ELECTRONIC MARKETS AND ELECTRONIC HIERARCHIES:

EFFECTS OF INFORMATION TECHNOLOGY ON MARKET STRUCTURES AND CORPORATE STRATEGIES

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Abstract

This paper analyzes the fundamental changes in market structures that may result from the increasing use of information technology. First, an analytic framework is presented and its usefulness is demonstrated in explaining several major historical changes in American business structures.

Then, the framework is used to help explain how electronic markets and electronic hierarchies will allow closer integration of adjacent steps in the value added chains of our economy. The most surprising prediction is that information technology will lead to an overall shift toward proportionately more coordination by markets rather than by internal decisions within firms.

Finally, several examples of companies where these changes are already occurring are used to illustrate the likely paths by which new market structures will evolve and the ways in which individual companies can take advantage of these changes.

Electronic Markets and Electronic Hierarchies:

Effects of Information Technology on Market Structures and Corporate Strategies

The innovations in information technologies of the past two decades have radically reduced the time and cost of processing and communicating information. These reductions have in turn brought many changes in the ways tasks are accomplished within firms. Data processing systems have transformed the ways in which accounting data is gathered and processed, for example, and CAD/CAM has transformed the ways in which complex machinery is designed. Underlying (and often obscured by) these changes in how business tasks are performed may be more fundamental changes in how firms and markets organize the flow of goods and services through their value-added chains. This paper addresses that more basic issue of how advances in information technology are affecting firm and market structures and discusses the options these changes present for corporate strategies.

In brief, our thesis is that new information technologies are allowing closer integration of adjacent steps on the value-added chain through the development of electronic markets and electronic hierarchies. (See Figure 1) While these mechanisms are making both markets and hierarchies more efficient, we argue that they will lead to an overall shift toward proportionately more market coordination. Some firms will be able to benefit directly from this shift by becoming "market makers" for the new electronic markets. Other firms will be able to benefit from providing the interconnections to create electronic hierarchies. All firms will be able to benefit from the wider range of options provided by these markets and by the possibilities for closer coordination provided by electronic hierarchies.

After presenting the analytic framework on which our argument is based, we illustrate its usefulness in explaining several major historical changes in American market structures. Then the central part of the paper uses the framework to predict the consequences that changing information technologies should have for our current market structures. In many cases, we are able to identify early examples of these changes that have already occurred for some companies. Finally, we summarize some of the implications of these changes for corporate strategy.

In addition to the changes in information technology that we discuss here, there are, of course, other important forces (such as changes in stock prices, antitrust regulations, and interest rates) that might

affect firm and market structures. The possible consequences of these other forces are outside the scope of this paper.

ANALYTIC FRAMEWORK

Definitions of markets and hierarchies

Economies have two basic mechanisms for coordinating the flow of materials or services through adjacent steps in the value-added chain: markets and hierarchies (e.g., see Williamson, 1975; Coase, 1937). *Markets* coordinate the flow through supply and demand forces and external transactions between different individuals and firms. Market forces determine the design, price, quantity, and target delivery schedule for a given product that will serve as an input into another process. That is, the buyer of the good or service compares many possible sources of it and chooses the one with the best combination of these attributes.

Hierarchies, on the other hand, coordinate the flow of materials through adjacent steps by controlling and directing it at a higher level in the managerial hierarchy, rather than by letting market transactions coordinate it. Managerial decisions, not the interaction of market forces, determine design, price (if relevant), quantity, and delivery schedules at which products from one step on the value-added chain are procured for the next step. Thus the procurer does not select a supplier from a group of potential suppliers; it simply works with a single pre-determined supplier. In many cases, the hierarchy is simply a firm, while in others, the hierarchy may span two legally separate firms in a close, sole supplier relationship.

Variants of the two pure relationships exist, but can usually be categorized as primarily one or the other. When a single supplier serves one or more buyers as a sole source of some good, the relationship between the supplier and each buyer is primarily hierarchical, since the buyers are each procuring their supplies from a single, pre-determined supplier, rather than chosing from a number of suppliers. If, on the other hand, a single buyer uses multiple suppliers serving only that buyer, the relationship between that buyer and each supplier is governed by market forces, since the buyer is chosing between a number of possible suppliers. As the number of suppliers is reduced towards one, relationships may exist that have characteristics of both types.

Factors favoring markets or hierarchies

A number of theorists (e.g., Coase, 1937; and Williamson, 1975, 1979, 1981) have analyzed the relative advantages of hierarchical and market methods of organizing economic activity in terms of various kinds of coordination costs or transaction costs. These coordination costs take into account

the costs of gathering information, negotiating contracts, and protecting against risks of "opportunistic" bargaining. Building on this work, Malone and Smith (1984; Malone, 1985) have summarized several of the fundamental tradeoffs between markets and hierarchies in terms of three types of costs: production costs, coordination costs, and vulnerability costs. Table 1 summarizes the part of their analysis that is most relevant to our argument here.[1]

Table 1

RELATIVE COSTS FOR MARKETS AND HIERARCHIES

Organizational form	*Production costs*	*Coordination costs*	*Vulnerability costs*
Markets	L	H	L
Hierarchies	H	L	H

In a pure market, with many buyers and sellers, the buyer can compare many different possible suppliers of the product and select the one that provides the best combination of characteristics (such as design and price), thus presumably minimizing production costs for the desired product. One of the obvious benefits of this arrangement is that it allows the demands of numerous buyers to be pooled in order to take advantage of economies of scale and load leveling. The coordination costs associated with this wide latitude of choice, however, are relatively high, because the buyer must gather and analyze information from a variety of possible suppliers. In some cases, these market coordination costs must also include additional negotiating or risk-covering costs that arise from dealing with "opportunistic" trading partners. Finally, since the selection of a given supplier at one time does not preclude selecting a different supplier at a later time, the market presumably also minimizes the buyer's vulnerability costs arising from changes in its requirements or disruptions in a supplier's ability to fulfill them.

