier decision rule. Thus, S_k is the smallest supplier that does not decrease his return by joining the system.

$$k = \max\{i \mid B_{eff,s}(i) > C_s\} \tag{3.4}$$

If the set in definition 3.4 is empty, let $k = 0$. It should be noted that in order to find the smallest supplier in the set in equation 3.4, one has to maximize due to the ordering of suppliers that starts with the biggest suppliers.

Similarly, let $S_{k'}$ denote the smallest supplier that still gets a positive return from the trading relationship with the manufacturer.

$$k' = \max\{i \mid \Pi_{old} + B_{eff,s}(i) > C_s\} \tag{3.5}$$

If the set in definition 3.5 is empty, let $k' = 0$.

Figure 3.4 illustrates the model so far. For graphic simplicity we shall draw discontinuous functions as continuous functions in the illustrations.

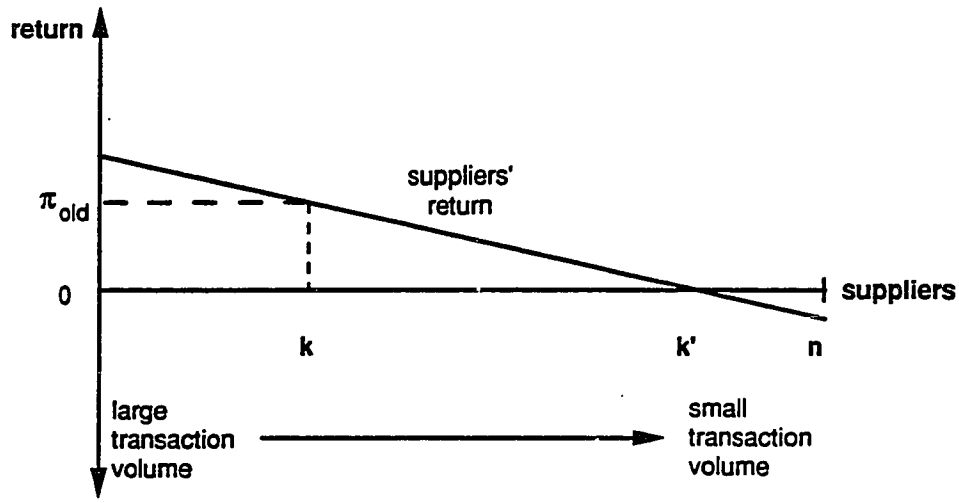


Figure 3.4 Illustration of definition of k

We now define what constitutes a credible threat by the manufacturer to substitute a supplier who is reluctant to join the system because joining would lead to a reduced return for the supplier. The credibility of a threat clearly depends on the decision rule of the manufacturer. In order to define a first version of this decision rule, let us start with the idea that a threat is credible if the manufacturer could substitute the reluctant supplier S_i rather than not harness the process benefits which depend on all suppliers being on the system. Thus, the credibility of the threat to S_i depends not only on the cost of substituting S_i, but also on the added cost of substituting $S_{i+1}, ..., S_n$, as suppliers smaller than S_i will be even less inclined to join the system according to the first part of the supplier decision rule. In a first version, the decision rule of the manufacturer is the following:

Manufacturer's decision rule (1. version)

- Assuming that suppliers $S_1, ..., S_{i-1}$ will join the system, the manufacturer will threaten and possibly substitute supplier S_i if the cumulated costs of substituting suppliers $S_i, ..., S_n$ are less than the process benefits and the cumulated efficiency benefits of having the transaction volume of those suppliers on the system.

Working 'backwards' from small suppliers to bigger suppliers, let l denote the first point, where the manufacturer cannot increase his return any more by threatening and possibly substituting reluctant suppliers, given the assumption that suppliers $S_1, ..., S_l$ will join the system. Let U_m denote the manufacturer's cost of substituting one supplier who refuses to join the EDI system with a supplier willing to adopt the system. Formally:

$$l = \max\{i \mid \sum_{j=i}^{n} B_{eff,m}(j) + B_{proc,m} < (n-i) * U_m\} \tag{3.6}$$

If there the set in equation 3.6 is empty, then let $l = 0$. Figure 3.5 illustrates the computation of l in the case of continuous functions. The maximization in the definition of l gives us a unique result if there are two intersections, as can also be seen from Figure 3.5. If there is only one intersection, the result is obviously unique. If there is no intersection between the cumulated substitution costs and the cumulated benefits of the manufacturer, all suppliers may be threatened. As the slope of the function of the cumulated substitution costs is determined by the the substitution costs in the given environment, it is important to analyze changes in the size of the substitution costs in the discussion of the model.

Let λ, μ and ν denote the intervals $(0, k], (k, l]$ and $(l, n]$ provided that $k < l$. The basic model can then be summarized graphically as in figure 3.6. An intuitive characterization of the intervals λ and ν can now be given immediately. Interval ν is described in the next section.

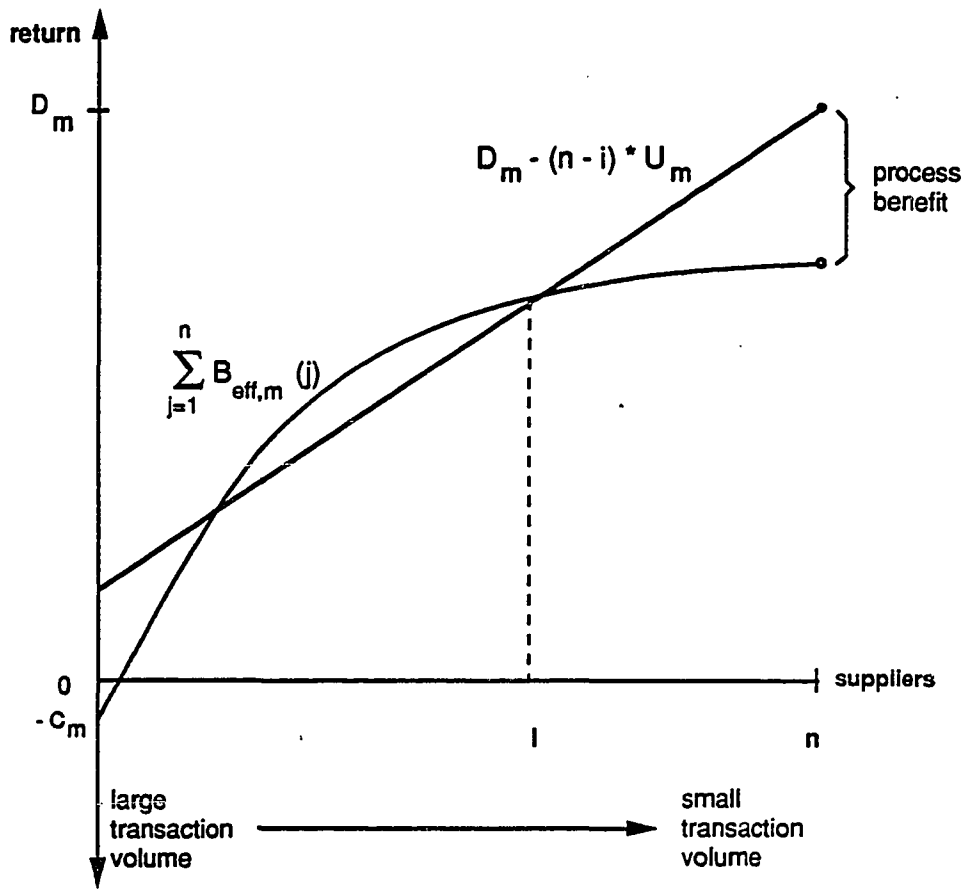


Figure 3.5 Definition of l

- Any suppliers with enough transaction volume with the manufacturer to be in the interval λ will eagerly support the EDI system, as it increases their returns. The first case of the supplier's decision rule applies.

- Suppliers in the interval ν are subject to credible threats of the manufacturer if the system already has got suppliers $S_1 ... S_l$ connected. If the aim of the introduction of an IOS is to have all suppliers on it, then having suppliers $S_1, ..., S_l$ join the system guarantees success in the model, as all remaining suppliers

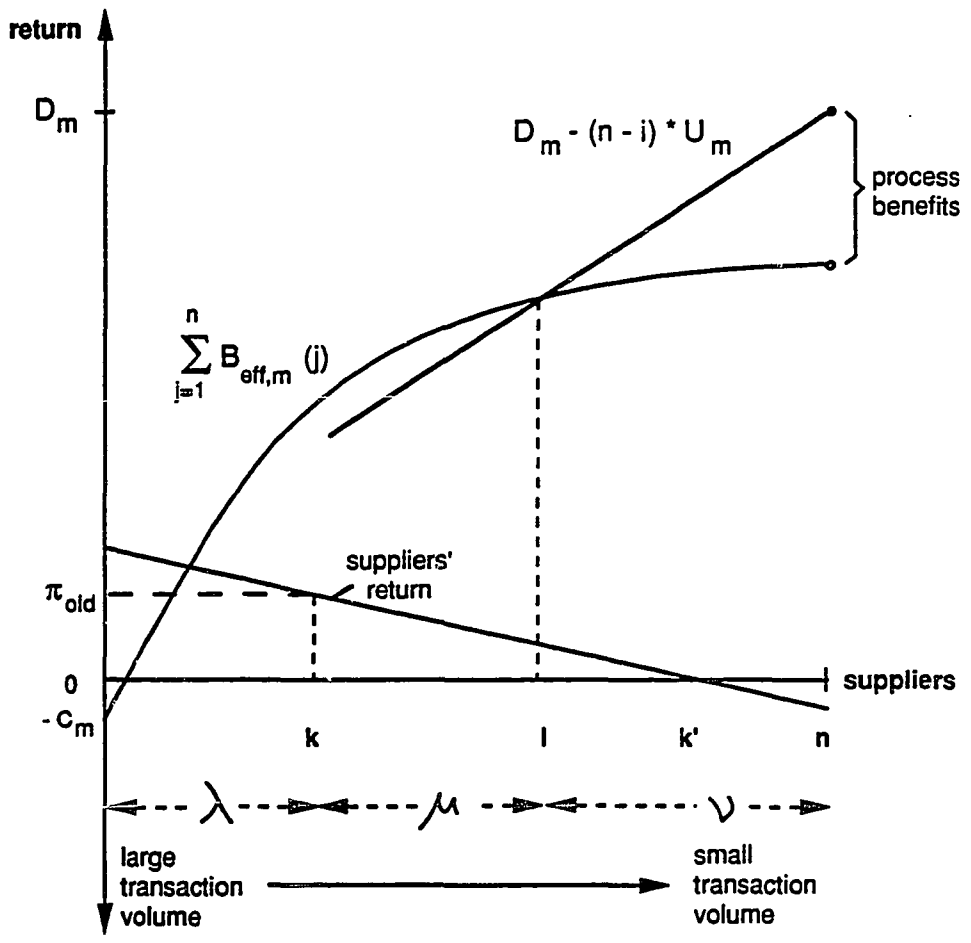


Figure 3.6 Summary of the model

will either succumb to the threat or will be substituted with a positive return to the manufacturer.[7]

3.3.4 Sponsoring of the system by the manufacturer

So far we have not discussed the implications of $k < l$, i.e., the case of suppliers in the interval μ. As none of the two cases of the supplier's decision rule applies to suppliers in interval μ, those suppliers will choose not to join the system. Thus, the model can only predict success of the introduction of an EDI system, if $k \geq l$. The goal of the manufacturer is to have $k \geq l$, as the manufacturer's threats can only be carried out successfully, if suppliers $S_1, ..., S_l$ have joined the system voluntarily. We shall now expand the scope of the model by discussing the option for the manufacturer to sponsor the system in case of $k < l$. Sponsoring aims at increasing the benefits of the users of the system. We look at two ways to sponsor the system:

1. Sharing with the suppliers their set-up costs
2. Passing on higher efficiency benefits through appropriate pricing schemes for the use of the system. This move increases the efficiency benefits of the suppliers that can be considered as aggregate functions of the gross benefits minus the price charged for variable use.

Decreasing the set-up costs for the suppliers results in the addition of a constant to the supplier's return function. Let $\overline{k_1}$ and $\overline{k_1'}$ be the results of equations 3.4 and 3.5 for a decreased set-up cost, $\overline{C_s}$, ($\overline{C_s} < C_s$). Then there exists a constant $a \geq 0$ such that $\overline{k_1} = k + a$ and $\overline{k_1'} = k' + a$.

Increasing the efficiency benefits for the suppliers leads to a steeper slope of the return function. In this case, there exist constants $a, b \geq 0$ with $a \geq b$, such that $\overline{k_2} = k + a$ and $\overline{k_2'} = k' + b$.

[7]In fact, one can interpret l as a quantifiable measure for the idea of 'critical mass' in a vertical market of suppliers. Suppliers $S_1, ..., S_l$ have to join the system before the system introduction has so much momentum that the manufacturer gets a positive return from threats and/or substitution that lead to all transactions being done electronically eventually.

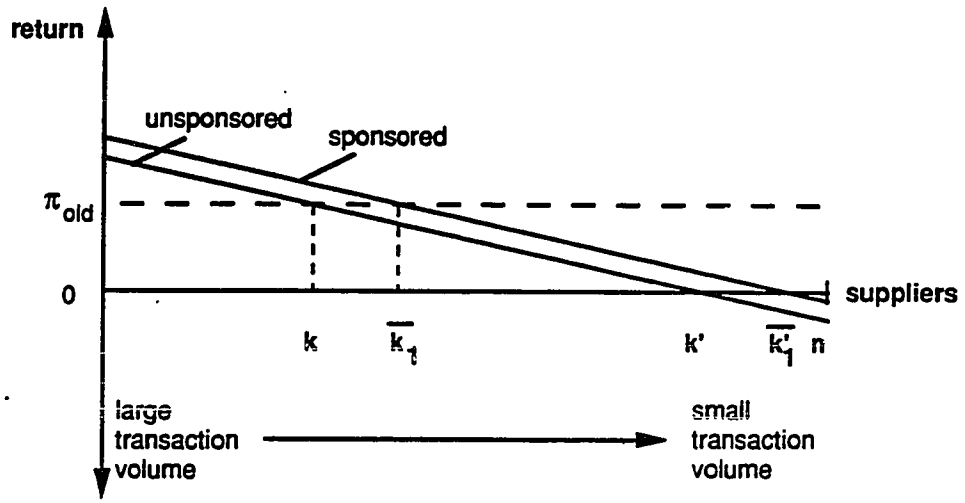


Figure 3.7 Decreasing a supplier's set-up cost

These results are illustrated in figures 3.7 and 3.8. Thus, a manufacturer who is interested mainly in big suppliers joining the system will prefer the second type of sponsoring, while a manufacturer who wants to keep the small suppliers may consider the first type more effective. With this in mind, we shall in the following extension to the manufacturer's decision rule confine ourselves to a generic option of sponsoring, which will result in an increase in k and k'.[8] Not surprisingly, one should expect sponsoring to be more likely to occur in environments that are characterized by high substitution costs of suppliers.

This reasoning is incorporated into our model by defining a second version of the manufacturer's decision rule.

Manufacturer's decision rule (2. version)

- If $k < l$, then the manufacturer sponsors the system, so that $\overline{k} \geq l$.
- Suppliers in ν are threatened and possibly substituted.

[8]At this point we leave it to later analysis to determine the optimal amount of sponsoring. This is not necessarily the amount needed to reach $\overline{k} = l$, as it may be better for the manufacturer to incur additional sponsoring costs than substitution costs.

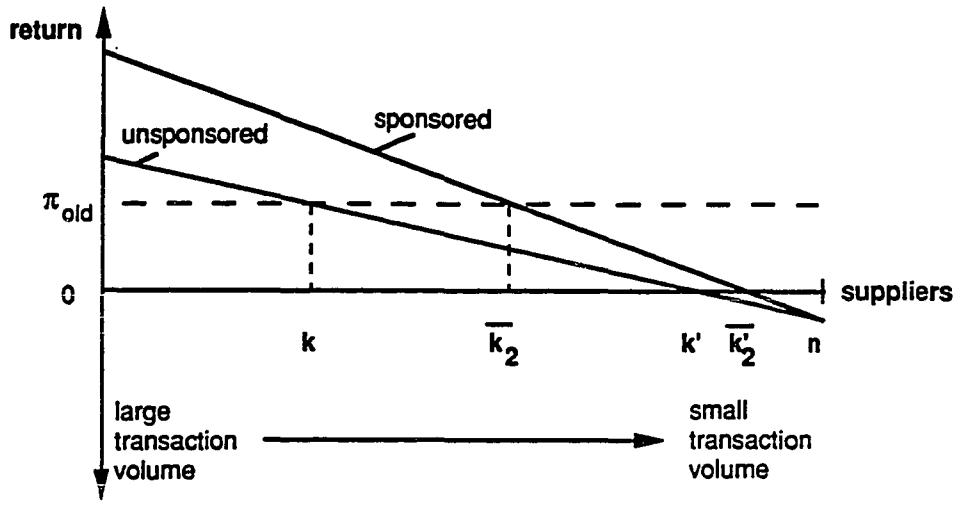


Figure 3.8 Increasing a supplier's efficiency benefits

3.4 Discussion of the model

Let us first analyze the impact of environmental characteristics on the number of suppliers subject to credible threats by the manufacturer, i.e., we need to investigate changes in l. As explained in section 3.2.3, different environments are characterized by different substitution costs, denoted in the following by U_m, of dropping a supplier without EDI and finding substitute suppliers with EDI capability. Let U_m and U'_m with $U_m < U'_m$ denote the substitution costs for two supplier environments.

Proposition 1 *Let l and l' denote the results of equation 3.6 for U_m and U'_m.*

i) If $U_m < U'_m$, then $l \geq l'$.

ii) If in addition $l > 0$, then $l > l'$.

Proof: An increase in substitution costs, U_m, implies a steeper slope of the function $U_m * (n - i)$. If there is an intersection between the cumulated substitution costs and the cumulated benefits starting at supplier n, then it immediately follows

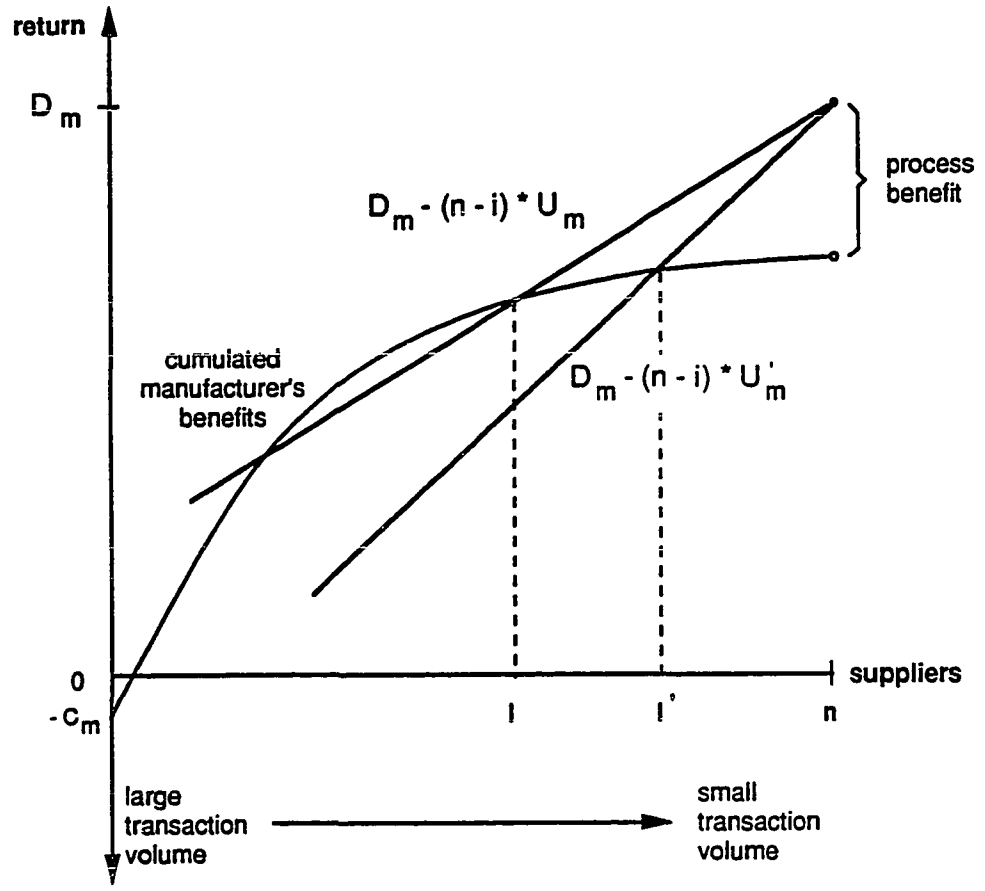


Figure 3.9 Effect of increase in substitution costs given constant process benefits

that $l > l'$ giving us the second part of proposition 1. If there is no intersection for l, i.e., $l = 0$ according to the definition of l, then there will be no intersection for l' either. Thus, $l = l'$, which completes the proof. Figure 3.9 illustrates the reasoning. q.e.d.

Three notes are appropriate with regard to our assumptions.

- The existence of process benefits is crucial to the formulation of proposition 1. To illustrate this point let us assume that the manufacturer introduces the IOS solely for efficiency increases and he does not expect any process benefits.

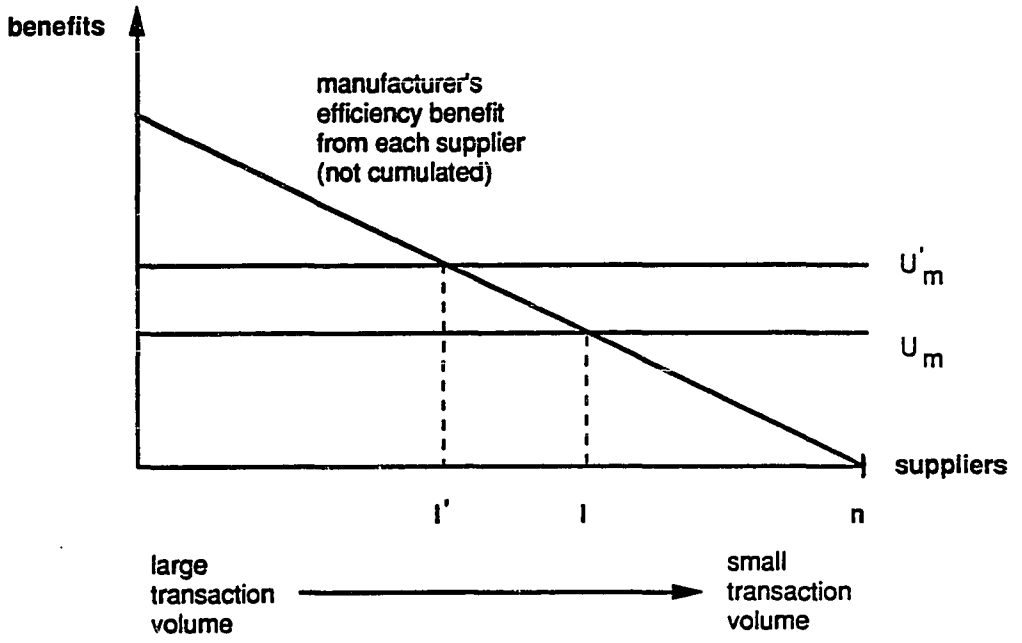


Figure 3.10 Effect of increase in substitution costs in case of no process benefits

In this case, the decision to substitute a supplier unwilling to join the system becomes purely a marginal phenomenon, i.e., we must look at the uncumulated benefit function of the manufacturer: A reluctant supplier can only be threatened if the manufacturer's efficiency benefits from this supplier's transaction volume are greater than the costs of substituting the reluctant supplier with an EDI-supplier. Again, with increasing substitution costs there are less suppliers that the manufacturer can threaten to substitute with a positive return. However, in contrast to the model with process benefits, smaller suppliers are here at an advantage. Figure 3.10 illustrates this reasoning and the effect of an increase in substitution costs.