Hierarchies, on the other hand, restrict the procurer's choice of suppliers to the one supplier hierarchically connected to the procurer, either within a single company or in a closely linked relationship between two companies, thus leading, in general, to higher production costs than in the market arrangement. This arrangement, however, reduces coordination costs over those incurred in a market by eliminating the procurer's need to gather and analyze a great deal of information about various suppliers. The hierarchical relationship also carries higher vulnerability costs than the market in that the procurer cannot readily shift to another supplier, and vice versa. However, the greater control afforded by the hierarchical arrangement may mitigate this high cost in some cases.

Various factors affect the relative importance of production, coordination, and vulnerability costs, and thus the relative desirability of markets and hierarchies (e.g., see Williamson, 1975, 1979, 1981). In this paper, we will focus on those factors that are particularly susceptible to change by the new information technologies. Clearly, at a very general level, one of these factors is coordination cost. Since the essence of coordination involves communicating and processing information, the use of information technology seems likely to decrease these costs (e.g., see Malone, 1985). Two other, more specific, factors that can be changed by information technology are also important in determining which coordination structures are desirable: *asset specificity* and *complexity of product description.* The importance of asset specificity has been amply demonstrated by previous analyses (e.g., Williamson, 1981), but the importance of the complexity of product descriptions has not, we believe, been satisfactorily analyzed before.

Asset specificity. An input used by a firm (or individual consumer) is highly asset specific, according to Williamson's definition (1981), if it cannot readily be used by other firms because of site specificity, physical asset specificity, or human asset specificity. A natural resource available at a certain location and moveable only at great cost is site specific, for example. A specialized machine tool or complex computer system designed for a single purpose is physically specific. Highly specialized human skills, whether physical (e.g., a trade with very limited applicability) or mental (e.g., a consultant's knowledge of a company's processes), that cannot readily be put to work for other purposes are humanly specific. We propose yet another type of asset specificity to add to Williamson's list: time specificity.[2] A perishable product that must arrive at its destination and be used (or sold) within a very limited period of time from its production, for example, is time specific, as is any input to a manufacturing process that must arrive at a very specific time in relation to the manufacturing process or involve great costs or losses.

There are several reasons why a highly specific asset is more likely to be obtained through hierarchical coordination than through market coordination (Williamson, 1979, 1981). Transactions

involving asset-specific products often involve a long process of development and adjustment for the provider to meet the needs of the procurer, and this process favors the continuity of relationships found in a hierarchy. Moreover, since there are, by definition, few alternative procurers or suppliers of a highly asset specific product in the market, both the procurer and the provider are at risk when they depend on each other. If either one goes out of business or changes its need for (or production of) the product, the other may suffer sizable losses. Thus, both participants are also potentially vulnerable to each other's opportunistic bargaining strategies.

Complexity of product description. Complexity of product description refers to the amount of information needed to specify the attributes of a product. Market transactions require a great deal of communication about the product to gather information and negotiate contracts. High complexity of product description increases the cost of such communication. Conversely, low complexity of product description decreases the cost of such communication. Thus, other things being equal, assets with highly complex descriptions are more likely to be transferred by transactions within hierarchies than across markets. Uniformly graded commodities, on the other hand, are simply designated and thus easily bought and sold in a large market.

At first glance, this factor seems to be related to asset specificity; that is, in many cases a highly specific asset will require a more complex product description than a less specific asset. The two factors are independent, however, in spite of this frequent correlation. For example, coal produced by a coal mine located right next to a manufacturing plant is highly site specific, though the product description is quite simple. Conversely, an automobile is low in asset specificity, but the description of its attributes necessary to fully identify it is quite complex.

As Figure 2A shows, then, inputs to a production process that are both highly asset specific and highly complex in product description are more likely to be obtained through a hierarchical relationship, while inputs that are not very asset specific and are simple in product description are likely to be obtained through a market relationship. Our framework does not predict the form of relationship more likely for obtaining inputs in the other two cells of the table.

HISTORICAL CHANGES IN MARKET STRUCTURES

To illustrate the application of our analytic framework, we briefly examine the historical evolution of market structures in America, paying particular attention to the effects of a key nineteenth century information technology, the telegraph. (The analysis in this section draws on arguments by Chandler

[1977], Williamson [1981], Malone & Smith [1983], Malone [1985], and Du Boff [1983]. Yates [1986] develops this application in more detail.)

Up through the mid nineteenth century, small scale local and regional markets, not hierarchies, coordinated adjacent stages in American industrial activity. In manufacturing, the three major functions - procurement, production, and distribution - were generally handled by different parties. By the middle of the nineteenth century, the dramatic improvements in communication and transportation provided by the telegraph and the railroads created a network for exchanging information and goods over great distances, thus effectively increasing the area over which markets or hierarchies might be established.

Our analytic framework helps explain how these developments encouraged first the expansion of markets and then the development of hierarchies. The expansion of areas over which rapid communication and transportation were possible allowed, for the first time, the development of large scale national markets. Furthermore, the reduction in time and cost for communication favored markets over hierarchies because (as Table 1 shows) decreases in communication costs benefit communication-intensive markets more than they benefit hierarchies. These nationwide markets are not equally desirable for all products, however. Just as our framework would lead us to expect, nationwide markets mediated by telegraph developed in such areas as the stock market and commodities futures. These products were non-specific assets (although commodities had been relatively site specific until the railroad improved transportation) with many potential buyers. In addition, they were easily describable, and consequently susceptible to standardization to reduce communication costs further. The commodities futures market, for example, only emerged on a national scale after a uniform grading scheme had been adopted (DuBoff, 1983).

The story did not end there, however, because the growth in market areas created by the telegraph and railroad also provided the impetus for the emergence of large scale integrated firms. In general, when the size of the economy increases, communication costs increase proportionately more for a market than for a hierarchy (see Malone and Smith, 1984; Malone, 1985). Depending on the relative importance of increases in the amount of communication necessary in larger markets versus any decreases in the cost of that communication, hierarchies may become more attractive than markets. In particular, when products are specific to certain kinds of customers or when they are difficult to describe, the coordination of their production and distribution in a national market requires a great deal of communication, thus often making a hierarchy more desirable than a market.

The detailed evolutionary path of large integrated hierarchies was more complex than that of national markets, and it involved several factors other than the telegraph. Nevertheless, our

framework again proves useful in the explanation of which conditions led to which forms. The growth of market areas and thus the potential number of buyers, according to Chandler (1977), encouraged producers to increase their production. They frequently did so by developing new techniques of mass production that offered economies of scale. Such firms, however, frequently found that existing procurement and distribution mechanisms did not support the high volume throughput necessary to realize the economies, especially when procurement or distribution for the product required specialized equipment or human expertise. As Williamson (1981) has pointed out, the companies that Chandler identifies as the first to vertically integrate procurement, production, and distribution within a hierarchy were those companies with asset specific products (such as meat packers with perishable products requiring railroad refrigeration cars and rapid delivery, and manufacturers of complex machine tools with specialized sales and support needs). For these firms, the telegraph provided a mechanism by which close hierarchical coordination could be wielded over great distances. While the economies of scale were the major factor driving this integration, asset specificity played a role in determining which firms were likely to integrate, using the telegraph as a mechanism of hierarchical coordination rather than as a mechanism of market communication.

Thus our analytic framework is useful in interpreting past changes in the balance between markets and hierarchies, even when non-communication factors play a large role. In the next section, we apply the framework to contemporary developments.

CONTEMPORARY CHANGES IN MARKET STRUCTURES

We can now give a fuller explanation of the nature of electronic hierarchies and markets, the conditions under which each is likely to emerge, and the reasoning behind our thesis that the balance is shifting towards electronic markets.

Emergence of electronic interconnection

Let us begin by looking briefly at the technological developments that make electronic integration of either type possible and desirable. New information technologies have greatly reduced both the time and cost of communicating information, just as the telegraph did when it was introduced. In particular, higher bandwidth telecommunications may (1) allow more information to be communicated in the same amount of time (or the same amount in less time), and (2) decrease the costs of this communication dramatically. These effects of new information technology may be termed the *electronic communication effect*, and they benefit both markets and hierarchies.

In addition to these well-known general advantages of electronic communication, electronic coordination can be used to take advantage of two other effects: the electronic brokerage effect, and the electronic integration effect. The *electronic brokerage effect* is of benefit primarily in the case of computer-based markets. A broker is an agent who is in contact with many potential buyers and suppliers and who, by filtering these possibilities, helps match buyers and suppliers to each other. The presence of the broker substantially reduces the need for buyers and suppliers to contact a large number of alternative partners individually (see Baligh & Richartz [1967] and Malone [1985] for detailed formal analyses of the benefits of brokering). The electronic brokerage effect simply means that electronic markets, by electronically connecting many different buyers and suppliers through a central data base, can fulfill this same function. The standards and protocols of the electronic market allow a buyer to screen out obviously inappropriate suppliers, and to compare the offerings of many different potential suppliers quickly, conveniently, and inexpensively. Thus the electronic brokerage effect offered by an electronic market can (1) increase the number of alternatives that can be considered, (2) increase the quality of the alternative eventually selected, and (3) decrease the cost of the entire product selection process.

When a supplier and a procurer use information technology to create joint, interpenetrating processes at the interface between value-added stages, they are taking advantage of the *electronic integration effect*. The benefits of the electronic integration effect are usually captured most easily in electronic hierarchies, but they are sometimes apparent in electronic markets, as well. One simple benefit of this effect is the time saved and the errors avoided by the fact that data need only be entered once. Much more important benefits of close integration of processes are possible in specific situations. CAD/CAM technology, for example, often allows both design engineers and manufacturing engineers to access and manipulate the design and manufacturing data to try out more potential designs and to create a product more acceptable to both sides. As another example, systems linking the supplier's and procurer's inventory management processes so that the supplier can ship the products "just in time" for their use in the procurer's manufacturing process, enable the procurer to eliminate inventory holding costs, thus reducing total inventory costs for the linked companies.

These advantages of electronic interconnections compared to existing non-electronic coordination methods provide substantial benefits. The recipients of these benefits (either buyers, suppliers, or both) should be willing to pay for them (either directly or indirectly), and thus the providers of electronic markets and electronic hierarchies should, in many cases, be able to realize significant revenues from providing these services.