In summary, the process benefits exert an externality on the smaller suppliers to join the system. The externality decreases with increases in substitution costs.

- We now review our assumption of constant process benefits that accrue to the manufacturer once all suppliers have joined the system either voluntarily or have been substituted with EDI-suppliers. In fact, one can argue that this is too stringent an assumption in that a manufacturer can realize part of his process benefits already before all suppliers have joined the system. A more general notion is that process benefits are increasing at least at a constant rate with the suppliers on the system. Adding such a more general process benefit function and the efficiency benefit function leads to a function with a saddle point, i.e., the function grows monotonically at a decreasing rate until the saddle point and continues to grow monotonically at an increasing rate from then on. Figure 3.11 depicts such a composite, cumulated benefit function for the manufacturer. The existence of a saddle point is sufficient for the proof of proposition 1 as is also illustrated in figure 3.11.

- Finally, we look at a situation where a manufacturer and his suppliers can harness process benefits simultaneously. In this situation threats of the manufacturer may not be necessary for the success of the system. Clearly, the introduction of an EDI system becomes easy, if all participants benefit from the introduction. However, without active support of the manufacturer aiming at process benefits of the suppliers, the goal of simultaneous process benefits by manufacturer and suppliers is unlikely, as we have argued in section 3.2.2. Early process benefits of suppliers are more likely to be achieved if a supplier sells only to one manufacturer. In such a tight manufacturer-supplier relationship the manufacturer is more inclined to help a supplier with implementation and the supplier is more interested in adapting to the changed environment by changing internal processes.

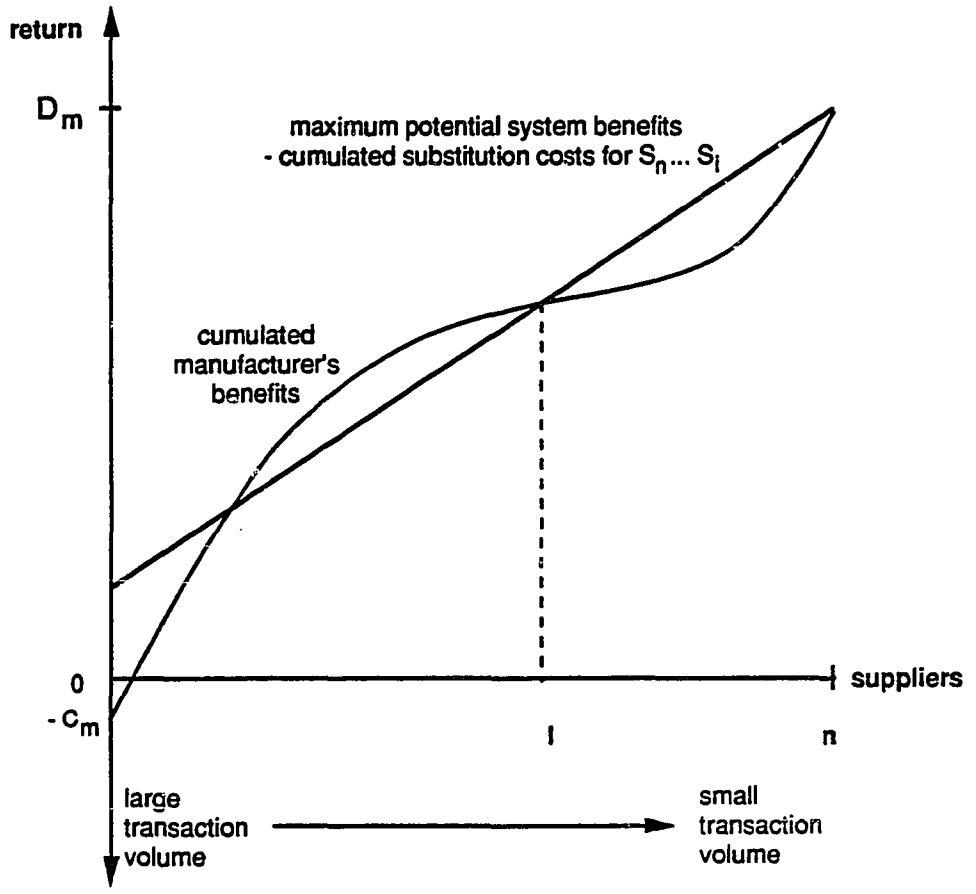


Figure 3.11 A more general process benefit function

3.5 Practical use of the model

If a manufacturer wants to use the model as the basis for an introduction strategy, he has to collect data on a number of parameters.

- As initiator of the system the manufacturer can determine the efficiency and process benefits and the set-up costs for all participants.
- The substitution costs for suppliers may be determined from previous substitutions provided these are not too limited or outdated.

- However, the manufacturer will usually not know the exact profit, Π_{old}, of the suppliers from the primary business activity.

The uncertainty on the manufacturer's part regarding the supplier's return from the trading relationship reflects the basic uncertainty with regard to the bargaining power of the supplier, as the old profit is a direct consequence of this bargaining power. In the model the effect of a higher or lower Π_{old} is the same as the effect of more or less sponsoring. Uncertainty on Π_{old} translates directly into uncertainty on k. Thus, with increasing uncertainty regarding Π_{old} the manufacturer will have to increase his sponsoring, if he wants to guarantee success of the system.

Another way to guarantee success of the system is through selective sponsoring. For example, price-discrimination in the form of non-linear pricing schemes could be used effectively by a manufacturer. The model provides an approach to simulate the effects of various schemes of selective sponsoring. However, antitrust considerations, such as the Robinson-Patman Act, may set limits to this approach in reality.

In general, the model can provide the basis for a sensitivity analysis in so far as different parameter settings lead to different sizes of the intervals λ, ν and μ. The manufacturer can then deduce the expected cost of sponsoring.

The model also contains a normative aspect regarding the introduction strategy. In order to harness the externality that forces suppliers in ν to join the system, it is essential that a critical mass of suppliers be reached first. Thus, an implementation should be phased accordingly:

- The first phase aims at getting suppliers $S_1,..,S_l$ to join the system. If the model shows k to be smaller than l, then appropriate sponsoring of the system is necessary.

- In the second phase the system becomes a 'must' for doing business with the manufacturer. Once the system has achieved critical mass it has achieved enough momentum to threaten smaller users into joining. This prediction is

in line with observations of EDI systems that turn from an optional into a standard way of communication between suppliers and manufacturers.

3.6 Conclusion

Our model with its focus on transaction volume and process benefits provides a framework to analyze the introduction of vertical IOS. The model is normative in helping a systems initiator to better understand the underlying economics of a new EDI system. Although the model is aimed specifically at EDI systems between manufacturer and suppliers, its conclusions can be easily adapted to the case of a retailer with multiple independent outlets where the retailer introduces the EDI system. Process benefits may then take the form of better market information and planning data based on current data on inventory and demand.

Future research may look at changes in the competitive structure of the suppliers' market. As the transaction volume dependent benefits favor bigger suppliers over smaller suppliers in terms of transaction volume in joining the system, a number of small suppliers, that do not want to join the system, might be substituted with one big supplier that can "afford" the system. This reasoning suggests that a consolidation process among suppliers associated with the introduction of an EDI system might be observed. For the analysis of this consolidation process it is important to realize that gains from consolidation may be partially offset by higher organizational costs that result from the consolidation process.

Finally, one may extend the perspective of analysis by looking at a more general setting where suppliers serve more than one manufacturer. In this case the question of standards among the EDI systems assumes importance, as suppliers will try to avoid having to maintain multiple data formats internally. This research opportunity is discussed in more detail in the context of business opportunities for third-party providers in section 7.2.2.

Chapter 4

The economics of switching costs of IOS

4.1 Introduction

This chapter concentrates on interorganizational systems that have been established in a market. Most of the previous research that can be applied to IOS has focused on issues of technology adoption. In particular, Katz and Shapiro take the technology provider's perspective, while Farrell and Saloner analyze the introduction of a new technology with network externalities from the users' point of view. Little is known about the competition among already established IOS. This issue, however, needs further attention, as, in contrast to the predictions of most models of technology diffusion and innovation adoption, we tend to find multiple competing IOS with even differing functionality in a number of industries.

More specifically, many questions about the economics of competing IOS remain open for investigation:

- Given increasing benefits to a user of a system as the total number of users on the system increases, why do we find multiple IOS existing in a single industry?

- How do switching costs embedded in an IOS affect the behavior of users of the system? Do such costs represent a competitive advantage to the provider of the IOS?

- What competitive moves does an IOS make available to a provider of the system and how should a firm respond to such moves by a competitor?

In this and the following chapter we address the above questions by developing an economic model of competing IOS and investigating the effects of network externalities in conjunction with switching costs on the behavior of firms in an industry.

In section 4.2 we begin by describing benefits and costs for system providers and users. We then introduce a basic model of the behavior of users of the IOS. The model, based upon concepts from industrial organization theory, characterizes a market with two competing IOS in which all customers use one of the systems. The market is assumed initially to be limited, i.e., there are no new users entering the market. The model is extended to incorporate switching costs. We show that switching costs induced by IOS can produce a stable, segmented market with multiple, competing system providers despite the fact that every user would be better off in an unsegmented market.

In section 4.3, we investigate competitive moves by the providers of the IOS. Four generic types of competitive moves are discussed: increasing benefits of the system to the users, decreasing user benefits, increasing switching costs away from their own system, and decreasing switching costs to their own system. In order to describe the effects of these competitive moves we introduce a formal notion of a 'competitive position' of a system provider.

The chapter ends with a number of extensions to the basic model that relax the initial limiting assumptions. Section 4.4 describes how the modeling approach can be applied to more than two competing IOS. While the basic model assumes uniform users, an extension of the model to nonhomogeneous users is introduced in section 4.5. Finally, new users are incorporated into the analysis in section 4.6.

While we look only at competitive moves by one system provider in this chapter, chapter 5 extends the analysis to moves and countermoves.

4.2 A model of IOS in a limited market

4.2.1 Benefits and costs for system providers and users

IOS are used in the financial, retail, wholesale, and airline sectors, to name just a few examples. In order to come up with a widely applicable model that is not specific to only one industry, we start analyzing the types of benefits and costs associated with a generic IOS.

The IOS provider expects to reap essentially two types of benefits: efficiency benefits and the possibility of locking in users. Efficiency benefits include operational benefits resulting from electronic order processing which are independent of the size of the IOS. Benefits may depend on the size of the IOS, such as better planning possibilities based on representative market information and economies of scale. Customers are locked in through start-up and learning costs that result in asset specificity in terms of transaction cost theory. The cost function for the provider includes the start-up costs, e.g., technology dependent fixed costs, and order processing costs that tend to be variable costs per order.

As with the providers, the benefits for the users are twofold. Electronic order processing produces efficiency benefits, such as reduced inventories and reduced paperwork. Bakos (1987) used information theory to prove that the exchange of information and the holding of inventories can be seen as substitute means for coordinating activities between organizations. Hospital purchasing terminals, that link hospitals to one supplier, such as the system offered by American Hospital Supply, are good examples. In addition to inventory reductions and elimination of paperwork, an IOS can provide valuable feedback on the user's purchases.[1] These benefits are independent of IOS size. Additional benefits based on the dissemination of market information are contingent on the total number of users on the system. These benefits constitute positive consumption externalities which are also referred

[1] In combination with POS capabilities (see section 2.1) an IOS can also provide feedback on the user's sales.

to as network externalities (Katz and Shapiro 1985). Network externalities can be direct or indirect. Direct network externalities indicate that the benefits to users of the network are directly proportional to the number of users on the network. For example, the more users there are on an electronic mail network, the higher the benefits from using electronic mail for communication. Indirect network externalities arise if more than one type of users use the network and an increase in one group entails higher benefits for another group. An example is the interdependence between hardware and software in the computer industry. As more hardware units of a given type are sold, it becomes more attractive for software developers to develop software for this type of hardware. Conversely, sales of a certain type of hardware will depend on the availability of software for that hardware. The cost function of the user includes start-up costs, in particular, costs of terminal equipment and software and costs of learning to use the system, and variable order-processing costs. It is important to note that proprietary inventory management software and discount systems by the IOS providers are used to further sole-source supply, as exemplified again by the case of hospital supply systems (Cash, et al. 1988). This may lead to additional costs for the user.

Figure 4.1 summarizes the characteristic attributes of an interorganizational system.

4.2.2 A basic model: the users' perspective

We begin by modeling an environment consisting of two competing IOS, owned by two separate providers, and a limited market with no growth through new users. At some point in time, users are given the option of remaining with their current IOS or switching to the competing system. Thus, we are looking at markets with two established IOS. Currently such markets exist in industries where the vast majority of the firms are using some IOS, an example being the travel industry with airline reservation systems.

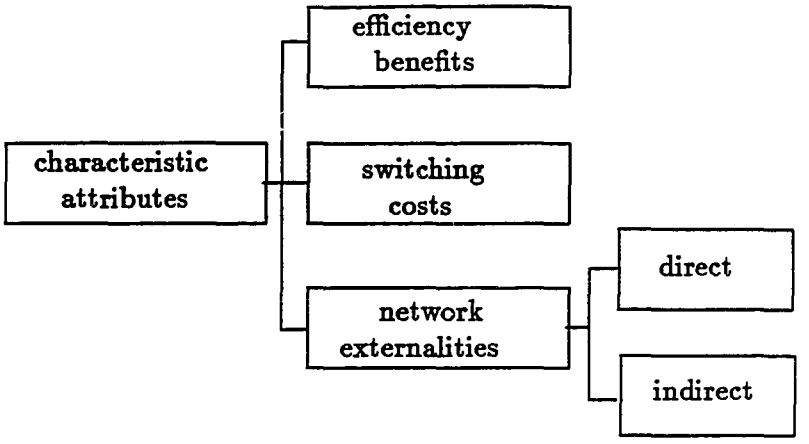


Figure 4.1 Characteristic attributes of an interorganizational system

Formally, we denote the two interorganizational systems by S_1 and S_2. We assume that all users use either system S_1 or S_2. Let $n_{i,p}$ denote the number of users on IOS S_i in a market segmentation p. Then a market segmentation p is defined by $p = (n_1, n_2)$. For notational convenience we will drop the subscript p whenever there is no ambiguity. We also assume that no new users enter the market. Let n be the constant number of users in the market. Then our assumptions about a segmented and limited market require $n_{1,p} + n_{2,p} = n$ for all p. Finally, we assume that all users are homogeneous and arbitrarily small cannot unilaterally change the market.

Given homogeneous users and the existence of network externalities, we can define a user utility function for each IOS as follows: Let b_i, $i = 1, 2$, be the utility functions; each b_i is strictly monotonically increasing in n_i. Utility functions are assumed to be continuous in the number of users of a system. As examples for the benefit functions b_i one may take the following linear functions: $b_i(n_i) := s_i + r_i * n_i$, $r_i > 0$ with s_i standing for the IOS benefits that are independent of size and $r_i * n_i$ denoting the size dependent benefits to the user.

Now consider the following two-stage, static game: In the first period, an initial market segmentation for the two systems exists and the users evaluate the

relative benefits of using each system in this segmentation. In the second period, the users are given a choice of staying with their old system or switching to the other IOS. Assuming that the possibility of collusion does not exist, users individually make comparisons of the relative utility of using each system. Users are assumed to have complete information on the relative utility of each system in the initial segmentation. At first, switching costs between systems are neglected.

Proposition 2 *There is at most one segmentation where the networks produce the same utility for each user.*

Proof: There are three cases to be considered. If $b_1(n_{1,p}) > b_2(n_{2,p})$ or if $b_2(n_{2,p}) > b_1(n_{1,p})$ for all p, we have the cases of one system dominating the other; thus, no segmentation exists where the utilities are equal. In the third case there has to exist p and $\overline{p}$ such that $b_1(n_{1,p}) \leq b_2(n_{2,p})$ and $b_2(n_{2,\overline{p}}) \leq b_1(n_{1,\overline{p}})$. Because of the continuous nature of the utility functions there has to exist a segmentation p' such that $b_1(n_{1,p'}) = b_2(n_{2,p'})$. The uniqueness of this segmentation follows immediately from the strict monotonicity of the utility functions. Note that if $b_1(n_{1,p})$ is strictly monotonically increasing in $n_{1,p}$ then $b_2(n_{2,p}) = b_2(n - n_{1,p})$ is strictly monotonically decreasing in $n_{1,p}$. q.e.d.

In the following we will only consider the nontrivial case where a segmentation exists in which the networks produce the same utility for each user, i.e., one IOS does not completely dominate the other.

Proposition 3 *In the absence of switching cost, there are three Nash equilibria, of which one has a negligible probability of occurring.*

Proof: At the segmentation p' where $b_1(n_{1,p'}) = b_2(n_{2,p'})$, no switching occurs. Because users are assumed to be arbitrarily small, this equilibrium has a negligible probability. All segmentations except for p' are characterized by a difference in benefits for the users of different systems. The homogeneity of users will lead all

those with the lower benefits to switch to the system offering higher benefits. We denote the outcome of these two equilibria by the segmentations p_1 and p_2 where $(n_{1,p_1}, n_{2,p_1}) = (n, 0)$ and $(n_{1,p_2}, n_{2,p_2}) = (0, n)$ respectively. q.e.d.

While both equilibria lead to the adoption of a single system, unless the two systems have identical utility functions, one outcome will Pareto dominate the other: All the users will be better off choosing the system with the highest benefits in an unsegmented market.

It has to be noted that equilibria that are not Pareto optimal are quite likely, as the users' decision to switch depends only on 'local' values of the benefit functions at the current segmentation, not on the global shape of the benefit functions. Even in the case of linear benefit functions and p' as current segmentation, this gives no indication as to the value of the benefit functions when all users are on one system, as p' does not need to be the 'middle' segmentation with the same number of users on both systems.

Although Katz and Shapiro (1986b) assume that users will choose the Pareto optimal system without explicit coordination, such a strategy involves risk taking on the part of some users. To illustrate this point, let S_1 be the system corresponding to the nonoptimal outcome. If, in the initial segmentation, the users of system S_1 have higher benefits than the users of system S_2, then these users will lower their utility by unilaterally switching. Their utility will rise only if a large portion of similar users switch. We think it unreasonable to assume that users would take such risks. Thus, unless some mechanism exists for reducing this risk, such as explicit coordination, users will make individual decisions, which will be either of the two equilibria in the above proposition.[2]

[2]In this context one may think about conditional contracts as another means of reducing risk. A conditional contract triggers switching of users only in case of a certain numbers of users willing to switch. From the provider's point of view such a contract would make it possible to offer certain benefits to users dependent on a large contingent of users switching to his system. From the users' point of view the potential dilemma between individual switching and switching as a group is avoided.

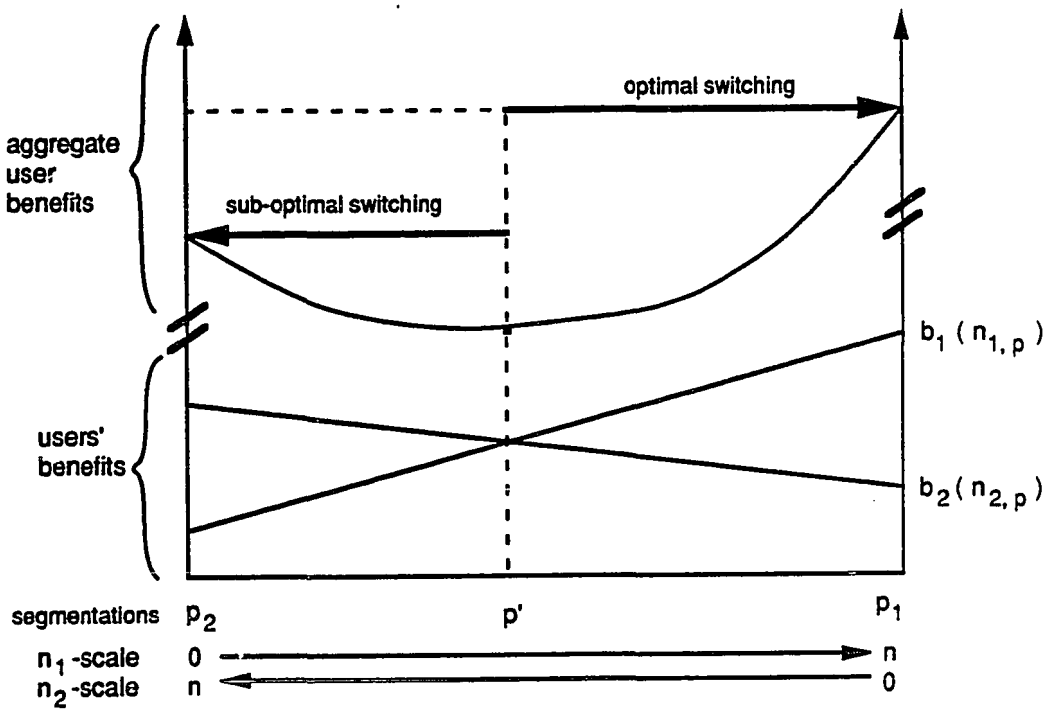


Figure 4.2 Linear utility functions

Figure 4.2 illustrates our model and its conclusions in the case of linear utility functions b_i. Note that the utility function $b_2(n_{2,p})$ is drawn in a coordinate system starting in the lower right corner. This is equivalent to the utility function $b_2(n - n_{2,p})$ in a standard coordinate system. Each vertical line in the coordinate system denotes one possible market segmentation p.

At initial segmentations to the left of p' the equilibrium outcome is p_2, where all users switch to system S_2. Note that the aggregate user benefits would be higher if the users of S_2 had switched to S_1, but those users would risk lowering their benefits. Of course, this paradox between rationality and optimality can only be noted by an observer with perfect and complete information on the benefit functions of the IOS. This information tends to be unavailable in real-life, when the decision to switch is more likely to be made based on much more limited information, such

as a comparison of one's current benefits with the benefits of a competitor using another system. In our model the users' information sets are limited: the users only have information about current decisions of other users; the users are not informed about future decisions of other users. Switching is determined by 'local' conditions.[3]

4.2.3 The impact of switching costs

We now extend the basic model by assuming a constant switching cost, sw_i, for switching *to* IOS S_i. Given the users' rationality, switching from one system to another occurs only if the users increase their utility by switching. Thus, switching from S_1 to S_2 occurs only if

$$b_1(n_{1,p}) \leq b_2(n_{2,p}) - sw_2. \tag{4.1}$$

Similarly, switching from S_2 to S_1 occurs if

$$b_2(n_{2,p}) \leq b_1(n_{1,p}) - sw_1. \tag{4.2}$$

Note that the switch to another system entails a change to another segmentation leading to an additional increase in the user's utility.[4]

Proposition 4

i) There is at most one segmentation, p_1', where $b_2(n_{2,p_1'}) = b_1(n_{1,p_1'}) - sw_1$.

ii) There is at most one segmentation, p_2', where $b_1(n_{1,p_2'}) = b_2(n_{2,p_2'}) - sw_2$.