Factors favoring electronic markets or electronic hierarchies

The factors shown in Figure 2A that favor markets or hierarchies, in general, apply to electronic markets and electronic hierarchies, as well. Products high in physical asset specificity often require a long and involved development and sales process. In such cases, the electronic integration effect is likely to offer advantages and lead to "electronic virtual integration" or "electronic hierarchies." Similarly, processes high in time specificity (i.e., those for which precise timing of delivery offers special advantages) can make use of the same effect. Moreover, products that are highly asset specific tend to have fewer suppliers (both because the demand is, on average, less and because the risk to suppliers is high), so the electronic brokerage effect, which involves comparing a number of alternative suppliers is less likely to be important.

Complexity of product description also affects the suitability of electronic markets and hierarchies. Products that are low in complexity of description are susceptible to the standardization of terminology necessary to establishing an electronic market. Such standards help reduce communication costs and make possible the manipulating of large amounts of information from many suppliers that is essential to achieving the *electronic brokerage effect.* Products with more complex descriptions are not as susceptible to standardization and thus are less likely to be obtained via electronic markets.

Shift from hierarchies toward markets

Our prediction that information technology will be more widely used for coordinating economic activities is not a surprising one, even though our analysis of the three effects involved (electronic communication, brokerage, and integration effects) is new. In this section, we move to a more surprising and significant prediction: that the overall effect of this technology will be to increase the proportion of economic activity coordinated by markets.

While the effects of information technology just discussed clearly make both markets and hierarchies more efficient, we see two arguments supporting an overall shift towards market coordination: the first is a general argument based on the analysis summarized in Table 1; the second is a more specific argument based on shifts in asset specifity and complexity of product descriptions.

General argument favoring shift towards markets

Our first argument for the overall shift from hierarchies to markets is a simple one, based primarily on two components. The first component is the assumption that the widespread use of information technology is likely to decrease the "unit costs" of coordination. By coordination, we mean the

information processing necessary to determine the design, price, quantity, delivery schedule, and other similar factors for products transferred between adjacent steps on a value-added chain. In markets, this involves selecting suppliers, negotiating contracts, paying bills, and so forth. In hierarchies, this involves managerial decision-making, accounting, planning, and control processes. Since, by definition, these coordination processes involve communicating and processing information it seems quite plausible to assume that information technology, when used appropriately, can reduce these costs. This is, of course, an empirically testable hypothesis, and there are already some suggestive data that support it (e.g., Crawford, 1982; Strassman, 1985; Jonscher, 1983).

The second component of our argument is based on the tradeoffs summarized in Table 1. As we noted above, and as Williamson (1981a) and numerous others have observed, markets have certain production cost and other advantages over hierarchies as a means of coordinating economic activity. The primary disadvantage of markets is the cost of conducting the market transactions themselves. For a number of reasons (including the "opportunistic" ones emphasized by Williamson and the purely "informational" ones emphasized by Malone and Smith [1984]), these coordination costs are generally higher in markets than in hierarchies. An overall reduction in these coordination costs would make this dimension less important and the other two dimensions more important, thus favoring market coordination.

We find the simplicity of this argument quite compelling, but its obviousness appears not to have been widely recognized. There is also another, less obvious, argument that leads to the same conclusion. This second argument is based on shifts in our key factors for determining coordination structures: asset specificity and complexity of product description.

Changes in factors favoring electronic markets versus electronic hierarchies

As Fig. 2B shows, some of the new, computer-based information technologies have affected both of our key dimensions in such a way as to create an overall shift from markets to hierarchies. Data bases and high bandwidth electronic communication can handle and communicate complex, multidimensional product descriptions much more readily than traditional modes of communication can. Thus the line between high and low complexity has in effect shifted upward so that some products with descriptions previously classified as highly complex, such as airline reservations, may now fall into the category of having descriptions that are low in complexity. The line should continue to shift upward for some time as the capabilities of information technology continue to evolve.

The dimension of asset specificity has also changed in such a way as to slightly favor markets over hierarchies. Flexible manufacturing technology allows rapid changeover of production lines from one

product to another. Thus some physically asset-specific components that are similar to other, non-specific components may begin to be produced by more companies. Companies that in the past would not have tooled up for such a small market now may produce small numbers of these components without significant switchover costs. Thus the vertical line in Fig. 2A moves slightly right in Fig. 2B, because some asset-specific components have become, in essence, less specific.

Both these changes increase the region of the chart in which market modes of coordination are favored, lending more support to our argument that there will be an overall shift in this direction.

Examples of shift toward electronic markets

A dramatic example of this process has already occurred in the airline industry. When airline reservations are made by a customer calling the airline directly (and the "commission" received by the airline's own sales department), the selling process is coordinated by the hierarchical relationship between the sales department and the rest of the firm. When airline reservations are made through a travel agent, the sale is made (and commission received) by the travel agent acting as an external selling agent for the airline. The selling process, in this case, is coordinated by the market relationship between the travel agent and the airline. Due, presumably in large part, to the greater range of choices conveniently available through the electronic market, the proportion of total bookings made by travel agents (rather than by customers dealing with airline sales departments) has doubled from 35% to 70% since the introduction of the American Airlines reservations system (Petre, 1985, pp. 43-44).

Similarly, there are many recent examples of companies such as IBM, Xerox, and General Electric substantially increasing the proportion of components from other vendors contained in their products (e.g., see Prokesh, 1985; Business Week, 1986). This kind of "vertical disintegration" of production activities into different firms has become more advantageous as computerized inventory control systems and other forms of electronic integration allow some of the advantages of the internal hierarchical relationship to be retained in market relationships with external suppliers.