[3]A different situation arises in the case of explicit coordination of users by trade organizations or implicit coordination by conditional contracts as mentioned above. Although not pursued further in the dissertation, the distinction between the rationality of individual users and the rationality of groups of users can be the basis for interesting future research.

[4]In a discrete representation of the benefit functions one has to resort to a slightly more complex definition taking account of the effect of the single user switching: Switching from S_1 to S_2 occurs only if $b_1(n_{1,p}) < b_2(n_{2,p'}) - sw_2$, where $p' = (n_{1,p} - 1, n_{2,p} + 1)$. Analogously for switching from S_2 to S_1.

Proof: The proof for each clause of the proposition is analogous to the proof of proposition 1; the addition of a constant sw_i does not change the strict monotonicity of the utility functions. q.e.d.

Let the regions of market segmentations α, β, γ be defined as follows.

$$\begin{aligned}
\alpha &:= \{p | b_1(n_{1,p}) \leq b_2(n_{2,p}) - sw_2\} \\
\beta &:= \{p | b_2(n_{2,p}) \leq b_1(n_{1,p}) - sw_1\} \\
\gamma &:= \{p | b_1(n_{1,p}) > b_2(n_{2,p}) - sw_2 \; and \; b_2(n_{2,p}) > b_1(n_{1,p}) - sw_1\}
\end{aligned}$$

While there exist six possible combinations of these regions determined by the parameters of the utility functions, namely, (α), (β), (γ), (α, γ), (γ, β), (α, β, γ), we shall consider only the last case: The most general case contains both market segmentations p_2' and p_1' from proposition 3.

Proposition 5 *If $b_1(n_1)$ and $b_2(n_2)$ are such that all three regions, α, β, and γ, exist, then there are three Nash equilibria.*

As in the first model, there are two equilibria leading to the adoption of a single system. These equilibria occur when the initial segmentation is in regions α or β. In addition, we now have a third equilibrium of no switching associated with region γ.

Note that, as in the earlier case, only one of these multiple equilibria will lead to a Pareto-optimal outcome in terms of aggregate user benefits. Switching costs lead to a nonempty set of market segmentations that are not Pareto-optimal in terms of aggregate user benefits. Further, the model shows that as switching costs increase, the set of segmentations where no switching occurs increases. Figure 4.3 illustrates these conclusions in the case of linear utility functions.

In order to further investigate the effects of IOS on markets, we must take into account the providers' motivation and possible competitive moves. In the next section, we widen the focus of the model to include these factors.

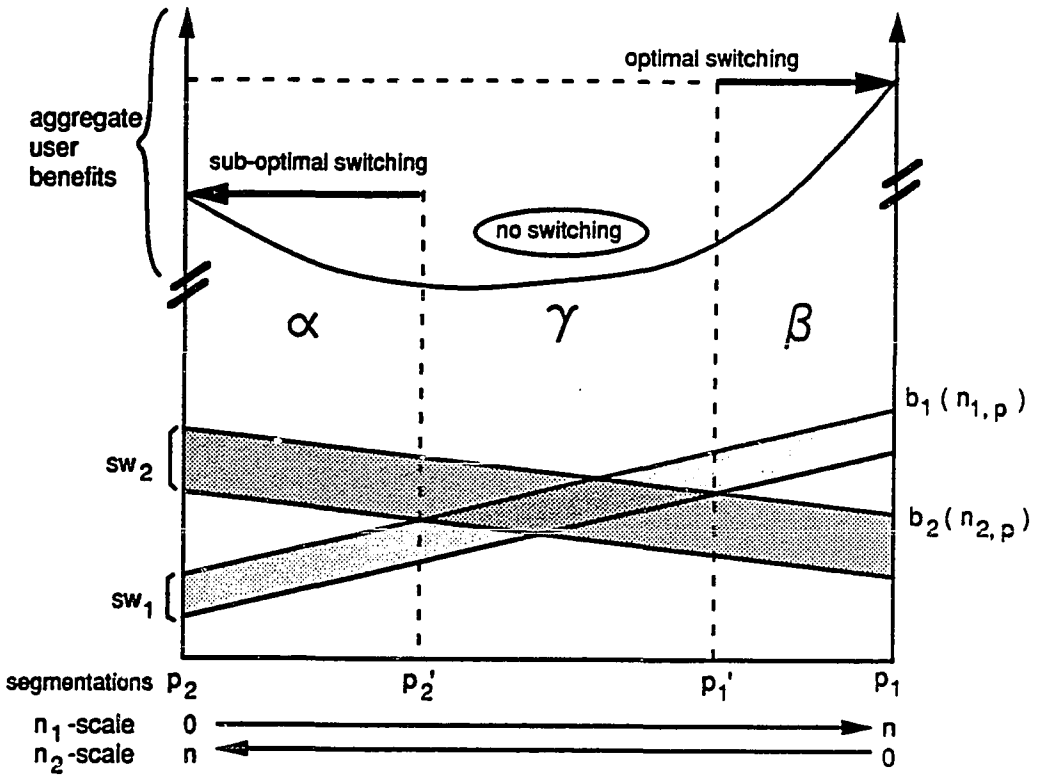


Figure 4.3 Linear utility functions and constant switching costs

4.3 Competitive moves by IOS-providers

4.3.1 Generic options for IOS-providers

In the previous section, we presented a model of IOS and looked at the behavior of users. The model can also provide the basis for an investigation of the options for competitive moves for providers of IOS. From the model two levers for competitive moves can be identified: A system provider can change the level of benefits associated with an IOS and he can influence the switching costs between systems. For this discussion it is necessary to distinguish between switching costs *from* a system and switching costs *to* a system. We analyze four generic moves.

- *Increasing the benefits of an IOS to its users*

  There are two types of benefit increases.

  - The first type is a form of subsidy. The costs of this user benefit increase are proportional to the number of users. Examples of this type of move by a system provider include charging less for system use and sponsoring IOS use by picking up some costs to the users, such as communication line charges.
  - User benefits can also be increased by a system provider at costs that are independent of the number of users of the system by increasing the number or amount of product characteristics. Examples of this second type include increased functionality of the system software, more user friendly interfaces, and allowing access to more information on the system.

- *Decreasing the benefits of an IOS to its users*

  A system provider may decrease the benefits[5] simply by charging more for system use. Another way is to drop services that entail high costs for the provider of the IOS.

- *Increasing switching costs away from own IOS*

  The most obvious way to increase switching costs is with the help of contracts. A contract may specify fines for switching before the end of the contract's duration. The fines may be justified by IOS providers in terms of the capital investment for the IOS and loss of sales of a product sold with the help of the IOS. The length of the time period specified in a contract is another important aspect for switching costs. The discussion of 'hostage-taking' by Williamson (1985) provides a more general context for this type of move.

[5]Throughout our analysis we are only interested in the net benefits of the system or changes to the net benefits due to a competitive move.

Another way to increase switching costs has been suggested by Ives and Learmonth (1984). By penetrating deeper into a customer's resource life cycle switching costs can be increased. Options include personalized services of an IOS that link to a user's internal files and increase a user's interest in long-term contracts.

Another possibility for an IOS provider with multiple system services is the 'cross-selling' of services to further bind a user to the IOS. In the case of cross-selling, a user of the IOS is targeted as a customer for other services or products of the IOS-provider that need not necessarily be IOS-based. Successful cross-selling increases the importance of the business relationship between the IOS-provider and a user and thus makes it harder for the user to endanger this relationship by using a competitor's IOS.

- *Decreasing switching costs to own system*

  There are two different types of moves available to a system provider to achieve a decrease in switching costs to his IOS.

  - First, sponsoring in the form of cash incentives, free use of the new system, or, as another example, defending a new user in law suits brought on by the user's former IOS provider because of contractual breaches. It has to be noted that the cost of this type of sponsoring are different from the previous sponsoring that aims at increasing benefits of the system globally. Here, we are dealing essentially with a promise to sponsor a new user in case of a switch. The associated costs are only incurred in case of a new switching user, while the global sponsoring is associated with costs for every user on the system.
  - Second, technology-based switching costs can be eliminated with the help of adapters. An asymmetrical adapter makes one IOS accessible for users of another IOS, but not the other way round. If an adapter is developed in such a way that the users of another IOS can still use the same type of

interface and hardware, learning costs on the users' side can be neglected. Allowing a user to keep his old data structures is especially important the deeper the competitor's penetration into the user's resource life cycle. The costs of adapters have to be incurred prior to any switching taking place. For example, software has to be developed that translates the data formats of a user of a competitor's system to your own format before this user can switch.

4.3.2 Effects of the generic moves in the model

This section describes the effect of the four generic competitive moves in the model. These moves are relevant to the competitive situation of providers in region γ of our model, where there are two system providers with switching costs, which inhibit users from switching. Although we look at two types of switching costs (*from* and *to* a system), it has to be emphasized that a user sees only the switching cost away from his current system.

To describe the competitive effects of various moves, we first introduce a measure of the system providers' competitive positions. The underlying idea of a system provider's competitive position is that the competitive position should reflect the danger of users switching away from his own system and the chance of getting users of a competitor's IOS to switch to his own system. The competitive position thus has to reflect the relative distances to the market segmentations where switching will occur first. Since, the critical market segmentations in our model are the two at which switching will occur first, p_2' and p_1' in figure 4.3 we define a system provider's competitive position as the distance between the current market segmentation and the segmentation where switching to the competitor occurs. We scale the distance to produce a measure between 0 and 1.

Formally, let $p_0, p_0 \in \gamma$, be the current market segmentation and c_i be the competitive position of the provider of S_i, then

$$c_i = \frac{|n_{i,p_0} - n_{i,p'_j}|}{|n_{i,p'_i} - n_{i,p'_j}|}, j \neq i$$

This measure has the properties that at $c_i = 1$, all users switch to that system provider; at $c_i = 0$, all users switch to the competitor; and $c_i + c_j = 1$. It has to be noted that a change in competitive position does not necessarily entail the switching of users. Only changes in competitive position that lead to $c_i = 1$ or $c_j = 1$ imply switching of users.

It is elucidating to compare this indicator to the traditional indicator of competitive position, market share. In our model, market share only changes if either of the competitors can corner the market. This corresponds to the values 0 and 1 of our indicator. However, market share cannot indicate less drastic changes in the segmentations *within* γ. Thus, our indicator is more appropriate especially when trying to attribute a value to a 'marginal' competitive move.

Increasing system benefits

In a market with no new users, a system provider can increase his market share only by inducing users of a competitor's system to switch. One strategy for a system provider is to increase the benefits of his system thereby increasing the attractiveness of his IOS. Formally, a move to increase benefits for users of S_2 (without loss of generality) results in a new benefit function $\bar{b}_2$ for the users of S_2 such that $\bar{b}_2(n_{2,p}) > b_2(n_{2,p})$ for all p. The function $\bar{b}_2$ is assumed to be monotonically increasing in $n_{2,p}$ so that the positive network externality remains in effect.

The next proposition states that the effect of a move to increase the benefits of users of S_2 can be characterized by a decrease in the distance of the current segmentation to the segmentation where switching to S_2 occurs and an increase in the distance to the segmentation where switching to S_1 takes place.

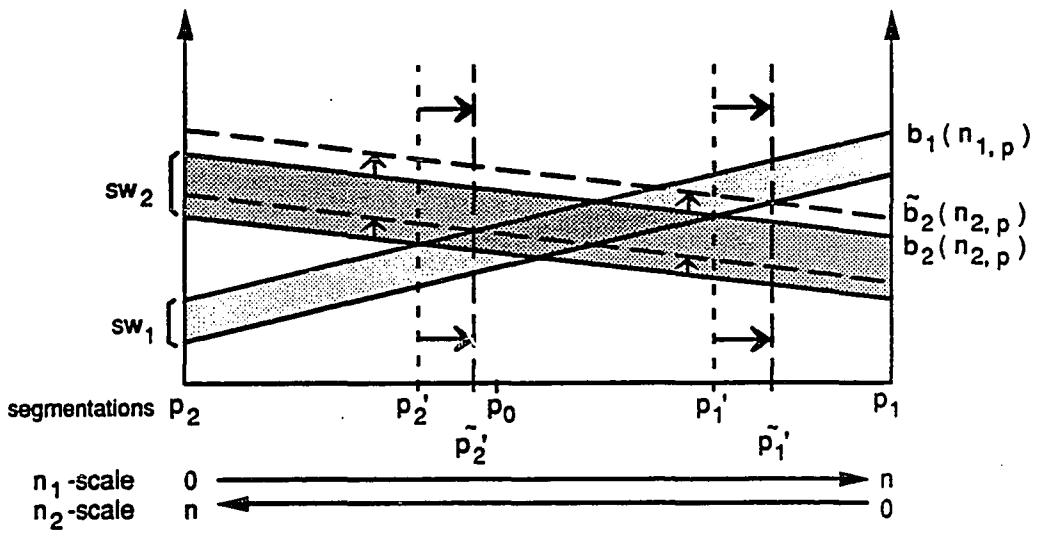


Figure 4.4 Increase in benefits of one IOS

Proposition 6 *Let c_i and $\tilde{c}_i$ respectively denote the competitive positions of the provider of S_i before and after the move to increase the benefits of IOS S_2. If p_0, the initial segmentation, lies in γ, then the following conditions hold:*

$$\tilde{c}_2 > c_2 \text{ and } \tilde{c}_1 < c_1$$

Proof: In order to compare the relative position of segmentations in our model we introduce a norm on the segmentations that is straightforward. Let p_a and p_b be segmentations, then we define $\mid p_a - p_b \mid$ as $n_{1,p_a} - n_{1,p_b}$, the difference between the number of users of system S_1.[6] It is easily seen that the monotonicity of the benefit functions will shift the switching point to S_2, p_2', closer to p_0 and the switching point to S_1, p_1' further from p_0, yielding the changes in competitive positions. q.e.d.

Figure 4.4 illustrates the above move in the linear case; p_i' and $\tilde{p}_i'$ denote the segmentations where switching to S_i occurs before and after the move, respectively.

[6]We shall implicitly apply the same reduction to scalar quantities when we speak of intervals of segmentations.

Decreasing system benefits

This move is the reverse of the first move: The competitive position of the system provider is reduced in exchange for higher returns. Proposition 7 is analogous to proposition 6.

Proposition 7 *Let c_i and $\tilde{c}_i$ respectively denote the competitive positions of the provider of S_i before and after the move to decrease the benefits of IOS S_2. If p_0, the initial segmentation, lies in γ, then the following conditions hold:*

$$\tilde{c}_2 < c_2 \text{ and } \tilde{c}_1 > c_1$$

Increasing switching costs away from own system

By increasing switching costs away from his own system, an IOS provider can *defend* his system by increasing the size of the interval of segmentations where no switching occurs.

Proposition 8 *Let γ and $\tilde{\gamma}$ respectively denote the intervals where no switching occurs before and after the move to increase the switching costs away from IOS S_2. Then:*

$$\gamma \subset \tilde{\gamma}$$

Proof: Again, due to the monotonicity of the benefit functions, the move shifts the switching point to S_1, p_1', further from p_0, while p_1' is not affected. q.e.d.

Figure 4.5 illustrates this result in the linear case.

Decreasing switching costs to own system

The effect of a decrease in switching costs to a system is a reduction in the size of γ. After such a move the current segmentation is closer to the switching segmentation to the 'attacking' provider's system. Figure 4.6 illustrates this result in the linear case.

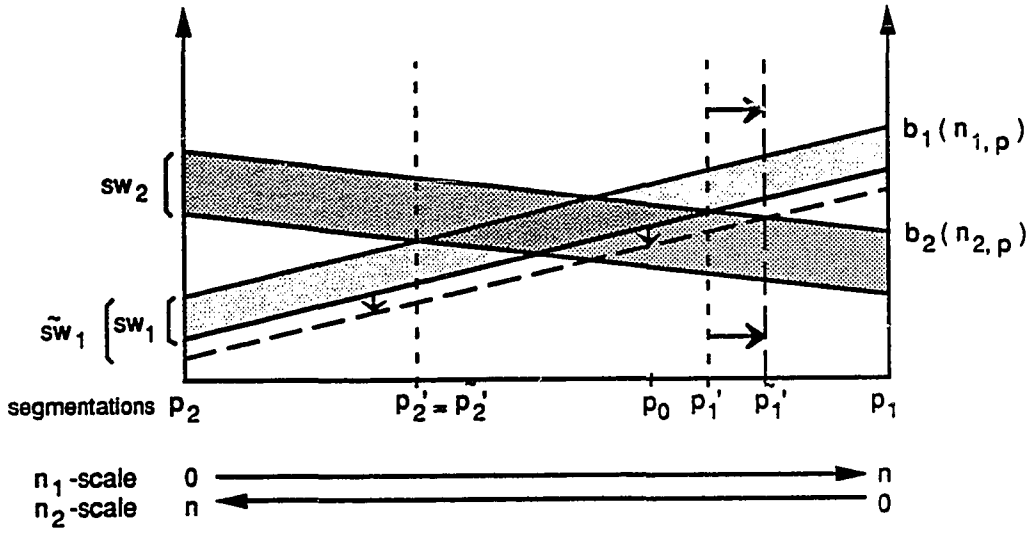


Figure 4.5 Increase in switching costs *from* S_2

In summary, our list of generic competitive moves provides a new framework that suggests that, instead of traditional indicators, such as market share, a new measure in the form of the competitive position is more appropriate in assessing the value of a competitive move.

4.4 Extension of the model to m competitors

In order to extend the model from two IOS-providers to m competitors we have to extend our notation for switching costs. Let $sw_{i,j}$ denote the switching costs for switching from S_i to S_j. All switching costs can be represented by a matrix SW that contains only zeroes on the diagonal.[7] Note that this is not a symmetric matrix.

[7]The case of two players translates into the matrix $\begin{pmatrix} 0 & sw_1 \\ sw_2 & 0 \end{pmatrix}$.

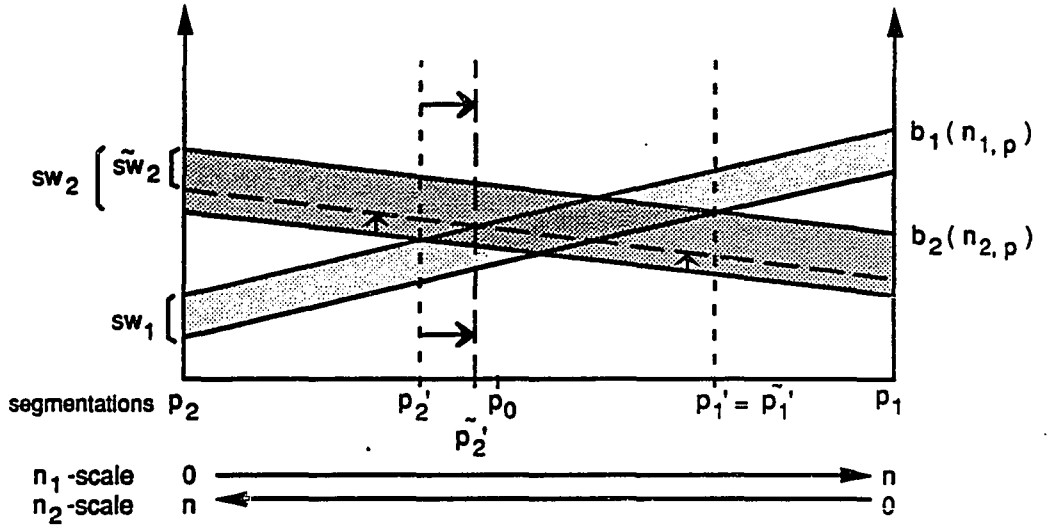


Figure 4.6 Decrease in switching costs *to* S_2

$$SW = \begin{pmatrix} 0 & sw_{1,2} & \dots & \dots & sw_{1,m} \\ sw_{2,1} & 0 & sw_{2,3} & \dots & sw_{2,m} \\ \dots & \dots & \dots & \dots & \dots \\ sw_{m-1,1} & \dots & sw_{m-1,m-2} & 0 & sw_{m-1,m} \\ sw_{m,1} & \dots & \dots & sw_{m,m-1} & 0 \end{pmatrix}$$

Furthermore, we extend the definition of S_i, n_i and b_i to m providers. The decision rule for switching now can be generalized for users of IOS. Switching from S_i is defined to occur if there exists $k \neq i$ such that

$$b_k - sw_{i,k} \geq b_i \tag{4.3}$$

In the case of the existence of more than one system fulfilling condition 4.3, the optimizing rationality of users requires switching to the system with the highest return from switching. Formally, users of S_i will switch away from S_i if M_i is not

empty with M_i defined as follows:

$$M_i = \{k \mid b_k - sw_{i,k} \geq b_i\} \tag{4.4}$$

Let l_i denote the $k \in M_i$ for which $b_k - sw_{i,k}$ is maximal. Thus, if $M_i \neq \emptyset$, then users of S_i will switch to S_{l_i}.

We can now give a necessary and sufficient condition for no switching to occur in a market segmentation $p = (n_1, ..., n_m)$. No switching occurs in the current market segmentation if and only if

$$M_i = \emptyset \ \forall\, i = 1, ..., m. \tag{4.5}$$

This shows that our result of the two-dimensional case indicating the potential parallel existence of two systems can be generalized to m systems.

Our graphic interpretation of γ can be used in the case of m competitors with slight modification. In the analysis of potential switching between systems S_i and S_j, we now use the same idea of two coordinate systems as before. However, as switching now affects only the users of S_i and S_j, the second coordinate system has its origin not at n but at $n_i + n_j$.

If switching occurs in the current segmentation, we now have to take account of higher order impacts of the changed benefits after the switching. The algorithm in figure 4.7 describes the necessary steps for calculating one equilibrium of the market after the original equilibrium has been disturbed by a set of simultaneous moves of the competitors. The algorithm terminates, as with each iteration the number of market participants is reduced by one. If the number reaches one, the algorithm has to stop at the latest.

One has to note that the choice of h in the loop-condition of the algorithm is not deterministic in our specification. In other words, the algorithm can be specified in different deterministic ways, so that different coalitions may occur in the course of

```
while ∃ h M_h ≠ ∅
    begin
        determine l ∈ M_h such that b_h − sw_{h,l} is maximal;
        reduce dimension of market segmentation by deleting n_h;
        delete row h and column h from SW;
    end
```

Figure 4.7 Computing an equilibrium for m competitors

the execution of different versions of this algorithm. The order of coalition building is important as it may influence the final market equilibrium. Note that if only one system provider makes a competitive move that disturbs the initial equilibrium the above algorithm is deterministic.

4.5 Extension to nonhomogeneous users

4.5.1 Motivation

Until now we have only analyzed homogeneous users that face by definition the same switching costs. In reality, however, we observe users with different switching costs. Differences in switching costs have been modeled in terms of different transportation costs between consumers and suppliers at geographic location.

A famous example of differences in switching costs in IOS is the case of airline reservation systems where geographic location determines to a large extent the switching costs of travel agents. Travel agencies located in the area of a hub of a major carrier face higher switching costs away from the reservation system of the respective carrier than travel agencies in the area of airports where the carriers and their reservation systems compete head on. A detailed reference to the airline reservation systems case is given in section 5.3.

In this section we extend the basic model to incorporate nonhomogeneous users by grouping users into sets of homogeneous users. Thus, users in each group face

the same switching costs. The switching costs are assumed to be different across groups. The grouping of users according to switching costs has to be viewed for each system separately. In other words, users in a group that face the same switching costs towards system S_1, need not all face the same switching costs towards system S_2. This construction is a natural extension of the basic model with the basic model being subsumed in the extreme case of all users in the same group for each system. The other extreme is given by the case where all users face different switching costs towards the systems and thus the group size is one.

4.5.2 Formal construction to incorporate differences in switching costs among users

The following construction ranks groups of users according to their switching costs towards one system. We shall apply the construction explicitly to users of system S_1 that face switching costs to system S_2. The construction is analogous for users of system S_2.

Let sw_2^i, $i = 1...k$, be the different switching costs faced by users of system S_1. The sw_2^i are assumed to be ordered to increase with i. Let the actual and potential users of system S_1 be grouped into groups g^i, $i = 1...k$, with the switching costs of users in group g^i being sw_2^i. Let $\mid g^i \mid$ denote the number of users in group g^i. Each user in the market is in one and only one group with respect to one system, i.e.,

$$\sum_{i=1}^{k} \mid g^i \mid = n \tag{4.6}$$

Let p_0 be the current segmentation. We assume that users in the groups $g^1,...,g^{j-1}$ are on system S_2 and users in the groups $g^j,...,g^k$ are on system S_1.[8] Thus,

$$p_0 = (\sum_{i=1}^{j-1} \mid g^i \mid, \sum_{i=j}^{k} \mid g^i \mid). \tag{4.7}$$

The market is assumed to be in an equilibrium in the current segmentation given the current values of benefit functions and switching costs. Looking back at our initial model this means that the current segmentation is in an interval of type γ where no switching occurs. Let us call this interval γ^j, as its left boundary is determined by the equation

$$b_2(n_{2,p}) - sw_2^j < b_1(n_{1,p}). \tag{4.8}$$

This corresponds to our previous definition of p_2'. We shall now label the respective segmentations that are defined as switching segmentations for the different sw_2^i as p_2^i. As we are only interested in switching to S_2 we may neglect the right boundary of the interval γ^j and just label it p_1'. Let $\gamma^i = [p_2^i, p_1']$. The increasing switching costs $sw_2^j,...,sw_2^k$ now lead to an ascending chain of intervals.

$$\gamma^j \subset \gamma^{j+1} \subset ... \subset \gamma^k \tag{4.9}$$

4.5.3 Effects of a competitive move

We are now interested in the users on system S_1 and their reaction to a competitive move by the provider of S_2. Research questions center on attributing a value to an investment into an offensive move by the competitor. As an initial investment that gets a group of users to switch also changes the returns from network externalities for all users, we have to take account of higher order effects of the initial competitive

[8] In fact, this assumption neglects that users on system S_2 might, when viewed as potential users of S_1, belong to a group with higher switching costs than sw_2^{j-1}. However, as our analysis only looks at the switching behavior of users currently on system S_1, the assumption does not impose a restriction to the generality of our results.

move. In this section we aim at identifying conditions when such a 'bandwagon' effect gets started and when it will stop. In terms of an investment decision this goal translates into the question of how much investment is necessary into offensive moves to get a certain marketshare. Answers to these questions will also identify the parameters that would allow the provider of system S_1 to stop the bandwagon effect in defense.

Our previous analysis of generic competitive moves gives the provider of S_2 two options to target the group of users of S_1 with the lowest switching costs for an offense. If users of g^j would switch to S_2 without switching costs, the provider of S_2 can decrease the switching costs sw_2^j of users in group g^j sufficiently to induce switching. The second option is to increase the benefits of system S_2 globally to the point where users in g^j will switch.[9]

Starting the bandwagon by decreasing switching costs

Let us start by looking at the first option of reducing the switching costs of users in g^j. The first-order effect of this move is the switching of users in g^j to S_2 if condition 4.10 holds. Let $s\tilde{w}_2^j$ denote the reduced switching costs of users in group g^j after the competitive move.

$$b_2(\sum_{i=1}^{j-1} \mid g^i \mid) - s\tilde{w}_2^j \geq b_1(\sum_{i=j}^{k} \mid g^i \mid) \tag{4.10}$$

Thus, there are now $\sum_{i=1}^{j} \mid g^i \mid$ users on system S_2 and only $\sum_{i=j+1}^{k} \mid g^i \mid$ users on system S_1. In other words we now face a new market segmentation, p_0^j, due to the competitive move.

$$p_0^j = (\sum_{i=j+1}^{k} \mid g^i \mid, \sum_{i=1}^{j} \mid g^i \mid) \tag{4.11}$$

A second-order effect now occurs if the new market segmentation and the ensuing different network externality values for the users induce the next group of users,

[9]These two options correspond conceptually to global vs. selective sponsoring of a technology.

g^{j+1} to switch. This is the case if the following condition holds.

$$b_2(\sum_{i=1}^{j} \mid g^i \mid) - sw_2^{j+1} \geq b_1(\sum_{i=j+1}^{k} \mid g^i \mid) \tag{4.12}$$

Naturally, a second-order effect may cause in turn higher order effects. This type of switching behavior corresponds to a bandwagon getting started.

Stopping the bandwagon

The bandwagon only comes to a stop before all users have switched, if there is one hurdle imposed by the switching costs of one group g^i, $i \leq k$, that cannot be compensated by the increase in benefits due to network externalities. Formally, the bandwagon will stop if there exists a switching cost sw_2^l such that:

$$b_2(\sum_{i=1}^{j} \mid g^i \mid) - sw_2^{j+1} < b_1(\sum_{i=j+1}^{k} \mid g^i \mid) \tag{4.13}$$

In summary, we can give a change balance (figure 4.8) of the users on both systems tracing the effect of the competitive move and the bandwagon effect.

Starting the bandwagon by increasing benefits

We can now have a brief look at the second option of starting the bandwagon by increasing the benefits of users of S_2. Let $\tilde{b_2}$ denote the benefit function of users of system S_2 after the benefit increase. The bandwagon gets started if

$$\tilde{b_2}(\sum_{i=1}^{j-1} \mid g^i \mid) - sw_2^j > b_1(\sum_{i=j}^{k} \mid g^i \mid). \tag{4.14}$$

The same basic principle regarding higher order effects applies. One only has to substitute $\tilde{b_2}$ for b_2 in equations 4.12 and 4.13.

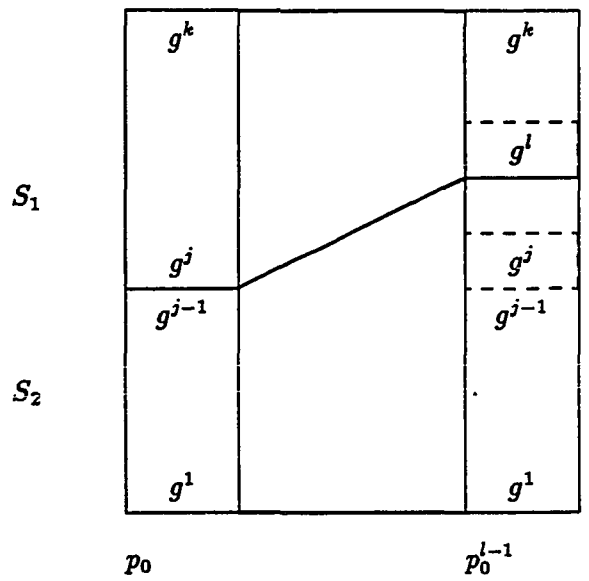


Figure 4.8 Effects of a competitive move

4.5.4 Quantification of the results in the linear case

In this section we quantify and expand on the previous results on bandwagons in the case of linear benefit functions. Two research questions are at the center of this section:

1. What factors affect the size of the necessary investment to get a group of users to switch?

2. What factors keep a bandwagon going?

In order to be able to quantify our results, we restrict the analysis to the case of linear benefit functions. Let the benefit functions be defined by

$$b_i(n_i) = e_i + f_i * n_i, \quad i = 1, 2. \tag{4.15}$$

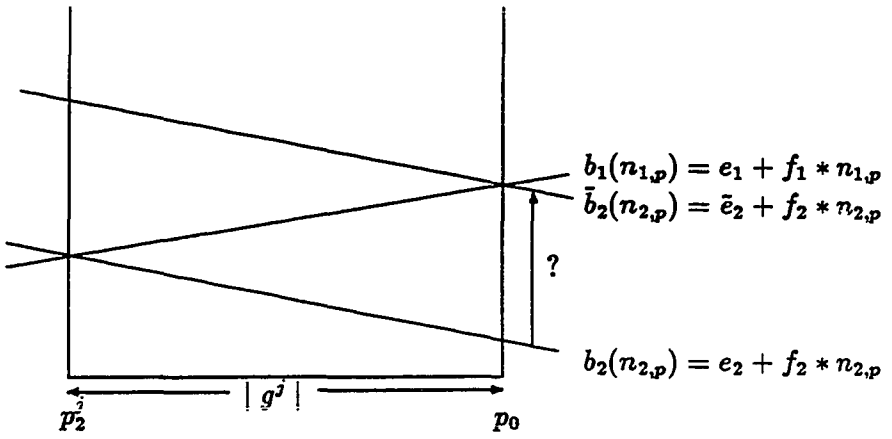


Figure 4.9 Quantification of necessary moves to get users in g^j to switch to S_2

Getting a group of users to switch

The analysis starts with the current segmentation given by equation 4.7. Again we focus on competitive moves by the provider of IOS S_2 to get users from system S_1 to switch. Following the notation in section 4.5.2 the task at hand for the provider of S_2 is to change the benefit function or the switching costs so that p_0 becomes the switching segmentation for users in group g^j. It should be noted that for this analysis it is not necessary to distinguish between increasing benefits of S_2 or decreasing switching costs from S_2, as only the difference of the two is taken into account by the users and the analysis concentrates only on users in g^j. Thus, we can restrict the following analysis to benefit increases as a competitive move without loss of generality. Figure 4.9 illustrates the problem. $\bar{b}_2(n_{2,p}) = \bar{e}_2 + f_2 * n_{2,p}$ denotes the new benefit function after the benefit increase.

From figure 4.9 it is clear that the necessary benefit increase is given by $\bar{e}_2 - e_2$. As the slopes of the benefit functions are known, the necessary benefit increase can be further calculated.

$$\bar{e}_2 - e_2 = (f_1 + f_2) * | g^j | \tag{4.16}$$

Thus, the costs of this move are proportional to the number of users that are being targeted for switching. Furthermore, the more important the role of network externalities in an industry the more difficult it is to get the first group of users to switch.

Unstoppable bandwagons

This part concentrates again on the bandwagon effect with regard to users switching from system S_1 to S_2. For mathematical simplicity, let the size of groups of users facing the same switching costs, $\mid g^i \mid$, be equal 1. Thus, users can be ranked uniquely according to their switching costs. Further, let the function describing the switching costs from system S_1 to System S_2 for each user be linear.

$$sw_2^i = sw_2(i) = g_2 + h_2 * i, \quad i = 1...n \tag{4.17}$$

Thus, for users of system S_1 switching costs to S_2 increase with their index. Given $p_0 = (n - (j-1), j-1)$ and a situation where no switching occurs, then user j of S_1 faces switching costs of $sw_2(j)$ and following equation 4.8

$$b_2(j-1) - sw_2(j) < b_1(n - (j-1)), \tag{4.18}$$

which is equivalent to

$$e_2 + f_2 * (j-1) - (g_2 + h_2 * j) < e_1 + f_1 * (n - (j-1)). \tag{4.19}$$

Assuming that the provider of system S_2 decreases the switching costs $sw_2(j)$ for user j by $b_1(j) - b_2(n-j) + sw_2(j)$, then user j will switch to system S_2. This is the first-order effect of the competitive move. Note that this move pertains only to user j. Thus, the costs of this highly selective sponsoring will be fairly small.

One can now analyze higher-order effects of this move. After the switch of user j to system S_2, the interesting question is whether further switches take place

due to the network externalities. In order for a bandwagon-effect to take place, condition 4.12 has to be fulfilled. In the linear case this condition translates into

$$e_2 + f_2 * j - (g_2 + h_2 * (j+1)) \geq e_1 + f_1 * (n-j) \tag{4.20}$$

Comparing equations 4.19 and 4.20 shows that condition 4.20 is fulfilled if and only if

$$f_1 + f_2 \geq h_2. \tag{4.21}$$

Thus, user $j+1$ will switch too if condition 4.21 holds true. In the linear case this reasoning can be extended immediately to users $j+2,...,n$. In other words, if the switching costs do not increase faster than the *combined* network externalities of both systems a bandwagon effect cannot be stopped in the linear case until all users have switched to system S_2.

Two aspects of this result are interesting to note. First, the necessary investment to start the bandwagon may very well be minimal. This stresses the potential danger of the dynamics of a bandwagon effect. Second, the bandwagon effect is fueled by the network externalities of *both* systems. Thus, we should expect to see an increasing importance of bandwagon effects in environments where network externalities play an increasingly important role. IOS that rely more on their efficiency benefits for their justification, such as, order-entry systems, are less susceptible to bandwagon effects than IOS that exhibit strong network externalities, such as, electronic markets.

4.6 Extension of model to incorporate new users

The last major restriction of the model was the assumption that no new users can sign up to either of the competing IOS. The market was assumed to be limited and completely segmented. In this section it is shown how the representation of two competing IOS can be extended to incorporate new users.

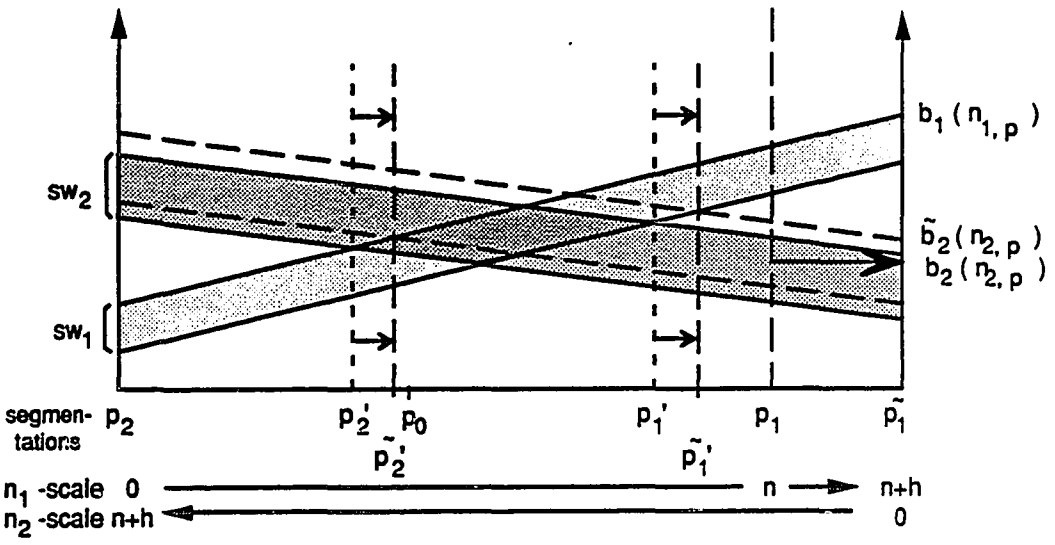


Figure 4.10 New users joining system S_2

Let us assume that h new users sign up on system S_2.[10] This means that the market size increases from n to $n+h$ users. The representation can now be adapted by moving the origin of the second coordinate system from the segmentation $p_1 = (n, 0)$ before the h new users joined system S_2 to segmentation $\tilde{p}_1 = (n+h, 0)$ after the new users joined the system. Once the second coordinate system's new origin has been determined, one can draw the benefit function of system S_2 anew in the second coordinate system. This corresponds to a shift to the right of the benefit function b_2 by $\mid \tilde{p}_1 - p_1 \mid$. Figure 4.10 illustrates this reasoning. The tilde is used to denote the segmentations and functions after the h users have joined system S_2. Similarly, new users that join system S_1 can be incorporated into our representation by shifting the origin of the first coordinate system to the left. As new users only lead to a horizontal shift of benefit functions in our representation, it is clear that

[10]At this point we are only interested in the effect of new users on the parameters of the model. An interesting direction for future research is the analysis of the choice between established IOS by new users. In particular, the effect of competitive moves on new users needs to be studied. For example, increases in the switching costs away from a system are likely to make this system less attractive to new users. In this context the distinction between a growing industry and a stable or declining industry is important.

the existence of an interval γ of segmentations where no switching occurs is not challenged.

Quantification in linear case

In the case of linear benefit functions it is easy to calculate the effect of new users joining a system on the switching segmentations. The effect of interest is the difference between the switching segmentation before and after the new users have joined the system.

Let the benefit functions be defined again by

$$b_i(n_i) = e_i + f_i * n_i, \quad i = 1, 2. \tag{4.22}$$

The segmentation p_2' is defined by the condition that $b_1(n_{1,p_2'}) = b_2(n_{2,p_2'}) - sw_2$. In the linear case this translates into

$$e_1 + f_1 * n_{1,p_2'} = e_2 + f_2 * (n - n_{1,p_2'}) - sw_2. \tag{4.23}$$

Solving this equation for $n_{1,p_2'}$ gives us the solution for p_2'.

$$p_2' = (\frac{e_2 - e_1 + f_2 * n - sw_2}{f_1 + f_2}, n - \frac{e_2 - e_1 + f_2 * n - sw_2}{f_1 + f_2}) \tag{4.24}$$

Once the h new users join system S_2, the segmentation $\tilde{p'}_2$ can be calculated similarly.

$$e_1 + f_1 * n_{1,\tilde{p'}_2} = e_2 + f_2 * (n + h - n_{1,\tilde{p'}_2}) - sw_2 \tag{4.25}$$

Solving for $n_{1,\tilde{p'}_2}$ gives

$$\tilde{p'}_2 = (\frac{e_2 - e_1 + f_2 * (n + h) - sw_2}{f_1 + f_2}, (n + h) - \frac{e_2 - e_1 + f_2 * (n + h) - sw_2}{f_1 + f_2}). \tag{4.26}$$

Given our definition of a norm on the segmentations, the distance between $\tilde{p'}_2$ and p'_2 is the following.

$$
\begin{aligned}
|\tilde{p'}_2 - p'_2| &= \frac{e_2 - e_1 + f_2 * (n+h) - sw_2}{f_1 + f_2} - \frac{e_2 - e_1 + f_2 * n - sw_2}{f_1 + f_2} \\
&= \frac{h * f_2}{f_1 + f_2} \qquad (4.27)
\end{aligned}
$$

Quite expectedly, the more users join a system the more the switching segmentation gets shifted. However, it is interesting to note that the effect on the switching segmentation of new users joining a system is inverse proportional to the combined slopes of the network externalities in the linear case.

From figure 4.10 it is clear that h new users on system S_2 have the same effect as a benefit increase of system S_2 in the coordinate system with origin at p_1. In fact, to have the same effect on the switching segmentations the benefit increase would have to be $h * f_2$, the divisor in equation 4.27. Thus, getting new users that have not used an IOS before on his system is another competitive move by an IOS provider that can be added to our framework of competitive moves.

Chapter 5

Competitive analysis of IOS providers

This chapter analyzes the interaction of competitive moves by two IOS providers. First, we take a traditional cost-justification perspective on investments into competitive moves. We then use non-cooperative game theory as a formalism for competitive analysis. We look at different games reflecting different scenarios. Finally, we tie in the results from this and the previous chapter with reality by taking a closer look at the airline reservation systems case.

5.1 Competitive analysis of the generic moves

5.1.1 Introduction

The previous chapter has provided us with a framework for the system providers' competitive options in the form of a list of generic competitive moves. We can distinguish the effects of the competitive moves in terms of the competitive position, i.e., the distances to the relative switching segmentations and the relative size of the interval γ. However, this framework is not yet rich enough to analyze competitive strategies of system providers. What is missing is a way to explicitly incorporate the costs and benefits of the generic moves. The benefits of any competitive move can only be correctly assessed given a strategic intent of the IOS providers. In the following we distinguish the generic moves in terms of their effectiveness for achieving two types of strategic intents.

- An *offensive strategy* aims at getting the users of a competitor's system to switch to your system, i.e., the goal is to shift the current segmentation into segmentation where switching to your system occurs.

- A *defensive strategy*, on the other hand, tries to prevent the competitor from cornering the market. Thus, the goal is a competitive position that provides a 'safe' distance from the switching segmentation to the competitor's system.

5.1.2 An analysis of competitive investment opportunities

In this section we analyze the opportunities for competitive investment into either an offense or defense. The idea is to identify intervals of segmentations where the return and cost structures are such that investing in an offense is possible or a defense against such an offense is feasible. We restrict ourselves to identifying rational investment volumes in the sense that the expected returns from the investment are higher than the net present returns[1] without the investment.

Investment in an offense

Without loss of generality let the provider of S_2 have the strategic goal of cornering the market given its current segmentation, p_0.

In a first step, a function $I_2(p)$ can be defined that gives for each segmentation the necessary investment for a successful offense assuming no countermoves. In other words, $I_2(p)$ gives the investment amount necessary to reach p_2' from p. $I_2(p)$ is monotonically increasing starting at 0 over the interval $[p_2', p_1']$. If the current segmentation is p_2', no further investment is necessary. It is increasingly expensive to change the current segmentation to p_2' the closer p_0 is to p_1'.

Secondly, let $R_2(p)$ denote the net present return from system S_2 in each segmentation. $R_2(p)$ is assumed to be monotonically increasing over the interval $[p_1', p_2']$,

[1] Net present returns contain future returns with appropriate discount factors.

as the return from a system is likely to increase with the number of users on the system. R_2^{win} denotes the expected return from cornering the market.[2]

There is a unique intersection, p_2^{be}, between the function $R_2^{win} - I_2(p)$, i.e., the net return from the investment in case of success, and the function $R_2(p)$, the net present return without the investment. This intersection denotes the break-even beyond which no further investment can rationally be justified in view of profit-maximizing IOS-providers.

Because of the symmetry of our model, a similar construction gives us a break-even segmentation, p_1^{be} for S_1.

Investment in a defense

The amount available for a defense by the provider of S_1 is given by the amount of net present returns of the system, $R_1(p)$ in the interval $[p_2', p_2^{be}]$, the interval where an offense by the provider of S_2 might be expected. The analogous assumption can be made for a defense by the provider of S_2.