In the next section, we will trace out in more detail the motivations and probable evolutionary paths for the development of electronic markets and electronic hierarchies as suggested by our framework. In many cases, we are able to cite early examples of companies that have begun to traverse these paths.

EVOLUTION OF ELECTRONIC MARKETS AND ELECTRONIC HIERARCHIES

Motives for establishing electronic markets: Possible market makers

As Figure 3 indicates, any of several participants in an emerging electronic market may be its initiator or market maker, each with different motives. In any existing market, there are already a number of participants. For a market to exist at all there must be both *producers* and *buyers* of some good or service. (Depending on the nature of the good or service and on the coordination mechanism used, "producers" may also be called "manufacturers" or "suppliers," and we use these three terms interchangeably. Similarly, we use the terms "buyers," "procurers," and "consumers" interchangeably.) In addition to these primary participants, an existing market may also include two other kinds of participants. First, there may be various levels of "middlemen" who act as distributors, brokers, or agents in the transfer of the goods being sold. We will usually use the term "distributors" to refer to all these levels. Second, there may also be various kinds of financial service firms such as banks and credit card issuers who store, transfer, and sometimes loan the funds involved in the transactions. Finally, we may regard as potential participants in any electronic marketplace the information technology vendors who can provide the networks, terminals, and other hardware and software necessary for a computer-based market. Each of these different kinds of market participants has different motivations and different possibilities for helping to form electronic markets.

Producers

As the initial maker of a product, the producing firm is motivated to have buyers purchase its products rather than those of its competitors. This motivation has already led several producers to establish electronic interconnections with their buyers. Although these electronic systems were originally established to encourage travelers to buy tickets from the airline providing the service, they now provide access to tickets from all airlines (Petre, 1985; Business Week, 1985c; Cash & Konsynski, 1985). Another example of an electronic interconnection established by a producer is American Hospital Supply's ASAP system. With this system, several thousand hospitals that buy American Hospital's (AHS) products are provided with terminals on their own premises that allow them to automatically enter orders for AHS products (Jackson, 1985; Petre, 1985). Since this system has only one supplier (AHS), we would classify it as an electronic hierarchy rather than an electronic market. As we will describe below, our framework suggests that, in spite of the original motivations of the producers, there are often strong forces that cause electronic hierarchies to evolve toward electronic markets that do not favor specific producers.

Buyers

In contrast to the producer, who would like to minimize the number of alternatives considered by buyers, the buyers themselves would like to maximize the number of alternatives considered and the ease of comparing among them. One way of doing this is for buyers to begin using computer databases containing information about alternative products. In some cases, the buyers are powerful enough in a market that they can require suppliers to provide this information. For example, General Motors already requires its primary suppliers to conform to the computer hardware and communications standards established by the Automotive Industry Action Group (Cash & Konsynski, 1985). These systems can then be used to speed order processing and implement innovations such as "just-in-time" inventory management (Business Week, 1985a). Groups of buyers are currently developing similar electronic markets in the grocery, chemical, and aluminum industries as well (Business Week, 1985a). Unlike systems provided by producers, which are motivated by the desire to establish an attractive distribution channel for certain products, these systems are established by buyers to make supplier selection, order processing, and inventory management more efficient.

Distributors

In some cases, the initiative for a computer-based market may come from distributors rather than directly from buyers or suppliers. In the pharmaceuticals industry, for example, wholesale distributors such as McKesson have followed the lead of producers such as American Hospital Supply in setting up electronic connections with their customers (Business Week, 1985b). Like American Hospital, such distributors established the electronic links in order to try to monopolize the business of their customers, and at this stage, the systems are still electronic hierarchies rather than electronic markets. Just as with systems developed by producers, however, we expect that electronic links developed by distributors will often have an initial bias toward one or more producers, but that these biases will usually disappear under pressure from competitive and legal forces. While the benefits to the distributor may initially have had their source in the bias, the distributor may soon find that the greater efficiency offered by the electronic market over conventional markets allows adequate compensation to the distributor for running an unbiased market.

Financial services providers

By transferring the funds and/or extending the credit required for transactions, banks and other financial institutions are already involved as participants in most markets. In some cases, this involvement can be the basis for providing a full-fledged electronic market. For example, some

banks, such as Citicorp, provide to their credit card holders a telephone shopping service for a wide variety of consumer goods (Stevenson, 1985). The system keeps a log of the lowest retail prices available for all the products included. Cardholders can call for a price quotation, order the goods over the phone using their credit card, and have the goods delivered to their door. In a similar spirit Citicorp and McGraw-Hill have formed a joint venture to make information about alternative oil prices for crude oil and to match buyers and sellers (Bennett, 1985). Similarly, Louie (1985) describes the evolution of the PRONTO home banking system at Chemical Bank, NY, from offering a single financial service (home banking) to becoming a full systems operator and providing home information services with stock prices and home retailing information.

The initial motivation of the financial institution in these cases is presumably not to favor the sale of any particular producer's products, but to increase the volume of transaction processing and credit-based income for the financial institution.

Information technology vendors

In all of the above examples, the hardware, networks, and often software necessary to create computer-based markets are provided by information technology vendors. Even though these examples illustrate how the line between information technology vendors and other kinds of firms is beginning to blur, there are still some cases where firms whose primary business is supplying information technology may be able to make computer-based markets themselves. For example, Western Union has a system for matching freight shippers with motor freight carriers and checking that the carriers have the necessary legal authorization and insurance coverage (Ives and Learmonth, 1984, p. 1199).