The interesting implication is that the funds available for a defense are lowest when the competitor faces the highest benefits from an offense.

Summary

This break-even analysis of investments is summarized in figure 5.1. This diagramming technique allows to identify intervals of segmentations where certain combinations of strategic intent are likely to occur. In particular, when the intervals of segmentations where both system providers expect a positive return from cornering the market overlap, we are faced with *offense* pitted against *offense*. This interesting situation motivates the ensuing analysis in section 5.2.

- What is a rational choice for the competitors in this situation?
- Should they invest in an offense or do nothing?

[2] Again the future returns are factored into this constant using a discount factor.

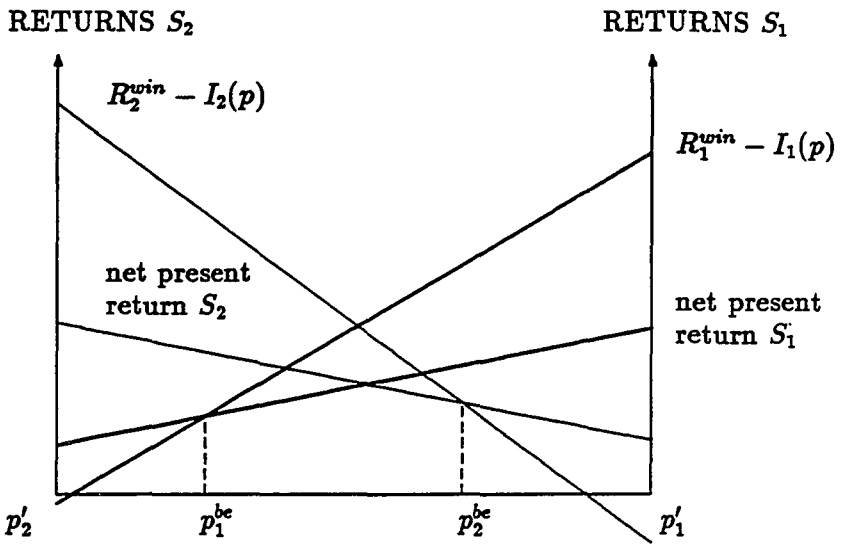


Figure 5.1 Cost and returns of defensive and offensive strategies

- What is the outcome if both competitors choose to invest in an offense?

In order to answer this type of questions we introduce a game theoretic formulation of the competition between IOS providers.

5.2 Competitive analysis using game theory

In this section we analyze the interaction of competitive moves by two IOS providers. We use non-cooperative game theory to formalize this analysis.

5.2.1 Simultaneous games

To analyze competitive moves and countermoves, consider the following noncooperative, two-stage game with complete information. The players are the two providers of the IOS. Both players have complete knowledge of the other player's payoffs. The players choose their actions simultaneously. In period one an initial market segmentation exists in the γ region, that can be observed by the players.

Game 1	*attack*	*defense*	*nothing*
attack	$(-C_a, -C_a)$	$(-C_a, -C_d)$	$(B_a - C_a, -B_a)$
defense	$(-C_d, -C_a)$	$(-C_d, -C_d)$	$(-C_d, 0)$
nothing	$(-B_a, B_a - C_a)$	$(0, -C_d)$	$(0, 0)$

Figure 5.2 General two system provider game

General game

In a first, very general game, we assume that each system provider chooses from three possible moves:

- attack the competitior's system with the goal of increasing your own competitive position to 1, i.e., cornering the market,
- defend your own system by increasing the distance between the current segmentation and the segmentation where users switch to the competitor,
- do nothing.

After a choice of a move has been made by both system providers in period one, the users choose in period two whether to switch systems. Figure 5.2 shows such a game with identical system providers with the variables defined as follows:

- C_a, the cost of an attack,
- C_d, the cost of a defense.
- B_a, the benefit from cornering the market after a successful attack. We assume that the loss of market share from not counter competitor's attack is $-B_a$.

The assumption of identical players implies that the normal form in figure 5.2 is symmetric.

For the equilibrium analysis we assume that

$$B_a > C_a, \tag{5.1}$$

i.e., the expected benefits from a successful attack are higher than the cost of the attack. Furthermore, we assume that

$$B_a > C_d, \tag{5.2}$$

i.e., the loss from losing to an attack is higher than the cost of mounting a defense. In fact, the analysis in section 5.1 allows us to identify those segmentations where conditions 5.2 and 5.2 are fulfilled.

Under these conditions it is easy to see that there exists no Nash equilibrium where no one player, regarding the other player as committed to his choice, can improve his lot. If the first player chooses to attack, player two will respond with a defense. However, if player 2 chooses a defense, player 1 is better off by doing nothing. Now, if one player chooses to do nothing, the other player will choose an attack, which brings us to a full circle. Thus, we cannot deduce any predictions as to what constitutes the best pure strategy for a player in this setting. In fact, knowing that there are no dominant strategies can very be useful and may be the most important outcome of finding a mixed-strategy equilibrium. [3]

Although, there is no equilibrium in the general game above, there do exist Nash equilibria in special environments. In the next sections we look at environments that allow to each player only two possible moves.

To increase or not to increase user benefits

The first subgame reflects an environment where system providers do not have the option to defend themselves by increasing switching costs from their system. We simplify this setting to a game where system providers can either increase their benefits or do nothing. Figure 5.3 shows such a game with the variables defined as above.

[3]For a discussion of the interpretation of mixed-strategy equilibria see Luce and Raiffa (1957).

Game 2	*increase benefits*	*do nothing*
increase benefits	$(-C_a, -C_a)$	$(B_a - C_a, -B_a)$
do nothing	$(-B_a, B_a - C_a)$	$(0,0)$

Figure 5.3 Game of increasing benefits or doing nothing

The only pure-strategy, Nash equilibrium is for both system providers to increase their benefits. Such moves would result in a decrease in profits of both system providers, no change in the competitive positions of the system providers,and increases in benefits to the users of both systems.

In fact, this game is just another version of the famous 'Prisoner's Dilemma' (Luce and Raiffa 1957). We shall interpret the Prisoner's Dilemma in more detail in chapter 6 in a more general context.

Eliminating switching costs via adapters

In some environments a system provider may be able to corner the market by eliminating the switching costs for users of a competitor's system. In particular, technological solutions for eliminating the switching costs for users of competitors, seem attractive at first glance. Adapters that allow users of the competitor's system to use your own system without modifications to their existing hardware and software suggest themselves as a powerful competitive tool. For example, in order-entry systems an IOS provider may include conversion routines and emulations into his system that allow users of a competitor's system to maintain their internal data formats and software when switching. In this case, from a technological point of view, the switch between systems may involve only the substitution of a telephone number for dialing into the system of another IOS provider.

In this section we look at a game where a system provider can eliminate switching costs to his system with the introduction of an asymmetrical adapter. An asymmetrical adapter allows only the switching of users of the competitor to your

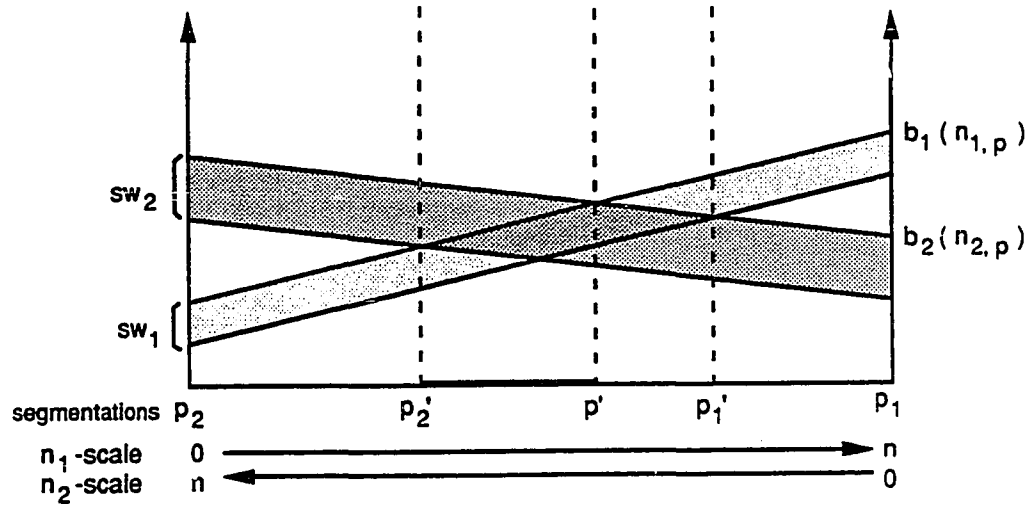


Figure 5.4 Introduction of an asymmetrical adapter

own system without facilitating the switching of your own users to the competitor's system.

Our model suggests that the segmentations that lie in the half-open interval $[p_2', p')$ are the only ones where the provider of S_2 should contemplate the introduction of an asymmetrical adapter. Figure 5.4 illustrates this reasoning graphically with the thickened interval denoting the segmentations where an adapter introduced by the provider of S_2 would lead to switching. Given an initial segmentation p_0, $p_0 \in [p_2', p')$, the introduction of an adapter by the provider of S_2 would eliminate the switching cost, sw_1; shifting the critical switching point, p_2' to the right of p_0 and inducing new users onto S_2.

The model indicates that the provider of S_1 can avoid losing his users by increasing the benefits to users of S_1 so that $\bar{b}_1(n_{1,p_0}) \geq b_2(n_{2,p_0})$. This shifts p' to the left of p_0 which results in p_0 being outside the interval $[p_2', p')$ and the elimination of the usefulness of the adapter.

Game 3	*introduce adapter*	*do nothing*
increase benefits	$(-x, -w)$	$(-x, 0)$
do nothing	$(-y, z)$	$(0, 0)$

Figure 5.5 Provider of S_2 with the option to introduce an adapter

Now consider the following two-stage game. In period one, an initial segmentation is given in the interval $[p_2', p')$ and each system provider makes one of two possible moves. The provider of S_2 may introduce an adapter or not; the provider of S_1 may increase benefits enough to counter the adapter or not. In period two, the users again decide whether to switch systems. Figure 5.5 shows such a game with the following variables:

- x, the cost of increasing benefits to the users,
- w, the cost of introducing an adapter,
- $-y$, the loss from not increasing benefits if the competitor introduces an adapter,
- z, the net gain from introducing an adapter if the competitor does not make a counter move.

Note that this setting is not a symmetric game.

The game has no Nash equilibrium in pure strategies; for each strategy, one of the system providers would prefer to change his move.

To find a mixed-strategy equilibrium, let P_A denote the probability that the provider of S_2 will introduce an adapter, as assessed by the provider of S_1, and P_I the probability that the provider of S_1 will increase the benefits of his system, as assessed by the provider of S_2. The evaluations of P_I and P_A would be based upon the competitive positions of each system provider and the position of p_0 relative to p'.

The calculation of the expected utilities of the system providers is now straight forward.

$$\begin{aligned} E(S_1) &= P_I * P_A * -x + P_I * (1 - P_A) * -x + (1 - P_I) * P_A * -y \\ &= -y * P_A + P_I * (y * P_A - x) \qquad (5.3) \\ E(S_2) &= P_I * P_A * -w + (1 - P_I) * P_A * z \\ &= P_A * (z - P_I * (w + z)) \qquad (5.4) \end{aligned}$$

The best reply for provider of S_i is 1 if the term in parentheses in the equation for $E(S_i)$ is positive, 0 if this term is negative, and can be anything if this term is zero. For S_1 this gives us the following conditions.

$$P_I = 1 \quad if \quad P_A > \frac{x}{y} \qquad (5.5)$$

$$P_I = 0 \quad if \quad P_A < \frac{x}{y} \qquad (5.6)$$

$$P_I \in [0,1] \quad if \quad P_A = \frac{x}{y} \qquad (5.7)$$

Similarly for the provider of S_2 the mixed strategy is defined as follows.

$$P_A = 1 \quad if \quad P_I < \frac{z}{w+z} \qquad (5.8)$$

$$P_A = 0 \quad if \quad P_I > \frac{z}{w+z} \qquad (5.9)$$

$$P_A \in [0,1] \quad if \quad P_I = \frac{z}{w+z} \qquad (5.10)$$

The mixed-strategy equilibrium now is given by $P_I = z/(w+z)$ and $P_A = x/y$.[4]

If $P_I < z/(w+z)$ then the provider of S_2 would introduce the adapter and if $P_I > z/(w+z)$, he would not. Similarly, if $P_A > x/y$ then the provider of S_1 would increase benefits to counter the adapter and if $P_A < x/y$, he would not.

[4]This can be visualized by graphing the expected utility of each player against the mixed strategy of the other player which results in a unique intersection of the graphs at the mixed-strategy equilibrium.

We conclude that the asymmetrical adapter, while appearing to be of competitive use in eliminating a competitor's switching cost, is of limited value. The introduction of an adapter is only viable over a range of initial market segmentations and, in those cases, is subject to effective counter moves under complete information and simultaneous or near-simultaneous choice of moves. Thus, the value of this type of competitive move depends very much on an environment where switching costs to your own system currently prevent users of a competitor's system from switching and where time lags prevent effective countermoves. Finally, note that, as in the case of system providers competing by increasing the benefits to the users of their IOS, competing via adapters primarily benefits the users, not the system providers.

So far our analysis of simultaneous games with complete information points at the danger that the advantages gained from competitive moves can be offset by countermoves. In particular, competition can drive system providers to increase the benefits of their systems to customers with no return to the system providers in terms of increased market share. Thus, the existence of an IOS, while necessary, may become a drain on the system provider's resources. In assuming identical system providers the previous analysis ignores the importance of different budgets for competitive moves available to system providers. Thus, we present another perspective on the interaction of competitive moves that includes the notion of different and fixed budgets for competitive moves in the next section.

5.2.2 Multi-period sequential games

In this section we look at the effects of fixed budgets for investment into the IOS on repeated versions of the game in figure 5.3.

Without loss of generality we assume that both system providers have the same cost structures, as different cost structures can be mapped into different initial sizes of the fixed budget.

The key notion concerning fixed budgets is that a fixed budget imposes constraints on the strategy of the IOS providers in the competition over time. A system provider, who has sufficient resources for moves to make the competitor spend all of his budget on countermoves, can win all of the users, once he is the only IOS provider left with resources for competitive moves. This game can be related to the 'war of attrition': Until the game ends, both players "earn a negative amount per period, and when one exits, he earns zero and the other player earns some reward" (Rasmusen 1989, p. 74). In the war of attrition players can choose to *stay* or to *exit* the market. If both players have the same structure, a mixed equilibrium probability can then be calculated so that both players are likely to stay long enough that their losses soak up the gain from being the survivor.

Our incorporation of a fixed budget under complete information avoids this outcome. Offers by the weaker system provider to collude are attractive to the stronger system provider if the benefits from cornering the market minus the aggregate costs of the competitive moves are less than the benefits from collusion. [5] Otherwise, we would expect a repetition of game 2 where one system provider would be forced out of the market, leaving a monopoly for the other system provider.

5.3 Tying the model's results to the airline reservation systems case

In this section we interpret the results of the model in the context of airline reservation systems. The case studies in the literature tend to emphasize short-term competitive advantages. With the help of our model we can look at the economics of airline reservation systems that go beyond short-term competitive advantage and focus on generic strategies and their impact on industry structure.

[5] Antitrust regulations may limit the possibilities for collusion.

Computerized airline reservation systems (CRS) started out as internal systems and communication networks of all major carriers. By the early-1970s, those internal systems provided in addition to passenger reservation and confirmation for the airline that owned the system functions, such as fare-quotation, advance check-in, boarding pass issuance, stand-by passenger handling, and itinerary generation (Copeland and McKenney 1988, p. 358). Other internal functions performed today by a typical CRS include crew management, gate assignment, flight scheduling, load and trim calculations, cargo reservations and tracking and, most important, after deregulation yield management.

Yield management denotes the practice of "charging different prices for the same item depending on what customers will pay" ("Travel & Transportation: Fairest of the Fares?" 1989, p. 60). The importance of yield management has to be seen in the context of deregulation. Before 1978, regulation had imposed an extremely simple fare structure on the industry. After deregulation sophisticated attempts at price discrimination have emerged. The success of yield management hinges to a great extent on the accuracy of a company's knowledge about the customers. A key factor in obtaining a knowledge base in the case of airlines are frequent flyer programs. Airline reservation systems are the primary means of obtaining and managing this knowledge.

Before 1976 all CRS relied on a common system architecture. Our analysis of CRS starts with the beginning of *retail automation*, "the practice of extending the reach of the reservations systems beyond the airline's organizational boundaries to the industry's distribution system" (Copeland and McKenney 1988, p. 358). Thus, our analysis basically begins in 1976 when United Airlines and American Airlines started offering travel agencies direct access to their reservation systems.[6] This move has resulted in systems that allow the travel agent today to give the traveler information on airline schedules, seat availability, destinations and fare

[6]In the following, we shall use the term 'airline reservation systems' for systems *with* retail automation.

quotes. The CRS terminals on the travel agents premises also allow the issuing of tickets, printing of boarding passes and seat assignments. Moreover, utilities support making arrangements for passports and visas, credit card checking, issuing of travelers checks and travelers insurance and currency conversions.

5.3.1 Players

Airline reservation systems involve four types of players:

- *Airlines owning a computerized reservation system* (CRS-airlines)

  In 1988 there were five major vendors of reservation system services (ordered according to revenues):

  1. American Airlines' Sabre (introduced in 1975)
  2. United Airlines' Apollo (introduced in 1975)
  3. Texas Air's System One (introduced in 1981)[7]
  4. TWA's Pars (introduced in 1976)
  5. Delta Airlines' Datas II (introduced in 1982)[8]

  An interesting historical detail is the failure of the only independent third-party provider of a CRS. The failure of the system, MARS PLUS, offered by Tymshare can be traced to the fact that Tymshare did not supply travel services in addition to the CRS. Thus, no incremental revenues gained, e.g., from increases in load factors of airplanes could be realized. Thus, MARS PLUS faced a substantial disadvantage compared to carrier-owned systems because it had to recover its costs directly from travel agents. A second potential source of revenue for an independent CRS are fees that airlines

[7] In fact, in 1981 Eastern Airlines introduced its proprietary reservation system and Texas Air gained control of this system after buying Eastern in 1986.

[8] A 1989 merger between Pars and Datas II has reduced the number of major CRS vendors to four. Section 5.3.6 gives references to this merger.

would have to pay so that their inventory is offered to the public. In the case of MARS PLUS, however, it turned out that airlines would not pay for inclusion unless the system had already achieved market penetration with travel agents (Levine 1987).

- *Computerized travel agencies*[9]

  According to *Travel Weekly Magazine* 34% of a total of 34,684 agencies subscribed in the beginning of 1988 to Sabre and 24.5% to Apollo making the two first initiators of reservation systems the major players even 13 years after the first introduction of those systems (Belitsos 1988). According to the *Economist* 95% of all travel agents in the U.S. were computerized by late 1987 ("Sabre Rattling" 1987). In line with the assumptions of our model, increased retail share can only be achieved today at the expense of incumbent systems given no significant growth in the number of travel agencies.

- *Travelers*

  We shall focus on the majority of travelers that use the services of travel agents for making their reservations. In 1987 88% of all tickets were sold through CRS. In principle, data services such as Dialcom, CompuServe or Geisco allow subscribers to bypass travel agents and make reservations from home and have tickets mailed (Feldman 1987). However, as there is no economic incentive to bypass the travel agents in such a way, we do not expect a major impact from this option and thus shall concentrate only on the use of CRS by travel agents. In fact, given today's complex fare structures one may even argue that the role of travel agents will become increasingly important as experts in the use of the increasingly complex CRS.

- *Travel suppliers not owning a CRS*

  Other travel suppliers that do not own a CRS include airline carriers,

[9]We view corporate travel planners as equivalent to travel agencies.

hotels, car rental agencies or tour organizers. With CRS the dominant method of distribution of tickets and reservations, these travel suppliers pay for being listed on a CRS (Scheier 1989). For example, in 1988 Sabre's network held the schedules of 650 airlines and information on 16,000 hotels and 33 car rental agencies (Belitsos 1988). This situation is especially precarious for airlines. It should be noted that most airlines do not own or will ever own a reservation system with retail automation. Thus, one has to make a crucial distinction between CRS-airlines, who have control over their own CRS, and non-CRS-airlines, who have little choice but pay the owners of existing systems for listing their information. CRS-airlines may very well be competitors of non-CRS-airlines, especially after the 1978 deregulation of the airline industry. This situation has led to numerous law-suits, congressional hearings and cries of foul play and explains why the case of airline reservation systems is probably the best documented. Especially interesting is the use of display and connecting point biases and the so-called "halo-effect" (favorable display placement equals more bookings) for competitive advantage by the CRS providers (Feldman 1988). CRS-airlines that have precise information on competitors can also design effective incentive programs with the help of 'commission overrides', i.e., incentives in the form of special services or extra commissions given to encourage travel agents to sell a seat on a particular airline. Before deregulation, commission overrides were illegal (Levine 1987). However, our analysis does not directly pertain to this conflict among airlines. Rather, we concentrate on the competitive moves between the vendors of the existing reservation systems that directly affect the users of the systems.

Figure 5.6 summarizes the principal dependencies among the players in the CRS industry. In fact, talking about the CRS industry instead of the airline industry reflects the fact that information in the airline industry has become a dominating production factor.

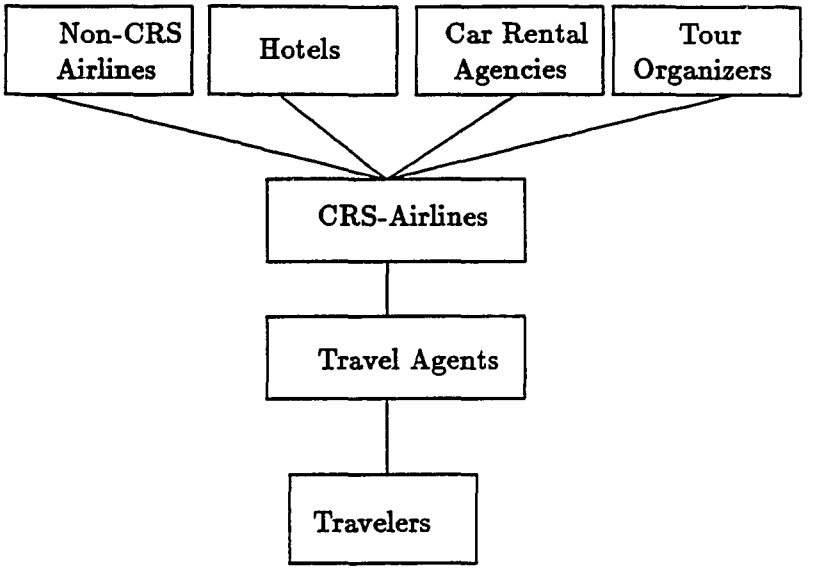


Figure 5.6 Players in the CRS-industry

In the following sections we shall try to identify parallels between our model and the case of airline reservation systems. The role of deregulation is important to consider a priori. A direct effect of deregulation was that the "heightened competition [...] made the airline industry very information-intensive, and the conduit for much of that information was the reservations systems" (Copeland and McKenney 1988, p. 366). Thus, deregulation may very well be the ultimate basis for the strategic importance that is attributed to airline reservation systems. An indicator for the importance of CRS is the daily transaction volume. For example, Sabre processes about 60 million messages per day (Semilof 1989). This translates into millions of dollars of revenue opportunity, as can be seen from the costs of a 13 hour breakdown of the Sabre system in 1989 (Steinberg 1989).