It is easy to imagine other examples of information technology vendors making markets. For example a natural extension of the classified directory now provided by telephone companies would be "electronic Yellow Pages," perhaps including capabilities for actually placing orders as well as locating suppliers. (A directory-only service of this type is already offered by Automated Directory Services [Koenig, 1983]).

Stages in the Evolution of Electronic Markets

We saw above that electronic markets may evolve from non-electronic markets or from electronic or non-electronic hierarchies. Frequently that evolution involves an intermediate stage, a biased market, but eventually proceeds to an unbiased market. In the future, that evolution may continue to a personalized market.

From biased to unbiased markets

Some of the first providers of electronic markets have attempted to exploit the benefits of the electronic communication effect in order to capture customers in a system biased towards a particular supplier. We believe that, in the long run, the significant additional benefits to buyers possible from the electronic brokerage effect will drive almost all electronic markets toward being unbiased channels for products from many suppliers. For example both American Airlines and United Airlines have introduced reservation systems that allow travel agents to find and book flights, print tickets, and so forth (Petre, 1985; Business Week, 1985c; Cash & Konsynski, 1985). The United system originally was established as an electronic hierarchy that allowed travel agents to book only flights on United. To compete with this system, American established a system that included flights from all airlines (thus making it a true market), but with American flights on a given route listed first. This shift to a biased market was possible both because airline reservations are not asset-specific and because they can be described in standardized forms and manipulated in standardized processes that may be quickly and easily handled by the new technology. United soon adoped the same strategy and by 1983 travel agencies that used automated reservation systems used one of these two systems in 65% of the reservations they made (Cash & Konsynski, 1985, p. 139). The significant bias in favor of their suppliers' flights that was introduced by these two systems eventually led other airlines to protest, and recent rules from the CAB eliminated much of the bias in the system. Now the systems continue to provide the same reservation service to other airlines for a significant fee.

A similar evolution may result in the case of American Hospital Supply's ASAP order entry system. American Hospital is apparently trying to prevent that outcome by making the shared processes themselves more asset specific. Jackson, 1985, p. 137 describes the many features built into the ASAP system to customize the system to a particular hospital's needs, in effect creating a procedural asset specificity in the relationship between buyer and seller. These features include purchase history files, computation of economic order quantities, and basic order file templates. In each case described, powerful one-to-one hierarchical relationships are established between buyer and seller. However, most of the medical products sold through the system meet the criteria listed above for electronic markets: they are not uniquely useful for specific customers, and their descriptions are relatively simple and standardized. Therefore, our model leads us to predict that this system (or its competitors) will move toward including products from many different suppliers. The same evolution is likely in the case of pharmaceutical distributors such as McKesson.

These examples illustrate what we suggest will be a very common case: Producers who start out by providing a biased electronic market will eventually be driven by competitive or legal forces to remove or significantly reduce the bias.

From unbiased to personalized markets

One of the potential problems with unbiased electronic markets of the sort we have described is that they might overwhelm buyers with more alternatives than the buyers can possibly consider. This problem will be less important in commodity-like markets where the product descriptions are well-known standards and where the only dimension on which products are compared is price. But the problem will be particularly acute in markets for which the product descriptions involve a number of related attributes that are compared in different ways by different buyers. Retail sales of consumer products, for example, would fall in this category.

For example, techniques from artificial intelligence used in filtering electronic messages of all kinds (Malone, Grant, & Turbak, 1986) can be used to screen advertising messages and product descriptions according to precisely the criteria that are important to a given buyer. Air travellers, for instance, might specify rules with which their own "automated buyers' agents" could compare a wide range of possible flights and select the one that best matches that particular traveller's preferences. The preferences might include decision rules for trading off between factors such as cost, convenient arrival and departure times, window seats vs. aisle seats, minimum number of stops, and so forth. A fairly simple set of such rules could, in many cases, do a better job of matching particular travellers' preferences than all but the most conscientious and knowledgeable human travel agents.

In addition to techniques from artifical intelligence for specifying complex qualitative reasoning processes, there are also a number of normative mathematical models (e.g., Keeney & Raiffa, 1976), and descriptive behavioral models (Payne, Braunstein, & Carroll, 1978; Russo & Dosher, 1983; Johnson & Payne, 1985) that could help in designing such systems.

Clearly these techniques will be more useful for certain products (e.g., those that are easily described and non-specific) and certain buyers (e.g., industrial buyers doing routine purchasing rather than consumers buying on impulse). Ultimately, however, such personalized decision aids may be widely useful in both industrial and consumer purchasing for screening large amounts of electronically stored product information on behalf of particular buyers.

Another intriguing possibility is that some of the preference rules specified by buyers might be made available to suppliers. There are clearly cases where protecting the privacy of buyers should preclude

making this information available. In other cases, however, making the preferences of large numbers of buyers automatically available (perhaps anonymously) to suppliers, could dramatically improve the efficiency of certain kinds of market research and the responsiveness of suppliers. Instead of having to painstakingly infer consumer decision rules from surveys or experiments, for example, suppliers might be able to simply observe the actual rules consumers had specified.

Motives for Establishing Electronic Hierarchies

While the previous sections present our reasons for expecting an overall shift toward electronic markets, there are still many cases where asset specificity is high and product descriptions are complex, and thus where electronic hierarchies will be desirable. In particular, as Figure 4 suggests, electronic hierarchies will be established to improve product development or to improve product distribution. In this section, we discuss why and how companies may establish electronic hierarchies for each of these functions.