5.3.2 Network externalities

Network externalities for both the travel agencies and the other users on a proprietary system arise indirectly. Travel agencies will aim for most complete information

to their customers as emphasized in a press release by the Associated Travel Nationwide (*ATN*) on August 2, 1982:

> As responsible travel agents, ATN members recognize their primary obligations to the consumers, and in order to meet their needs, full and complete unprejudiced information about air transportation must be available at all times.

This implies that travel agencies will favor the system with most airline schedules, hotels and car rental agencies. On the other hand, it is most attractive for the airlines, hotels and car rental agencies to advertise on the system where they can reach the most customers. In other words, the system with the most travel agencies connected will be favored in a first approximation of the decision process of the travel agent.[10] Taking those two effects together explains network externalities on the side of the travel agencies as well as on the side of the other users of the reservation system.

5.3.3 Switching costs

The CRS rely heavily on switching costs to keep travel agents on their networks. Among the costs for an agency switching to another reservation system are:

- Paying the former system provider for the cost of removing the equipment and for the lost equipment rental fees.
- Opportunity costs in the form of liquidation damages: agencies may be "responsible for the estimated value of the offline booking fees from carriers whose passengers they would have booked" (Belitsos 1988, p. 40).
- Costs for lawsuits brought by the carrier whose contract is being broken.

[10]This is only an approximation, as the role of geographic differences among travel agencies is neglected at this point. In section 5.3.4 it is explained how geographic differences lead to nonhomogeneous users in terms of our model.

- Learning costs: "For an agent to use a new system, he or she would need to stop work and undergo a complete retraining program" (Saunders 1985, p. 173).

Donald Sohn, president of Heritage Travel Inc., a Cambridge, MA, travel agency, estimates the cost of terminating a reservation system contract in a large agency to reach into millions (Belitsos 1988, p. 41).

Although some travel agents initially acquired more than one system, the airlines "through severe financial penalties or pressure" (Feldman 1987, p. 5) managed to impose contracts forbidding multiple systems. From the travel agent's point of view, using more than one system increases learning costs and reduces flexibility of personnel in a travel agency. The push for exclusive use of one CRS in a travel agency was in line with the quest for competitive advantage through display bias and halo-effect by the carriers that owned the CRS. In fact, although the Department of Transportation officially banned display biases in 1984 (D.O.T. Rule 225), more sophisticated forms of bias can still be observed today. (Caldwell and Fillon 1989) Similarly, the right to equal access of information on a CRS by participating carriers is hard to enforce, if one does not control the system's operations. The CRS providers had also pushed travel agents to sign long-term contracts for the respective CRS use. However, in 1984 the Department of Transportation imposed constraints on the contracts (D.O.T. Rule 225) that limited the maximum length of a contract to 5 years and forbid exclusivity clauses. Thus, the assumption of our model that users can only connect to one system is only partially fulfilled in the case of airline reservation systems, as there exists the principal option of maintaining links to multiple systems today. However, the majority of all travel agencies still subscribe to only one system today, as the financial burden of subscription to two or more parallel CRS can be justified only by very large travel agencies and CRS-airlines can still exert considerable pressure on travel agencies.

More recently, CRS providers have started to offer backoffice systems for travel agents (Belitsos 1988). This is in response to a desire by travel agents for both office automation and access to an airline CRS on the same screen ("More power from CRS's" 1989). This is part of a major shift in system architecture for most CRS: Dumb terminals are being replaced by PCs, mainly IBM Personal System/2. This not only provides the basis for new product features, such as the introduction of imaging technologies, it also is the key to becoming part of the travel agent's backoffice. Thus, CRS become personalized systems for travel agents. Following Ives and Learmonth this deeper penetration in the customer's resource life cycle increases the switching costs of the travel agent.

In view of these huge switching costs and the importance of network externalities, it comes as no surprise that we find multiple system providers in reality as predicted by our model.

5.3.4 Nonhomogeneous users

So far we have neglected in the discussion of the CRS case that market geography may change the preference for the most 'complete' system. The dominance of different carriers in different areas actually implies that information on different carriers has different *weights* for the travel agencies. Most carriers operate on a hub and spoke system where the majority of flights emanate from central airports. A travel agent that serves a market of travelers around a hub of a major airline (e.g., American's Dallas/Fort Worth, Northwest's Minneapolis or TWA's St. Loius) has strong preferences for the CRS that gives easy access to the respective carriers. A study of the Department of Justice identified twenty-nine urban areas[11] "where a CRS accounts for more than a forty percent share of the market, with five areas having CRS market shares of seventy percent or more" (Saunders 1985, p. 171).

[11]The study was based on urban markets with at least $100 million of annual revenue. The percentages refer to travel agent subscribers of CRS (Saunders 1985, p. 171).

The value of a hub is increased to an airline if the airline also has geographic CRS domination in this region. The complementary character of hub and spoke systems and CRS is the key to understanding geographic differences in the travel industry.

In this context our model points at the potential importance of bandwagon effects. The above mentioned commission overrides can be used by CRS providers for selective campaigns for getting a group of travel agents in a certain market to switch systems. Further empirical research is needed to determine whether selective campaigns by CRS providers have second-order effects beyond the targeted area. The product indivisibilities in hub and spoke systems and the recent mergers of many regional airlines with major carriers makes such an investigation especially interesting, as there is a clear trend that the characteristics associated with a regional definition of the market may disappear (Saunders 1985, Labich 1987, Levine 1987).

5.3.5 Competitive moves by reservation system providers

It is now interesting to look at the competitive moves taken by the system providers.

Changing user benefits

The increase of user benefits as a competitive move has a long history in the competition of CRS providers. Beginning in 1978, American and United both added features, such as invoice/itinerary print-outs, that were aimed at increasing the productivity of travel agents. The introduction of graphics terminals and a decentralized system architecture is just another example of this type of move.

Another way to increase user benefits is to to provide travel agents with additional information on other carriers. American Airlines was the first to introduce co-host agreements with other carriers that gave those carriers preferential treatment of their schedules on Sabre in 1978. Such co-host agreements especially with carriers that did not compete directly with American allowed American to increase

Sabre's presence in the market and increase the travel agent market share (Copeland and McKenney 1988, p. 361). Interestingly enough, United immediately introduced its own co-host option to counter this increase in benefits by American.

Thus, we find a pattern of near-simultaneous benefit increases to the users of the CRS similar to the outcome of the game in section 5.2.1. The implications for the CRS industry structure are interesting. Economies of scale favor large providers in this type of strategy, as software development costs for increased functionality can be recovered from a larger user base. The increase in benefits to the customers provided by large systems including the co-host programs, mentioned above, required a multiprocessor installation and supporting communication network with all its attendant remote hardware that "drove all but the largest carriers from the retail automation area" (Copeland and McKenney 1988, p. 362).

Another way to increase user benefits is to improve the timeliness of the available information on the CRS. The idea is to provide up-to-date flight data of all participating airlines, not only the vendor's airline. System One was the first to introduce this feature by directly linking to other airline's databases. Without direct access links CRS providers can only store the flight schedules information for all airlines as compiled in the Official Airline Guide (OAG) on a weekly basis[12] and the airlines' fare information as collected by the Airline Tariff Publishing Company (ATP) on a daily basis (Saunders 1985). From the travelers' and the travel agents' standpoint, there clearly is an urgent need for more current and reliable information in view of the scope of the changes due to deregulation and CRS. "The consensus among agents is that the more direct the access to the internal system of the particular carrier, the more reliable the information" (Saunders 1985, p. 161). The need for up-to-date information can be illustrated by the huge number of daily fare changes due to yield management. For example, on a single day in 1987 Delta used its CRS to make 79,000 fare changes, "adjusting them up and down as tickets were

[12]In fact, only direct flight schedules are available via OAG. For non-direct flights CRS providers have to make connections to the respective airline. (Saunders 1985)

sold," while "American adjusted 106,000 fares the same day" (Labich 1987, p. 68). System One's network of direct access links is currently most useful for travel agencies with fast access to the databases of 23 carriers (Belitsos 1988). Thus, direct access is "probably System One's strongest selling point for agencies using rival [systems]" estimates Nadine Godwink, automation editor of *Travel Weekly* (Belitsos 1988, p. 41). The success of these moves can be seen in System One's increased market share of 18% of the travel agency market in 1987, up from 15% in 1986 according to *Travel Weekly* magazine. Direct access also allows travel agents to make and confirm reservations directly from the inventory of other carriers. Although there exist a U.S. network, ARINC, and an international network, SITA, set up by the airline industry in the 1970s for switching messages and inquiries to and from each airline's database, direct (physical) access links provide the necessary improvement in speed for the travel agents.

Changing switching costs

As mentioned above, more recent applications offered by the CRS providers include personalized services. A good example is "the ability to build individual or corporate customer profiles that can be automatically merged with the Passenger Name Record whenever new bookings are made" (Belitsos 1988, p. 39). Agencies clearly benefit from increased functionality through personalization of service. As these new services require personalized data files, they are hard to transfer to a competitor's system. This brings us to a discussion of the strategies involving switching costs.

In line with our model's suggestions, there have been reports on large bonuses paid to switch reservation systems. In the addendum to the "Report to Congress on Airlines Computer Reservations Systems" (U.S. Civil Aeronautics Board 1983), Frontier Airlines refers to the business press to show that United has engaged in different types of sponsoring ranging from cash bonuses, the dropping of user fees, to installation givebacks. A 1985 congressional hearing contains testimony by North-

west that, for example, United offered an agent in Northwest's territory for a switch from Sabre to Apollo the following incentives: $500,000 in cash, a 10% 'override' (on top of the regular commission) for sales on United and five years' free use of Apollo including telephone line charges (Feldman 1987, p. 6).

Particularly elucidating are observations of the competitive moves of the late-comers to the market, especially Texas Air. Texas Air tries to lower an agency's switching costs to its system by defending agencies that switch to System One in lawsuits. The expected revenue increases from the switching travel agents are "seen to more than compensate for even vast sums in damages, according to SystemOne" (Feldman 1987, p. 8). This provides justification for our assumption in the model that the benefits from eliminating switching costs are higher than the costs of this move.

It is clear from this overview that the system vendors use switching costs in both ways described in our model: reducing the switching costs to their own system and increasing switching costs *from* their own system.

5.3.6 Notes on cooperation

The traveller's perspective

With regard to the aggregate user utilities our model emphasizes the existence of non-optimal market segmentations. In the case of airline reservation systems we find ample evidence for this problem in the addendum to the "Report to Congress on Airlines Computer Reservations Systems" (U.S. Civil Aeronautics Board 1983). The cited attempts of United to coerce agents into exclusive use of Apollo restrict the travel agents access to information. In the travel industry press it has been pointed out that agents "resent a 'dealership' relationship" as it would "jeopardize their integrity" (*The Travel Agent*, October 11, 1982, p. 94). From the travel agents' point of view, an appealing alternative would be open access to joint and

standardized CRS databases. This raises the issue of cooperation among CRS providers.

Domestic attempts at cooperation

There were five attempts from 1967 through 1980 to set up a joint and standardized reservation system (Feldman 1987, p. 4):

- 1967: Donnelly Official Airline Reservation System (DOARS)
- 1970: Automatic Travel Agency Reservation System (ATARS)
- 1974: Joint Industry Computer Reservation System (JICRS)
- 1976: Multi-Access Agent Reservation System (MAARS)
- 1980: Attempt by American Express

Among the reasons for failure of these efforts is the government's suspicion "that a joint system would be anti-competitive". (Feldman 1987, p. 4) A better understanding of network externalities and switching costs, as provided by our model, might have helped in correcting this suspicion which "in the light of what is happening today, [...] is a source of amusement within the industry" (Feldman 1987, p. 4).

Recent attempts at mergers between CRS are another significant form of cooperation in the U.S. In the first half of 1989 a merger was announced between American Airlines' Sabre system and Delta's Datas II. It is interesting to note that American Airlines president and CEO Russell Harrison stressed that the new joint system was not designed to be a competitive tool (Ryan 1989a). The new system would have had a market share of 46–48% raising the fear of higher charges for travel agents. (Layne and Caldwell 1989, Ryan 1989b) However, the merger was terminated after the Justice Department threatened to file a civil antitrust suit based on an alleged violation of the Clayton Act and the Sherman Act by the merger (Layne and Caldwell 1989). In the second half of 1989 plans for another merger were announced.

This time Delta, Northwest and TWA agreed to merge Datas II and Pars (Doyle 1989). As Datas II and Pars trail behind Apollo and Sabre in terms of marketshare, no objections were mounted by the Justice Department. In terms of our model these merger attempts indicate that, with travel agents in the interval γ locked tightly to their CRS providers, market share can only be increased through buyouts or cooperation. Achieving a sizable market share is extremely important due to the role of network externalities. Eventually, concerns about monopoly pricing may have to be added when analyzing further consolidation the airline reservation systems.

International cooperation

So far we have focused on the U.S. market for airline reservation systems. This corresponds to the assumption in our model of a limited market of users. Currently, we see this assumption being challenged by an effort of airline reservation systems vendors to seek expansion abroad. For example, in 1987, according to *Travel & Tourism Analyst*, there were 160 Apollo terminals installed in the Pacific region and Asia, 70 Datas II units in West Germany, 352 Pars terminals in Europe and the Middle East, and 316 Sabre terminals outside the U.S (Feldman 1987). As foreign travel agents already tend to be linked with national flag airlines' reservation systems, the challenge of global systems is very much to incorporate existing foreign systems into the U.S. systems. Feldman, however, points out that "national airlines have used their ability to approve who writes their tickets to prevent real incursions" (Feldman 1988, p. 18). In fact, these protectionist measures can be regarded as a very effective raise in the switching costs away from the national airlines' reservation system, as travel agents cannot afford not to issue tickets of the airline dominating the national market. Thus, with foreign travel agents largely out of direct reach, U.S. airline reservation system vendors are currently establishing links with new reservation systems established by consortia of national airlines in Europe (Galileo, Amadeus), the Pacific region (Fantasia, Abacus) and Canada (Gemini) based on cooperation in the form of joint ventures (Steinberg 1988, Feldman 1989, Powell

1989). Clearly, the network externalities in the CRS industry drive these forms of cooperation.

Finally, it should be noted that before deregulation airlines tended to cooperate not only on booking tickets, but also on the development of the technology for reservation systems (Copeland and McKenney 1988, Feldman 1987). Then came a phase where the system architecture was regarded as the basis for competitive advantage (Belitsos 1988). Today, all major CRS providers seem to match each other's competitive moves. Thus, the question arises whether the quest for competitive advantage has not turned into the response to strategic necessity. This question is at the center of the last part of this dissertation. It also calls for a better understanding of the opportunities and limits of cooperation.

Chapter 6

Competitive advantage and strategic necessity

6.1 Introduction

Having looked at scenarios of competition in the previous chapter, we shall now try to identify and analyze a more abstract pattern of competition involving IT and IOS, in particular.[1] Once this general pattern has been identified, it is interesting to reevaluate the particular features of IOS and how they can affect the outcome of this pattern.

As an introductory step, a close look at the issue of competition involving IT in the MIS and strategic management literature is elucidating. An abundance of articles has emphasized the competitive advantage to be gained by IT-investments. The evidence cited for this claim tends to come from a limited and often repeated set of case studies. Famous cases involving IOS include the following.

- The case of American Airlines describes the phenomenal success gained by American Airlines with its SABRE airline reservations system.

[1] We shall use the term IT in this chapter whenever our analysis goes beyond the special case of interorganizational systems. When using the term IOS, we do not claim to be able to generalize the respective propositions to IT in general.

- American Hospital Supply managed to obtain a dominant role in the hospital supply market by introducing with the ASAP system an electronic order-entry link to hospitals.

- McKesson managed to achieve a major growth in the independent pharmacy supply market with the help of its Economost order system.

It is interesting to note that all these success stories have in common that they represent the introduction of IT or new IT-based products by a first mover. Moreover, each of these first movers had a significant 'footprint', i.e., established business relationships, in the respective industries already.

However, managers that extrapolate from the early success stories or follow frameworks that extol the virtues of IT-investments *per se* may be in for a painful surprise. In fact, a lot of second-movers found themselves unable to duplicate the competitive advantage of the first movers. Rather it seems that in many cases competitive advantage due to IT-investments has turned into strategic necessity of IT-investments. Peter Keen (1988, p. 1, 2) describes this "new competitive reality" as follows:

- In financial services the telecommunications network is the franchise; customer data is the product base.

- In manufacturing, computer-integrated manufacturing is a critical survival factor. Without a communications strategy, the firm will be out of the game.

- In distribution, electronic customer service links define the value-added chain.

- In the airline industry, the reservation infrastructure defines the customer relationship opportunity.

- In publishing, the value of data depends on electronic access and distribution.

This chapter focuses on the question when and why competitive advantage due to IT turns into strategic necessity of IT. We provide a theoretical basis for the

analysis of this problem by relating this question to the Prisoner's Dilemma in game theory.

Research questions include:

- Is there a theoretical need for a continued investment into IT?
- Can strategic necessity be anticipated? What are characteristics of scenarios where competitive advantage turns into strategic necessity?
- How should managers behave when investment into IT turns into a strategic necessity?
- In the case of IOS, what is the role of users in this context?

In the next section, we take another look at the Prisoner's Dilemma that was first mentioned in the scenario in section 5.2.1. In this scenario two IOS providers have to decide whether to try to gain competitive advantage by increasing their system's utility for users. We review the literature on the Prisoner's Dilemma interpreting the results in the context of the issue of competitive advantage vs. strategic necessity. This analysis suggests that chances for sustainable competitive advantage are much more limited than one might infer from the essentially singular case studies. Rather, the Prisoner's Dilemma raises the question of how beneficial cooperation between the competitors can be achieved. If a collusive agreement can be reached, the problem of observance of this agreement arises. The problem of observance of a collusive agreement can be viewed as another instantiation of the Prisoner's Dilemma.

The issue of cooperation leads the analysis to another scenario that is particularly relevant to the analysis of interorganizational systems. In section 6.5 a scenario is looked at where IOS providers have to decide whether they should aim for competitive advantage by relying on proprietary standards or whether they should share development costs by supporting an open standard. This scenario can also be formalized in terms of the Prisoner's Dilemma.

Users benefit from the noncooperative equilibrium in the first scenario. If the IOS providers compete directly on user benefits, e.g., by charging less, the users can expect to increase their aggregate utility. At the same time we should expect declining returns from the IT-investment on the part of the suppliers. A different situation arises in the second scenario. The issue of proprietary vs. open standards has direct effects on the users' utility because of the network externalities. The incorporation of not only the perspective of the competing IOS providers, but also the interests of the users of the IOS, suggests a way to 'solve' the Prisoner's Dilemma in this situation.

Finally, in section 6.6 the case of automatic teller machines is used to illustrate some of our results.

6.2 IT-Investment and competitive advantage

6.2.1 A characterization of competitive advantage

Competitive advantage denotes the ability to obtain returns on a firm's investments that are better than normal in a given industry. In the simplified setting of two competitors competitive advantage and disadvantage can be described in terms of an imbalance between the returns of the competitors.

From an abstract point of view each competitor may try to seek above normal returns on his investments or be content with normal returns. We first generalize the one-shot game of section 5.2.1 where competitive advantage resulted if one competitor increased user benefits while the other competitor did nothing. In terms of our model the competitive advantage was due to users switching to the IOS with the increased user benefits.

Let us start the analysis with the simplifying assumption that both competitors have the same cost and return structures. A competitor who achieves competitive advantage due to an IT investment will have the return from competitive advantage

Scenario 1	*do not seek comp. adv.*	*invest into IT for comp. adv.*
do not seek comp. adv.	$(0,0)$	$(-L_{comp.disadv.}, R_{comp.adv.} - C_{IT})$
invest into IT for comp. adv.	$(R_{comp.adv.} - C_{IT}, -L_{comp.disadv.})$	$(-C_{IT}, -C_{IT})$

Figure 6.1 To seek or not to seek competitive advantage through IT investments

minus the cost of the investment, $R_{comp.adv.} - C_{IT}$. Assuming the investment decision to be rational implies that

$$R_{comp.adv.} - C_{IT} > 0. \tag{6.1}$$

In this case the other competitor faces a loss from the competitive disadvantage, $-L_{comp.disadv.} < 0$. We shall assume that this loss is higher than the costs for the IT-investment, i.e.,

$$-L_{comp.disadv.} < -C_{IT}. \tag{6.2}$$

If both competitors invest into IT at the same time, neither competitive advantage nor disadvantage is incurred, while both competitors face the cost of the investment. This corresponds to the situation in our model, where the simultaneous increase in user benefits does not change the competitive position of the IOS providers. It should be noted at this point that not every simultaneous investment into IT necessarily leads to a net cost for the competitors. The benefits from the IT investments may lead to increased benefits for provider and user of the technology. In fact, this is the case of normal technological progress. In the following, we shall concentrate on situations where a failed quest for competitive advantage is associated with costs. Thus, we are faced with a game with the payoffs for the four possible combinations of moves and countermoves as in figure 6.1. The constants can be ordered as follows.

$$R_{comp.adv.} > 0 > -C_{IT} > -L_{comp.disadv.} \tag{6.3}$$

The similarity of the game in figure 6.1 with the game in section 5.2.1 is obvious.

The most elementary game has both competitors make a simultaneous choice under complete information on the payoff matrix. A rational procedure is to look for choices where the competitor would not want to change his choice of action. More specifically, a Nash equilibrium denotes a strategy where both competitors would not want to change their choice after their opponent's choice. The only pure-strategy[2], Nash equilibrium in the above game is for both competitors to seek competitive advantage through IT as can be easily seen: If the first competitor decided not to seek competitive advantage through IT, the second competitor would gain a competitive advantage by investing into IT. The strategy to seek competitive advantage dominates the strategy to cooperate and not to seek competitive advantage in the matrix, as payoffs from competitive advantage are higher than the payoffs from cooperation. If the first competitor decided to seek competitive advantage through IT, the second competitor can only avoid the losses from a competitive disadvantage by investing too. Because of the symmetry of the game we have found a Nash equilibrium.

With regard to interorganizational systems it is important to note that, if the quest for competitive advantage is characterized by a scenario where IOS providers compete on increasing user benefits (see section 5.2.1), the Nash equilibrium implies that users benefit from the competition. From the IOS providers point of view, however, cooperation may be beneficial.

6.2.2 Relating the quest for competitive advantage to the Prisoner's Dilemma

The Prisoner's Dilemma

The game of making an investment into IT for competitive advantage as delineated above is an instantiation of the famous Prisoner's Dilemma. The nickname

[2]Pure strategies do not allow a mixed choice from the action set with different probabilities given to each action choice.

Prisoner's Dilemma is attributed to A. W. Tucker and derives from the following anecdotal illustration of the game.

> Two prisoner's who are suspected of having committed a crime are interrogated separately by the police. If both maintain silence, at most they can be booked on a minor charge. Each is encouraged to incriminate the other with a promise of leniency if he is not himself incriminated. If they double-cross each other, they are both in trouble.
> (Shubik 1989, p. 254)

Shubik (1982, p. 284) gives the following payoff matrix for the Prisoner's Dilemma.

$(5,5)$	$(-5,10)$
$(10,-5)$	$(0,0)$

Now let $C_{IT} = 5$, $R_{comp.adv.} = 10$, $L_{comp.disadv.} = 10$. We then obtain the following matrix.

$(0,0)$	$(-10,5)$
$(5,-10)$	$(-5,-5)$

This matrix is equivalent for game-theoretic purposes to Shubik's matrix as a linear transformation of adding the constant 5 to each payoff does not affect the differences between the payoffs.

Rapoport and Chammah (1965) give a generic description of the Prisoner's Dilemma's payoff matrix. Let the players have the choice between *cooperate* and *defect*. If they both cooperate, they obtain an reward R. A player who cooperates while the other player defects gets the sucker's payoff S. The defecting player who gets away with it gets the temptation payoff T. Finally, if both players defect, they are punished with payoff P. In order to have a Prisoner's Dilemma situation the

following relations have to be satisfied.

$$T > R > P > S \tag{6.4}$$

Equation 6.3 fulfills this condition with the obvious substitutions. The payoff matrix then has the form given in figure 6.2.

Prisoner's Dilemma	*cooperate*	*defect*
cooperate	(R, R)	(S, T)
defect	(T, S)	(P, P)

Figure 6.2 The generic Prisoner's Dilemma

Although we have only looked at one-shot games so far, iterations of the Prisoner's Dilemma have attracted a lot of interest. For their study it is useful to introduce another constraint, namely

$$2 * R > S + T \tag{6.5}$$

This constraint aims at reducing the available forms of collusion to only one option. If $S + T \geq 2 * R$, there is another form of collusion in addition to the option of both players choosing to cooperate. In this case players in a repeated game might choose to alternate between *(cooperate, defect)* and *(defect, cooperate)*, thus obtaining with each alternation at least the payoff $2 * R$. The constraint in condition (6.5) implies that an even chance of exploitation and being exploited is not as good an outcome for a player as mutual cooperation, thus making mutual repeated *(cooperate, cooperate)* the only reasonable option for collusion in the repeated version of the Prisoner's Dilemma.

The Prisoner's Dilemma has attracted a lot of interest in the literature because it is a poignant example of a game where individual rationality leads to a worse outcome for all players than is possible. Thus, the self-interest by each turns out to be nonoptimal for all. That is why the term 'dilemma' is quite appropriate for

this game. Rapoport and Chammah (1965, p. 23) point out that the Prisoner's Dilemma constitutes an example of a situation where the "applicability of game theory as a normative (or prescriptive) theory" is limited. This does not imply that game theory looses its power as a tool for analyzing logical structures of conflicts of interest. However, it suggests that we may have to take a non game-theoretic perspective to 'solve' the Prisoner's Dilemma.

Interpretation of the basic Prisoner's Dilemma in the context of IT investments

Returning back to our scenario, that faces the manager with the decision whether to seek competitive advantage with an IT investment, the Prisoner's Dilemma is an elegant way of explaining the increasingly common observation of continued investment into IT becoming a strategic necessity. This scenario shows how the original motivation for the IT investment, the quest for competitive advantage, is negated by the parallel investments by all competitors. The structure of this game can now give us further clues as to the type of environment where we should expect to see investments into competitive advantage turn into strategic necessity.

- First of all, the equilibrium selection assumes complete information by both players on the payoff matrix. This translates into complete information on a competitor's cost and benefit structures in real life. Thus, the environment is characterized by a high degree of transparency.
- Second, the choice of an action is made simultaneously by both competitors.
- Finally, the above game is a one-shot game. Thus, the decision of seeking competitive advantage or not is a matter of survival for the competitors. This suggests a very dynamic environment.

In section 6.3 we review research that relaxes these assumptions and discuss the implications for IT investments.

Regarding the assumptions of complete information and simultaneous choice it is elucidating to incorporate some observations on the nature of current IT use. First of all, IT use is becoming increasingly more complex. While hardware costs have decreased rapidly, information systems design and software costs have gone up considerably. Common requirements of user friendliness of applications and incorporation of graphics, for example, make the development of new information systems more demanding. As a result, the lead times of introducing new IT applications tend to increase. Although fourth generation languages and CASE[3] tools can shorten some phases of the system development life cycle, there still is a substantial lag between acceptance of an IT investment proposal and the time when eventual benefits can be gauged (Clemons and Weber 1990). The complexity and length of development projects of IT applications make it increasingly hard to surprise competitors. This is true especially for interorganizational systems, as in the development of these systems organizational boundaries have to be crossed by definition. The assumption of complete information on the competitor is quite appropriate in this context.

The current introduction of PC based airline reservation system terminals by many CRS providers is a case in point (Belitsos 1988). The complexity of the change of a system architecture makes it difficult to hide such a change. A competitor can hardly be surprised. The lead times of developing an interorganizational system are especially long because of the coordination effort involved. For example, an attempt to connect major manufacturers, distributors and retailers in the German shoe industry with the help of an interorganizational system took more than three years from its conception in 1987 to the eventual implementation in 1990 (Koch 1990). Thus, it is not surprising that IOS competitors can often react to a first mover's investment in IT even before the respective application is introduced to users.[4] Therefore, the assumption of a simultaneous choice makes sense too.

[3]Computer Aided Software Engineering

[4]With IT cost decreasing rapidly, an imitator may even be at a cost advantage.

In the context of IT investments and especially competitive moves by IOS providers this reasoning gives some theoretical support to the hypothesis of Clemons and Kimbrough that "competitive advantage is more rare than strategic necessity" (1986, p. 105). The reverse implication of this reasoning is that a necessary condition for competitive advantage through information technology requires the ability of a competitor to avoid the simultaneous game described above. A competitor who can rely on resources that cannot be matched by a competitor is in this position. A good example is the Cash Management Account (CMA) system by Merill Lynch. It took competitors nine to eighteen months to respond with similar systems.

In order to check the robustness of these results we look at different extensions of the Prisoner's Dilemma in the next section.

6.3 Extensions to the Prisoner's Dilemma

6.3.1 Repeated games

In many environments competitors will have the chance to take multiple decisions over time regarding whether to aim for competitive advantage against a competitor through IT-investment. Thus, we now relax the assumption of a one-shot game and look at a repeated version of the basic game in section 6.2.1. One has to distinguish between finitely and infinitely repeated games.

Finitely repeated games

In a finitely repeated game it is easiest "to start by understanding the end of a multi-period game, where the future is shortest". (Rasmusen 1989, p. 88) In the last iteration of the game both players will try to achieve competitive advantage following the same reasoning as in the one-shot game. As the players will not cooperate in the last period anyway, there is no point in building a reputation in previous games. By a process of backward induction it is clear that the unique

perfect equilibrium outcome of the finitely repeated Prisoner's Dilemma has both competitors aiming for competitive advantage in each period. Thus, backward induction effectively eliminates the possibility for cooperation. This phenomenon is known in the literature as the 'Chainstore Paradox'. (Rasmusen 1989) One way to avoid this paradox is the incorporation of incomplete information.

Incomplete information in the repeated Prisoner's Dilemma

One way to avoid the defection equilibrium of the repeated Prisoner's Dilemma is to incorporate incomplete information. This has been shown by Kreps, Milgrom, Roberts and Wilson (1982).

Let us first look at a strategy that punishes defection immediately.

Tit-for-tat strategy

1. Start with *cooperate.*
2. In period n, $n > 1$, choose the action of the competitor in period $n - 1$.

Both players playing tit-for-tat is no perfect equilibrium under complete information: Assume that one player chooses to *defect.* In this case, a painful alternation of defections results. If the other player had not punished the first player's defection and deviated from the tit-for-tat strategy by choosing to *cooperate*, a higher payoff would have resulted. Thus, it is not rational for the second player to punish the initial defection. Under complete information tit-for-tat is not a rational strategy.

However, the assumption of the existence of a few irrational players may make sense in reality. In the model by Kreps et al. some players are unable to play any strategy but tit-for-tat and many firms pretend to be that type. They introduce incomplete information into their model by assuming with a small probability that one of two players is a tit-for-tat player. The model then looks for a perfect Bayesian equilibrium. As the modeler has to check all out-of-equilibrium subgames in addition to the equilibrium path for finding a perfect Bayesian equilibrium, it is easier

to characterize the outcome than actually determine the equilibrium. In this case it can be shown that the number of periods where the players resort to defection is independent of the number of periods of the game. However, this characterization encompasses a multiplicity of equilibria and makes it difficult to derive normative implications from the model.[5] The problem of multiple equilibria becomes even more pronounced in infinitely repeated games.

Infinitely repeated game

In an infinitely repeated game or a game where the number of repetitions is unknown, backward induction is not applicable. In choosing their present actions players have to take account of the fact that they may meet their opponents again in the future. The "future can therefore cast a shadow back upon the present and thereby affect the current strategic situation" (Axelrod 1984, p. 12). Depending on the weight of the next move relative to the current move, room arises for the development of mutual cooperation. The discount rate specifies this weight. The present value of payoffs of an event in the future decreases the further away the event is. Clearly, a high discount rate reduces the importance of repetitions of the game.

[5] Milgrom and Roberts (1987) give an overview of the problems involved in models with asymmetric and incomplete information.

An equilibrium can now be found easily. For example, a simple perfect equilibrium for the infinitely repeated Prisoner's Dilemma is the situation where both players adopt the "grim strategy" (Rasmusen 1989, p. 91).

Grim Strategy

1. Start by choosing *cooperate*
2. Continue to choose *cooperate* unless some other player chooses to defect, in which case choose *defect* forever thereafter.

However, this is not the only possible equilibrium. There now exist a multitude of equilibria. As indicated by the so-called 'Folk Theorem' (Rasmusen 1989, p. 92) the multiplicity of equilibria in the infinite game allows not only the above perfect equilibrium of eternal cooperation but also practically anything else, including eternal defection. Not surprisingly the strategy of eternal defection becomes more attractive with an increasing discount rate.

In summary, the multiplicity of equilibria makes the claim of a certain behavior of players arising as a perfect equilibrium in the infinitely repeated game rather meaningless. For our interpretation it is important, however, to note that it is necessary for the development of cooperation that there is a continuing chance of interaction. Moreover, one has to realize that this is not a sufficient condition. Identifying additional factors in the evolution of cooperation thus is an interesting research phenomenon which has been addressed primarily by psychologists.

6.3.2 A psychological perspective

The starting point for psychologists is that human subjects, who play the Prisoner's Dilemma in experiments many times in succession, provide another perspective on the 'solution' to the Prisoner's Dilemma. The Prisoner's Dilemma, "a nonzero-sum game where the "best" decision remains ambivalent" (Rapoport and Chammah 1965, p. 24), is of interest to psychologists as a situation where mixed motives play

an essential part. The Prisoner's Dilemma has formed the basis for experimental studies ranging from the existence of aggression in career-oriented women to the consequences of different thinking styles.[6] Many experiments have studied the level of cooperation obtained when subjects are playing the iterated Prisoner's Dilemma against programmed strategies, such as tit-for-tat or the grim strategy from above (Oskamp 1971). The results are useful for identifying guidelines for managers that are caught in a Prisoner's Dilemma like situation.

- Not surprisingly do high levels of cooperation in the programmed strategy produce significantly more cooperation from subjects than lower levels.
- Small differences in cooperation levels do not usually produce significant differences in the subject's cooperation levels. This points at the necessity to signal the desire to cooperate clearly.
- A contingent strategy, such as tit-for-tat, produces significantly higher levels of cooperation by the subjects than a noncontingent strategy with the same level of cooperation.
- Tit-for-tat is especially interesting because it also results in significantly more cooperation than free play, where two groups of subjects play against each other without any predetermined strategies. This emphasizes the importance of these results for real-life situations that usually correspond to free play.
- Early trial outcomes are particularly important as one can identify 'lock-in' effects of mutual cooperation *and* mutual defection.

These results illustrate the need for a comprehensive plan for the strategic use of IT investments. If a company seeks cooperation with competitors on IT developments, it is necessary to signal this intent through appropriate behavior early on. Further

[6] Axelrod (1984) and Rapoport and Chammah (1965) give further references to this line of literature.

help as to how to do this effectively can be obtained from an interpretation of an approach to the repeated Prisoner's Dilemma through computer experiments. The goal of these experiments is to reveal how to play the game well. In contrast to most other psychological experiments, the participants in those experiments are not players that see the formal game for the first time. Rather the emphasis is on finding out how experts play the game.

The most famous experiment is the tournament described by Axelrod (1984). In this tournament 14 programs implementing different strategies for a 200-repetition game played against each other and the winner was chosen according to the sum of payoffs over all playoffs. The winning strategy turned out to be the tit-for-tat strategy.[7]

It is interesting to note that tit-for-tat is only suboptimal for any given environment, i.e., that tit-for-tat tends not to beat other strategies in a one-to-one contest. Tit-for-tat won by robustly scoring high, though not the highest, payoffs through cooperation. Earlier laboratory experiments also have pointed at the robustness of tit-for-tat as a strategy for scoring high on the average (Wilson 1971). Yet it should be emphasized that the success of cooperation until provocation is the best approach to the iterated Prisoner's Dilemma only when the goal is maximization of payoffs. Behr (1981) has reinterpreted the Axelrod tournament results when other policy objectives are important. His most important finding is that occasionally taking advantage of cooperative opponents is most successful when the goal is consistent victory or maximum average margin of victory. This has an interesting interpretation in the context of competitive IT investments. If victory denotes for example an increased market share, it may well be reasonable for a player in our game of competition involving IT to *defect* occasionally rather than just maximize his average payoff. Factors affecting the decision to *defect* in this case are the

[7]Tit-for-tat also won in a modified tournament with 62 programs where a probability of 0.00346 that the game would end after each round was added.

relative weight given to the payoff that results from periods of cooperation and the severity of expected retaliation.

Axelrod traces the success of the tit-for-tat strategy to three factors.

- **Niceness:** It never starts defecting.
- **Provokability:** Any defecting of the opponent is immediately punished.
- **Forgiveness:** Once an opponent stops defecting, the strategy starts choosing cooperation again too.

It should also be noted that tit-for-tat is very easy to recognize. The clarity of the strategy is beneficial when opponents try to probe the strategy initially before choosing their end-game strategy. Axelrod has found a good performance of the tit-for-tat strategy across a number of different environments. This supports the robustness of the tit-for-tat strategy.

Interpreting the above attributes of the tit-for-tat strategy in the context of the quest for competitive advantage is fairly straightforward.

- Niceness basically implies that one should abandon the quest for competitive advantage if there is the danger of the IT investments becoming a strategic necessity. The idea is to establish an atmosphere for possible cooperation early on. Trade organizations may serve as means for communicating this 'niceness'. In general, clarity as to the intentions of the IT investments is necessary. Communication between the competitors thus is essential.
- Provokability requires first of all the ability to retaliate. Thus, one has to counter early on any competitive moves that may become irreversible. Again a credible commitment to retaliation is necessary. A company without the resources for effective competitive moves cannot communicate provokability credibly. In fact, in the context of interorganizational systems a provider has to be able to demonstrate the potential capability to execute the competitive moves of our framework in chapter 4. In terms of the various possible

Asymmetric Prisoner's Dilemma	*cooperate*	*defect*
cooperate	(R', R)	(S', T)
defect	(T', S)	(P', P)

$$T > R > P > S \tag{6.6}$$

$$T' > R' > P' > S' \tag{6.7}$$

Figure 6.3 The asymmetric Prisoner's Dilemma

executions of the competitive moves, this requirement may translate into the need for current technological expertise, financial resources and even legal resources.

- Finally, the effectiveness of forgiveness in establishing cooperation depends again on the clarity of the communication between the competitors. The offering of collusive agreements where possible is one way of demonstrating forgiveness. Section 6.4 expands on some problems involved with the observation of collusive agreements.

In summary, the previous research on the Prisoner's Dilemma indicates that choosing to *defect* is the only equilibrium, if players are rational and that rationality is common knowledge. However, given irrational players (in the game theoretic sense) or the assumption that some players are irrational by other players, no optimal strategy exists. Tit-for-tat, however, is a robust and suboptimal choice for any given environment.

6.3.3 Asymmetric payoffs in the Prisoner's Dilemma

For reasons of completeness we now relax the assumption of both competitors having the same cost and benefit structures. In fact, the reasoning underlying the determination of Nash equilibrium does not require symmetric payoffs of the players. In a more general setting one can look at the matrix in figure 6.3.

The interesting implication of the Nash equilibrium of eternal defection in the finitely repeated game in this type of game is that the asymmetric payoffs may make it impossible to survive repeated nonoptimal payoffs. In fact, this reasoning ties in with the description of the war of attrition in section 5.2.2 so that no further explanation is necessary at this point.

6.4 Observing collusive agreements

The conflict between individual rationality and collective rationality in the Prisoner's Dilemma makes cooperation among competitors and collusive agreements a natural issue. In a cooperative game the solution to the Prisoner's Dilemma is chosen according to the collective interest. However, it has to be noted that an agreement in a cooperative game has to be enforceable in order to make a difference in the choice of the strategies. As an example, Rapoport and Chammah (1965) cite the extremely severe underworld sanctions against squealing as an example for the application of sanctions as a means of enforcement of an agreement. As all the payoffs in the game matrices are assumed to be calculated as net payoffs, it is clear that a prisoner not only has to incorporate the payoffs from the original payoff matrix into his decision but also the consequences of the enforcement of any previous agreement. In fact, this leads to another payoff matrix determining the choice.

A similar approach is the imposition of a tax on defection. This idea comes from research on the allocation of a public good. (Tideman and Tullock 1976, Clarke 1980) The Prisoner's Dilemma in this context is the problem of the free rider. A solution is the introduction of incentive taxes that ensure correct demand revelation. The incentive tax allows "each person to accept the choice made by all other persons or change the result by paying the cost to others of doing what that person wants done instead of what would otherwise be done" (Clarke 1980, p. 8). In this situation neither of the players can gain more from noncooperation than from cooperation.

To illustrate the effect of changes to the payoff matrix, let us assume a sanction of -15 for breaking an agreement of cooperation in the Prisoner's Dilemma described in section 6.2.2. The original payoff of 10 in the Prisoner's Dilemma matrix in becomes -5, leading to the following matrix.

$(5,5)$	$(-5,-5)$
$(-5,-5)$	$(0,0)$

The strategy of investing for competitive advantage no longer dominates in this game. Obviously, any sanction that is greater or equal than the original payoff from the competitive advantage will guarantee the cooperative outcome.

The problem with this approach is the need for a neutral agency imposing and collecting the tax. In the case of IT investments it is not clear who can fulfill such a regulating role. As mentioned in section 5.3 the attempts by the Civil Aeronautics Board and the Department of Transportation respectively to limit anticompetitive use of airline reservation systems have seen only partial success. However, in the case of interorganizational system users may in certain contexts play an important role as shown in section 6.5.

It is interesting to note that the question of whether to observe a collusive agreement can be viewed again as a Prisoner's Dilemma. Observing the agreement is equivalent to *cooperate*; to *defect* implies cheating on the agreement. The key to the observance of the collusive agreement is that the detering mechanism against not observing the agreement must be clear to all players. Moreover, cheating must be detectable by all players. Thus, perfect and complete information is a necessary condition for collusion to work and emergence of maximized joint profits.

Again, we find the need for clarity in the communication between the competitors a crucial requirement for avoiding the *nonoptimal* outcome of the Prisoner's Dilemma.

6.5 Competitive advantage and standardization of IOS

In this section another scenario relevant to the analysis of IOS competition is introduced. This scenario centers on the question of standards of IOS and cannot necessarily be generalized to all types of IT.

The issue of standardization is an important issue for the analysis of cooperation and competition between IOS providers. An IOS provider seeking competitive advantage with the help of the IOS will want to keep the IOS proprietary. On the other hand, providers of IOS may share development costs and establish an open standard by cooperating. The IOS then is viewed not as a source of competitive advantage but as an infrastructure resource.[8]

The problem of interest now is whether to aim for a proprietary standard or opt for an open standard. This problem again contains the question of whether to seek competitive advantage or not, but with a different set of actions than in the previous scenario.

The payoff matrix is very similar to the payoff matrix in the first scenario. Let S_{IT} denote the costs of supporting a shared or open standard, while C_{IT} denotes the costs of a proprietary standard. We assume

$$R_{comp.adv.} > -S_{IT} > -C_{IT} > -L_{comp.disadv.}. \tag{6.8}$$

This assumption parallels assumption 6.3. Figure 6.4 gives the corresponding payoff matrix.

In the first scenario users profited from the noncooperative equilibrium and had no incentive to intervene. In this scenario, however, the question of standardization

[8]Note that this form of cooperation does not imply that the IOS providers cooperate at all levels of their business activity. Thus, this form of cooperation need not imply that the negative effects of the lack of competition, as pointed out, e.g., by Porter (1990), have to arise.

Scenario 2	*support open standard*	*invest into proprietary standard for comp. adv.*
support open standard	$(-S_{IT}, -S_{IT})$	$(-L_{comp.disadv.}, R_{comp.adv.} - C_{IT})$
invest into proprietary standard for comp. adv.	$(R_{comp.adv.} - C_{IT}, -L_{comp.disadv.})$	$(-C_{IT}, -C_{IT})$

Figure 6.4 Shared vs. proprietary IOS standards

affects directly the network externalities of the systems and the users' perspective becomes relevant. Thus, we shall analyze the provider's and the user's point of view separately in the following.

6.5.1 The provider's point of view

From the provider's point of view another instantiation of the above problem of competitive advantage vs. strategic necessity has to be faced. Figure 6.5 gives a framework for the provider's perspective.

Provider's Strategic Grid	*cooperate on IOS development*	*seek competitive advantage*
cooperate on IOS development	possibility for coordinated joint standard	risk of losing to proprietary standard
seek competitive advantage	chance of winning with proprietary standard	competing proprietary standards

Figure 6.5 The supplier's perspective: proprietary vs. open standards

Figure 6.5 reflects a Prisoner's Dilemma matrix if the payoff for both providers from competing on proprietary standards is less than sharing development costs for a joint standard. Moreover, the payoff from a competitive advantage that is based on a proprietary standard exceeds the payoff from the cooperation. Similarly, the competitive disadvantage faced by a competitor, whose attempt at cooperation did not prevent the opponent from establishing a successful proprietary IOS, implies a

payoff less than the payoff from a head on competition. Thus, the above discussion of the Prisoner's Dilemma applies to this case.