Product development. In product development, CAD/CAM, electronic mail, and other information technologies can be used to enhance the hierarchical coordination between design and manufacturing groups. The electronic integration effect can be used, in this case, to (1) shorten the development cycle, (2) increase the number of alternative designs considered, (3) reduce development (i.e., coordination) costs, (4) reduce manufacturing costs (by involving manufacturing engineers in the design process), and (5) produce a higher quality product. The President of Xerox's newly integrated Engineering and Manufacturing Group, for example, says of such integration that "It is the key to faster and less costly development, to lower manufacturing costs, and to better products" (Hicks, 1984).

The key data that must be shared in the product development process are engineering drawings, parts descriptions, bills of materials, engineering change notices, machine tool configurations, and so forth. For example, in many companies the engineering change notice process is considered a people-intensive, time-consuming, and error-prone administrative activity. Because the shared data base of an electronic hierarchy allows people directly involved in the change to work with the ECN process electronically, the large bureaucracy previously needed for administering this process coordination may be severely reduced.

Xerox's new electronic ECN process, for instance, involves three parties: the design engineer, who is also responsible for the manufacturability of the change and the entering of the change in the spare parts ordering process; the manufacturing engineer, who designs the actual manufacturing process; and the manufacturing analyst, who updates the necessary manufacturing data bases to

accommodate the change. In the previous process, a number of other people were also involved: the advanced manufacturing engineer, who worked with the design engineer to determine general manufacturability; the administrator of the record center where all data on the part was kept, who managed copying and distribution to necessary parties; the manufacturing configuration specialist, who provided information on the manufacturing bill of materials and maintained any changes required; and the spare parts planner, who did the entering and ordering of spares for initializing the product in the distribution system. The electronic data base permits significant reduction in administrative coordination costs, and, more importantly, increases the quality and timeliness of the product development process as well.

Although the example just described is of electronic integration within one organization, there have also been examples of linkages between design and manufacturing groups in different companies in both heavy manufacturing and the auto industry (Prokesh, 1985; Cash & Konsynski, 1985) In the design of semiconductor circuits, for instance, over 100 different processes and over 30 to 40 separate organizations have traditionally been involved (Strassmann, 1985; and Feigenbaum and McCorduck, 1984). Use of the Mead Conway method for VLSI design and electronic integration between organizations has dramatically reduced the number of processes and people involved. Designers in remote organizations use standardized languages in functionally rich workstations, then send their standardized design data bases over a network to a supplier fabrication facility where they are linked to the supplier's manufacturing process data bases. The end result is that the test circuits are delivered to the procurer at much lower cost and in much shorter time.

Thus electronic integration of product design and development, whether within or between firms, uses linked or shared data bases to achieve more efficient and effective product development cycles. The electronic integration effect may also be realized in product distribution.

Product distribution. In product distribution systems, there are two primary participants: the procurer and the supplier. The procurer's goal for establishing electronic hierarchies may be to have the inventory available to the factory production process "just-in-time," thus eliminating inventory carrying costs as well as all production control necessary to manage staging of inventory (Nakane and Hall, 1983). That is, to lower inventory costs, procurers may raise the time specificity of the process. Firestone, for example, is part of the physical and electronic inventory system of two of the major car manufacturers, with the result that it carries the inventory of tires, rather than the car manufacturer. Similarly, the large battery manufacturer that supplies the tire manufacturer's retail stores is tied into the store's physical and electronic inventory systems.

As we saw above, these electronic interconnections are allowing many manufacturers to rely increasingly on external suppliers of components rather than on manufacturing the components themselves (e.g., Prokesh, 1985). One somewhat paradoxical aspect of this shift is that even though manufacturers are increasing the volume of components purchased externally, they are decreasing the number of suppliers from which these components are purchased (Prokesh, 1985, p. D5). This paradox can be resolved, however, by noting that the reasons given for decreasing the number of suppliers (e.g., to become preferred customers and thus increase leverage with the suppliers) amount to ways of increasing the asset specificity of the products. In other words, these buyers are using information technology to "get the best of both worlds"--they are making increasing use of electronic markets, but their relationships with each of the suppliers in these markets are becoming increasingly like electronic hierarchies.

The supplier may be motivated to enter such a just-in-time arrangement for defensive reasons--doing so may be a condition of doing business with the procurer. The supplier, however, may also perceive other advantages in an electronic arrangement. Jackson (1985, p. 134) asserts that a buyer is unlikely to tamper with an established just-in-time relationship: "because changing would require another substantial investment in learning to work with the new vendor." That is, the shared data bases and shared physical and electronic processes may become physically and humanly specific, as well as time specific, increasing the likelihood of a hierarchical rather than market relationship. As we saw above, this is clearly a consideration in early systems such as that developed by American Hospital Supply. As we saw earlier, however, such electronic hierarchies frequently develop into biased, then unbiased electronic markets when the products themselves are not asset specific and are easy to describe in standardized terms.

In addition to these separate motives, both the procurer and the supplier may be motivated to reduce the time, cost, and errors produced by an extensive procurement system that requires repeated entries, transmissions, translations into different terms, and re-entries of information between paper and computer systems of suppliers and procurers. For the auto makers and component suppliers, for example, this costly process results in errors in approximately 5% of all procurer/supplier documents, according to an industry group. (Business Week, 1985a). This group, the Automotive Industry Action Group, is establishing standard forms and processes for the four big auto companies and their many suppliers to use. Once these standards are established, the existing electronic hierarchies between buyers and sellers in this market are likely to evolve into electronic markets.