6.5.2 The user's point of view

The users of the IOS are by definition participants of the system with some control over the system's use. Thus, the users add another necessary dimension to the analysis. From the users's point of view the existence of switching costs between IOS and network externalities give the problem a non-competitive aspect. In addition one has to take the problem of monopoly power into consideration.

If the providers compete with proprietary standards, the model in chapter 4 points at the lower benefits from network externalities in both systems compared with users only on one system. In fact, users need not be on the same system in order to obtain the benefits of high network externalities. It is sufficient for both systems to be compatible. Two IOS based on the same open standard allow users, in principle, to use both systems and harness the combined network externalities of both systems.

An example can be given from retailing where users of IOS based on the same standard may use their terminal to connect to various IOS. This requires compatibility of protocols and interfaces of the IOS. In this case users may enjoy higher network externalities through extended options for discounts based on order pooling. Another example from the airline reservation systems case comes to mind immediately. Travel agents that can use their terminal to access the databases of more than one CRS have a higher return from their use of the IOS than travel agents who can only access one database due to the increase of information available.

In the case of a proprietary IOS gaining competitive advantage and cornering the market users can be either on the system of the winning or the losing system. Losing to a proprietary standard from a provider's point of view translates into incurring switching costs to another standard for the users of the losing system. On

User's Strategic Perspective	*cooperate on IOS development*	*seek competitive advantage*
cooperate on IOS development	high network externality	risk of facing switching costs to other standard
seek competitive advantage	danger of monopoly due to lock-in	low network externality

Figure 6.6 The user's perspective: proprietary vs. open standards

the other hand, users on the winning proprietary IOS face the danger of monopoly power of the provider of the winning IOS.

The interesting observation regarding the payoffs for the users for the actions of the providers is that for users of both systems the cooperation of the IOS providers to establish an open standard is the preferred outcome. Figure 6.6 summarizes the user's perspective for the same actions taken by the providers as in figure 6.5.

6.5.3 A solution to the Prisoner's Dilemma in the IOS case

The discussion of the user's perspective suggests a possible 'solution' to the Prisoner's Dilemma in the second scenario. As users are affected by the actions of the IOS providers, they in turn enter a game with the providers. In this game it is being decided whether the socially beneficial form of the IOS is supported through a cooperation of the IOS providers. Thus, users have an incentive to influence the IOS providers. This can be the lever to solve the Prisoner's Dilemma of the providers in situations similar to scenario 2.

Users may enforce the cooperative solution. A potent means of enforcement is the threat of establishing an independent system. To make this threat credible a strong user organization is necessary. The growing power of users that can be seen in the computer industry may indicate such a trend (Hodges 1989). A current example in the area of IOS is the recent attempt by e-mail network users to force

the providers, such as, GE or MCI to cooperate and ease communication between users of different networks.

6.6 Conclusion

In the conclusion, we now take a closer look at the case of automatic teller machine (ATM) networks. It turns out that the above interpretation of the Prisoner's Dilemma helps in understanding why the quest for competitive advantage with ATM networks resulted in strategic necessity. Although ATM networks in the banking industry today constitute a major strategic asset, these ATM networks have not fulfilled their original promise of competitive advantage.

In trying to understand the network externalities at play in this case, one also has to take account of the option of a bank to join an already established network of another bank. The results on competitive advantage vs. strategic necessity that have arisen out of the analysis of scenarios of competition in our model can be reevaluated in the context of current ATM networks.

Clemons (1989) has documented the experience of Philadelphia National Bank that provides striking parallels to the results of this dissertation. Philadelphia National Bank (PNB) today owns and operates the largest single-owner shared ATM network in the U.S., called MAC. However, it is interesting to note that the shared MAC network originated in response to another network of a competitor that aimed at competitive advantage. In 1976 Girard, a major competitor of PNB, introduced the first widely used network of teller machines in Philadelphia. The wide usage of the Girard network was possible because of Girard's existing strength in retail banking. The Girard network was aimed at competitive advantage, as can be seen from the fact that Girard designed the system as a closed network not allowing other banks to participate in the development or share the ATM use.

A study by PNB concluded in 1977 that a proprietary ATM network by PNB could not become a meaningful ATM offering in terms of access for PNB's retail

customers. PNB's minor retail presence made it especially hard to justify a proprietary ATM network. On the other hand, bank officials saw the necessity to respond to Girard's network in order not to loose their market share in retail banking. Realizing that other banks were in a similar position of having to answer to a strategic necessity, PNB decided to develop a nonproprietary ATM network. Participating banks could make use of a generic service ATM network that was implemented in 1979. PNB remained the sole owner of the MAC network, but guaranteed a "long term commitment to develop MAC and to maintain it as a truly generic multi-bank offering despite its sole ownership" (Clemons 1989, p. 218).

The disadvantage of remaining caught in the Prisoner's Dilemma in the quest of competitive advantage can be illustrated with the example of Provident National Bank in 1977. Provident responded to the Girard network by an own proprietary network. However, in contrast to the shared PNB network Provident could only harness the network externalities involving its own retail banking customer base. In 1982 the Provident network comprised about 80 ATM while the MAC network was accessible from over 400 machines. As retail banking customers face only moderate switching costs and as access to bank services is a major factor for customer benefits, our model would predict a switching of users of Provident's network to the MAC network. In fact, in 1985 Provident joined the MAC network abandoning its quest for competitive advantage through its proprietary network.

With easy access to machines being the main factor for the users' utility of the system, it is clear that we should expect most of the competition between the ATM networks to occur through increases in network externalities of the systems. This clearly favors the shared networks over the proprietary networks. Thus, it comes as no surprise that the originally proprietary Girard ATM network eventually also allowed other banks to participate. It should be duly noted, however, that this move has to be seen in the context of the acquisition of Girard by Mellon, a bank that already owned a shared network called CashStream.

The last development of importance for the interpretation of our results is the decision by Mellon not to compete further in the management of local ATM networks in 1988. CashStream tellers effectively joined the MAC system (Fix 1988). This was beneficial from the customer's point of view in that a consolidation of the two networks allowed economies in advertising, greater coverage and increased simplicity in identifying an eligible ATM. A Senior Vice President of the holding company of PNB, Bonnie E. Hill, describes the consolidation as beneficial for all participants (Fix 1988, p. C 9).

> We don't see this as a win-lose situation. It's good for all the parties – both networks, banks participants, and, ultimately, consumers.

Clemons stresses the role of users in the joining of the networks. "CashStream's customers wanted the sale to go forward" (Clemons 1989, p. 220).

A similar trend of increasing the network externalities of ATM networks can be witnessed in the merging of other local ATM networks. Chicago's two biggest ATM networks – Cash Station and Money Network – merged in 1988 and four major networks in the Southeast – Avail, Honor, Relay and Most – announced plans to merge their operations in 1989 (Cohen 1988, Mallory 1989). At the same time the biggest domestic ATM networks – Cirrus and Plus System – are striving to expand internationally by cooperations with foreign countries (Hirsch 1989).

One final comment is appropriate as to the form of the cooperation. In the case of PNB as sole owner of MAC, PNB sells services to numerous industry participants. The servicer yields economies of scale and network externalities are increased for customers. For the interpretation of our results it is sufficient that the network externalities are increased for the users independent of whether this is achieved with a servicer, a consolidation, a consortium or a coalition (Clemons 1989, Sager 1989).

In summary, this chapter has highlighted the danger of investments into IT becoming a strategic necessity rather than resulting in the intended competitive

advantage. The Prisoner's Dilemma is an aesthetically pleasing paradigm for looking at this problem. It provides a theoretical basis for the notion that we are more likely to see strategic necessity than competitive advantage in the case of IT investments. The extensive research on the Prisoner's Dilemma allows us to obtain a better understanding of the strategic implications of this situation.

Chapter 7

Conclusion

7.1 Summary

In this dissertation we have addressed the problem of interorganizational information systems using a formal modeling approach. The emphasis in the research has been on gaining a better conceptual understanding of the costs and benefits of IOS, the opportunities and dangers for IOS providers and the impact on IOS users.

Introduction of a vertical IOS

The first model in chapter 3 analyzed the introduction of a single vertical IOS between a manufacturer and his suppliers. Factors were identified that influence the introduction of an IOS between a manufacturer and his suppliers. The model emphasized efficiency benefits as first order factors influencing the introduction of a vertical IOS. Suppliers were ranked according to their transaction volume with the manufacturer, as efficiency benefits tend to be directly proportional to the transaction volume. In addition to efficiency benefits, the notion of process benefits, i.e., benefits that accrue to a manufacturer due to changes in internal processes made possible by the IOS, was introduced. Process benefits were used to explain how a manufacturer may be able to pressure suppliers with small transaction volume into joining the system. The IOS introduction was shown to have very different effects on the profits of suppliers depending on their transaction volume: Small volume

suppliers are faced with profit extraction by the manufacturer, while suppliers with a big transaction volume will benefit from the introduction. Thus, the introduction of an IOS may change power considerably in existing business relationships. Based on this model normative guidelines for the introduction of a vertical IOS were derived.

Competing IOS

While the first model had concentrated on a single IOS, the second model analyzed two or more competing IOS in chapter 4. Switching costs and network externalities associated with IOS formed the basis for this model. The model explained the coexistence of two IOS of different value to homogeneous users. The model was extended to include nonhomogeneous users in terms of their switching costs which made it possible to demonstrate the danger of bandwagon effects and the dynamics of selective sponsoring. The extension of the model to more than two competing IOS pointed at the importance of coalition building between IOS providers.

From the model a framework of generic competitive moves was derived for an IOS provider. The model demonstrated that market share has only a limited function as an indicator of the effect of a competitive move. Thus, a new indicator was defined and the effects of the competitive moves from the framework were discussed in terms of this indicator.

Formal scenarios of competition were analyzed in chapter 5 with the help of game theory. The limited competitive use of adapters was shown. In a limited setting it was demonstrated that investment into users' benefits did not result in competitive advantage but rather in a strategic necessity for the investment by the IOS providers. In a repeated version of this game with fixed budgets for IOS investments, an opportunity for collusion between the IOS providers was identified.

Finally, the model formed the basis for a historical analysis of the competitive use of airline reservation systems in section 5.3.

Competitive advantage and strategic necessity

In chapter 6 the problem of competitive advantage due to information technology investments versus strategic necessity of such investments was analyzed. A general pattern in this conflict was identified and the problem was linked to the Prisoner's Dilemma of game theory. As the equilibrium outcome in the Prisoner's Dilemma is not pareto optimal for the actors, the issue of cooperation was raised.

Two scenarios relevant for the study of IOS were considered in more detail. The first scenario, motivated by the previous chapter, centered on the quest for competitive advantage by investing into user benefits. The second scenario addressed the issue of standardization of IOS. The driving assumption was that proprietary standards can be used for obtaining competitive advantage, but result in higher costs than shared development of a joint standard. Both scenarios were formalized as instantiations of the Prisoner's Dilemma. Thus, the results from the Prisoner's Dilemma implied that the Nash equilibrium outcome was not optimal for the IOS providers in both cases. Looking at different versions of the Prisoner's Dilemma showed that the problem cannot be solved within the limits of game theory. By drawing on psychological research on the Prisoner's Dilemma, conditions were identified that support cooperation between the competitors.

In the context of interorganizational systems the existence of two groups of participants, providers and users, suggested the handle for another possible solution. It was posited that users with a high interest in the cooperative outcome of the Prisoner's Dilemma have an incentive to provide the coordinating mechanism between the competing IOS providers. Thus, while users in the first scenario benefited from the competition of the providers, they would want to avoid the lower network externalities associated with the competing proprietary standards in the second scenario.

The case of ATM networks was reviewed to illustrate this reasoning.

7.2 Opportunities for further research on IOS

7.2.1 Opportunities for empirical work

Validating the models

We have supported the assumptions underlying our research by referencing cases of EDI use in chapter 3, airline reservation systems in chapter 5 and ATM networks in chapter 6. These cases provide a promising basis for empirical research on interorganizational systems.

In addition, electronic mail networks, such as, the services offered by MCI, GEISCO or CompuServe are interesting examples for the empirical study of the role of users of IOS in influencing standardization.

While this dissertation has focused on interorganizational systems, an extension of the models beyond this focus holds promise. The computer industry comes to mind as a possible area of applicability for the results from chapters 4, 5 and 6. The computer industry in each of its segments provides examples of the existence of switching costs in the presence of network externalities. In particular, indirect network externalities arise as independent suppliers of software and accessories closely look at the installed base of machines of a certain type. The role of adapters in the form of extension boards with different architecture processors, software emulators and multiple format disk drives may be interesting to analyze with regard to their ability to offset the installed base advantage of big competitors.

Implementation issues

A major hurdle in the implementation of IOS is the lack of skills necessary for introduction, control, maintenance and adaptation. Not only does an IOS cross an organizational boundary, these skills must cross organizational boundaries too. This poses an interesting technology management problem that calls for empirical investigation. It would be valuable to identify common problems encountered in

all phases of the introduction of interorganizational systems. This could lead to practical guidelines for managers that have to confront these problems. Results on types of organizational interdependence and interorganizational policy implementation from organizational theory and political science research (O'Toole and Montjoy 1984) pose this issue in a larger context and may constitute a starting point for a framework that concentrates on the implementation of interorganizational systems.

Implementation issues become more complicated when interorganizational systems cross national boundaries. Transborder flow of information can create an imposing set of technical, organizational, legal, and political problems (e.g., Tallackson and Vallejo 1986, Yoder 1988). A comprehensive overview of the current problems involved in international IOS would be a valuable contribution, especially in view of the growing awareness of the global nature of the economy. As little research has been documented in this area, there is ample room for empirical work. Surveys can identify the current spread of international IOS and their importance in different industry sectors. Case studies can then point at problems encountered and solutions found for these.

7.2.2 Third-party providers

An interesting extension to our research could address the question of chances for third-party providers of IOS.

By taking account of technological implementation issues of IOS, the role of third-party providers can be explicitly modeled. The role of third-party providers depends on a hierarchy of services that are necessary for the implementation of an IOS. These services range from the basic provision of communication lines to network management services and the support of mailbox services. The provision of communication lines for an interorganizational system can be based on a wide array of options available ranging from nonexclusive or leased telephone lines to proprietary fiberoptics or microwave networks. A factor that needs to be modeled

is the existence of economies of scale in the provision of communication channels and a technological infrastructure.

Another modeling approach to third-party providers can be deduced from the the model in chapter 3. There we concentrated on the relationship between one manufacturer and his suppliers. Extending this model to more than one manufacturer raises some important problems for the suppliers. A supplier who wants to supply parts to more than one manufacturer has to be able to communicate with these manufacturers through their respective IOS. Especially if a supplier has customers in different industries it is quite likely that the different IOS use different standards. Clearly, the supplier does not want to maintain a multiplicity of data formats internally. In this situation a third-party service may have a profitable chance of doing data conversions in addition to the provision of a communication infrastructure between the organizations. It should be easy to quantify this opportunity by extending the approach of chapter 3. In particular, one needs to compare the costs of supporting multiple IOS for a supplier of parts to multiple manufacturers with the costs of supporting only one internal standard. The focus here is again on transaction volume. Depending on the economies of scale realizable by a third-party service provider one can then explicitly pinpoint the chance for doing profitable data conversions.

One interesting side question arising out of this analysis is the role of third-party providers with regard to the standardization of IOS. If the electronic data interchange for interorganizational systems was completely standardized across industries, the above opportunity for a higher level service offered by the third-party would not exist. Hence, it might be productive to probe deeper into the role of third-party services in the emergence of standards for EDI. We would expect that third-party service providers do not actively push for standards.

7.2.3 IOS as a building block of collective strategy

In most strategic planning research, including strategic IS research, the unit of analysis is the single organization. Organizations are viewed as autonomous actors with a large freedom and latitude to exercise "strategic choice" (Child 1972). This pertains to both corporate strategy and business strategy. Corporate strategy determines the choice of environments to operate in, while business strategy focuses on how to compete effectively in those environments. (Pfeffer 1987) Clearly, IS have become an important factor in both respects. The fact that environments are part of this concept of strategy does not negate the point that organizations are basically viewed as autonomous. Although environments may even be described extensively in terms of number of competitors, market shares, resource access, substitute products, etc., one has to note that these factors tend to be viewed as exogenous (e.g., Porter 1980). They pose external constraints or opportunities that a focal firm has to adapt to. Astley (1984, p. 526) has stressed that "organizations are viewed, basically, as solitary units confronted by faceless environments". Pfeffer expands on this thought. "Although each of these actions affects the environment, the actions are taken within the organization's boundaries and are, in this sense, internal" (Pfeffer 1987, p. 120).

Interorganizational systems can be viewed as just another way to adapt to the environment from an internal perspective. By taking this perspective the competitive use of IOS is quite naturally at the center of attention. However, our results on strategic necessity resulting out of a simultaneous quest for competitive advantage point to potential drawbacks of this perspective. A new perspective on strategic management is called for. Pfeffer has argued that "one important objective of strategic management should be to enhance the firm's interorganizational power" (Pfeffer 1987, p. 123). As interorganizational systems by definition cross company boundaries, it seems that IOS may be a good starting point for incorporating this type of 'network thinking' into the strategic management process. The IOS can then

be viewed as a manifestation of a collaborative strategy. A better understanding of collaborative strategy and interorganizational systems may be reached by investigating the strategic relationships between companies by changing the perspective from a single organization to a network of organizations as unit of analysis.

First, one has to classify relationships in an interorganizational network. Such a classification is likely to lead towards a new understanding of organizational boundaries. Some steps in this direction have been taken already (Miles and Snow 1986, Luke, et al. 1989). Luke, et al. have emphasized that intended permanence and perceived high importance are two necessary conditions for the purposes of interorganizational relationships to be strategic. They define quasi-firms as an organizational form that has a high degree of strategic purpose and a low tightness of coupling. (Luke, et al. 1989, p. 12) IOS may provide a building block for such strategic relationships in that the financial commitment through set-up and learning costs fulfills both conditions for a high degree of strategic purpose. It comes as no surprise that the automobile industry and the health care industry, both industries with innovative IOS use, are most prominent examples of quasi-firms according to Luke, et. al.

The idea of strategic relationships in networks of organizations may have practical implications for the make/buy decisions and vertical integration. IOS as a coupling mechanisms with low tightness but with a high degree of strategic purpose suggest the existence of more options than the internalizing of an activity or externalizing with a market mechanism. In other words, interorganizational systems may not solve the make/buy problem but enhance it by adding more options. The framework by Harrigan (1983) on vertical integration is a good starting point for this type of research. Further research on a taxonomy of strategic purposes of interorganizational systems in a network of organizations is needed.

7.3 The evolution of interorganizational systems

Finally, we attempt to look into the future of interorganizational systems. The understanding of interorganizational systems gained in this dissertation helps in drawing parallels to the evolution of internal information systems. This parallel provides the basis for predictions of the evolution of interorganizational systems. The result is a challenging research agenda.

In the evolution of internal IS one can identify an initial period where IS pioneers were able to introduce IS for competitive advantage. With technology becoming more readily available, information systems tended to become a strategic necessity. This general trend has been identified in scenarios of competition involving IOS in this dissertation.

The key to understanding the evolution of IOS is that this parallel can be extended in another dimension too. Internal IS comprise a variety of applications ranging from payroll processing and accounting systems to executive support systems. The evolution of IS can be analyzed by differentiating along this variety. Initially IS developments were most successful in automating well-structured procedures. First, well-structured procedures are much more easily automated than less-structured procedures. Second and no less important, the potential for cost reductions was greatest in this area, as these activities tend to involve high volumes of transactions. Initially, this type of well-structured transaction processing relied on centralized IS architectures that quickly became a necessary part of all companies.

With increasing sophistication of IT less structured activities became accessible to IS support. They are characterized by a low volume of transactions with a high value or cost per transaction. The output in these problem oriented information systems is less defined than in systems that support or automate well-structured procedures. A wealth of research in the last decade on decision support systems, executive information systems, and executive support systems attests to this evolution. In addition to an increase in efficiency, IS started to be developed to increase

effectiveness of an organization. In terms of an evolution of IS, IS that focus on well-structured activities are the "wave of the past" (Sprague and McNurlin 1986, p. 10). This does not imply that these systems are less important. Rather they have become a strategic necessity. One may think of an *incremental evolution* where IS support started with well-structured activities and increasingly added less structured activities. The idea is not so much that one technology is replaced by another, but rather that new types of IS support are added to the existing ones that have become a common part of the IS portfolio.

In drawing a parallel between the evolution of internal IS and the current and future role of IOS, it is first necessary to determine the current focus of IOS. Most activities supported by IOS today are well-structured activities. In fact, the focus on well-structured data is exactly reflected in the definition of EDI as given in section 2.1. IOS, such as computerized order entry systems and airline reservation systems, aim first of all for increases in efficiency. The emphasis on transaction volume has been an explicit concern of chapter 3.

However, the use of EDI is becoming increasingly common. EDI is used today by fewer than 10,000 U.S. companies. However, the growth rate of installations is about 50% annually, leading to more than 100,000 companies using EDI in 1995 (Dillon 1989). In terms of an evolution of IOS we should thus expect a continuing application of IOS to automate well-structured transactions that cross company boundaries, but at the same time our parallel to the internal IS evolution predicts an increasing interest in IOS that address less structured activities.

In some areas first steps in this direction can be observed already. As mentioned in section 5.3, the providers of airline reservation systems are starting to extend their systems to provide support for the travel agents backoffice. This support is likely to evolve towards support for travel agents in making decisions regarding the management of the travel agency. Decision support systems are likely to be incorporated into these backoffice systems.

This reasoning now suggests a major research agenda. The goal has to be to gain a better understanding of interorganizational systems that support all activities that cross organizational boundaries. This goal calls for combining the research from areas, such as DSS, with research on IOS. Such research is likely to develop new concepts for the use of IOS. In fact, this type of research may give substance to the vision of EDI as a "a general approach to do business electronically" (Silverman 1990). While this dissertation has resulted in a better understanding of IOS mostly ex post, the proposed research agenda will have a more proactive emphasis. We just want to point at one promising area where we see the potential for such a development.

Computer supported cooperative work (CSCW) has attracted a lot of research interest. The concepts and experiments, however, tend to focus on cooperating groups within a single organization, even within a single location. It would be highly interesting to expand the research on CSCW by incorporating the potential of IOS. The idea is to come up with a concept and a prototype of an IOS that allows cooperation between managers in different organization. Some research on semi-structured messages in electronic mail systems by Malone, et al. may be a first building block (Malone, et al. 1987a, 1987b). In the long run, this type of research on new higher-level types of IOS is likely to have profound implications on the way we view work in organizations. The idea of dynamic networks of specialist organizations (Miles and Snow 1986) assumes new importance in this context. Once interorganizational systems allow cooperation on complex tasks, such as design and engineering of products, systems design and programming, new forms of organization can be conceived. This in turn poses new challenges for researchers concerning the evaluation and measurement of the effectiveness of these new forms and the underlying information systems. If these high-level types of IOS cross national boundaries, cultural aspects of cooperation may be studied.

While this dissertation has contributed to a better understanding of current interorganizational systems, it ends with a vision of future interorganizational systems that transcend the current applications. Interorganizational systems are certain to remain an interesting and challenging area for research.

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