Relative power of participants

As these examples illustrate, one of the critical factors involved in the establishment of electronic interconnections is the relative power of the participants. The interconnections that emerge are determined, in part, by the pre-existing power relationships of the participants, and these power relationships may, in turn, be changed by the new electronic arrangements. For example, suppliers may enter into a just-in-time inventory arrangement in order to continue doing business with a powerful buyer, and the knowledge this arrangement gives the buyer about the inventory positions of all its suppliers may enhance the buyer's power even more.

Sometimes, merely agreeing on the standards for electronic systems can be the battleground on which many of the power issues arise. For example, in the insurance industry, both the independent agents and the major commercial and property carriers are hotly contesting the control of standards (Benjamin, 1983). The large carriers would like to tie independent agents to their own systems and see their proprietary standards as a means to achieve this. However, the independent agents, through an industry association, are defining a set of standards for the primary insurance transactions that will give them the freedom to do business with multiple carriers. A number of large carriers have indicated that they will now live with the more general standards.

Stages in the evolution of electronic hierarchies

As we have seen above, shared data bases, made possible by advances in information technology, are at the core of electronic hierarchies. They provide the mechanism for integrating processes across organizational boundaries by allowing continuous sharing of information in easily accessible on-line form (Benjamin and Scott-Morton, 1986).

Our primary basis for predicting the evolutionary path of these mechanisms is the observation that both the benefits and the costs of electronic integration become greater as the coupling between adjacent steps on the value-added chain becomes tighter. Thus we would expect organizations to obtain limited benefits at low cost before moving to greater benefits at higher cost. Figure 4 indicates a plausible trajectory that this observation suggests: stand-alone but mutally accessible data bases should appear first, then be replaced by electronically linked data bases and, eventually, by fully shared data bases. We are not aware of good examples of all three stages of this trajectory occuring in a single system, but we can describe examples of systems at each of the three stages.

Stand-alone data bases. In this stage, one or both parties makes their data bases accessible to the other party in the electronic hierarchy. This often requires the other party to use a separate

workstation. For example, the early versions of the American Hospital Supply order entry system required customers to use a separate workstation to access the AHS order entry programs and purchasing history databases (Harvard Business School, 1985). Even though the database that is built up in this process is, in some sense, "shared" by the customers and AHS, it is not connected to the customers' accounting and other application systems, so we classify it as a stand-alone data base.

Linked data bases. In this stage, the data bases are still separate, but a formal on-line mechanism passes information from one party's data base to the other. The most recent version of the AHS order entry system (see Harvard Business School, 1985) allows this kind of direct computer-to-computer communication. Orders are prepared by the customer's internal computer system, transmitted electronically to AHS, and then order confirmations are returned to the customer's computer and used to update the hospital's files. Another example of this level of linking is provided by the Mead-Conway VLSI design methodology. Here, electronic networks are used to transfer product design specifications from the CAD system on the designer's workstation to a manufacturing system that is located at a remote site and owned by another organization.

Shared data bases. In this final stage, one data base contains information of value for both parties in the electronic hierarchy. The Engineering Change Notice process we described above illustrates a simple example of this situation and great effort is currently being expended by CAD/CAM vendors and manufacturing companies to implement and use the integrated engineering/manufacturing data base environment successfully (e.g., Meyers, 1982).

CONCLUSIONS AND STRATEGIC IMPLICATIONS

A casual reading of the business press makes clear that electronic connections within and between organizations are becoming increasingly important (e.g., Petre, 1985; Business Week, 1985c; Cash & Konsynski, 1985). The framework we have developed in this paper helps understand many of these changes. We have shown how the increasing use of electronic interconnections can be seen as the result of three forces: the electronic communication effect, the electronic brokerage effect, and the electronic integration effect. We have analyzed how factors such as the ease of product description and the degree to which products are specific to particular customers affect whether these interconnections will take the form of electronic hierarchies or electronic markets. Finally, and perhaps most importantly, we have argued that, by reducing the costs of coordination, information technology will lead to an overall shift toward proportionately more use of markets rather than hierarchies to coordinate economic activity. By applying this framework, it is possible to see how

many of the changes occuring today fit into a larger picture and to predict some of the specific evolutionary changes that are likely to occur as information technology becomes more widely used.

Our analysis has several implications for corporate strategy:

(1) All market participants should consider whether it would be advantageous for them to try to provide an electronic market in their marketplace. For some participants, providing such a market may increase the sales of their current products or services. For all participants, it provides a potential source of new revenues from the market-making activity itself.

(2) All organizations should consider whether it would be advantageous for them to coordinate some of their own internal operations more closely or to establish tighter connections with their customers or suppliers using electronic hierarchies.

(3) Market forces make it very likely that biased electronic sales channels (whether electronic hierarchies or biased electronic markets) for non-specific, easily described, products will eventually be replaced by unbiased markets. Therefore, the early developers of biased electronic sales channels for these kinds of products should not expect that the competitive advantages these systems provide will continue indefinitely. They should instead be planning how to manage the transition to unbiased markets in such a way that they can continue to derive revenues from the market-making activity itself.

(4) All firms should consider whether more of the activities they currently perform internally could be performed less expensively or more flexibly by outside suppliers whose selection and work could be coordinated by computer based systems.

(5) Advanced developers of computer-based marketing technology should begin thinking about how to develop intelligent aids to help buyers select products from a large number of alternatives. Such intelligent aids may eventually be able to act, in part, as automated agents for the buyers. They may also, in some situations, be able to provide detailed information to suppliers about their customers' preferences.

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Footnotes

[1] This table compares the performance that is achievable with separate divisions in a product hierarchy to the performance that is achievable with separate companies coordinated by a decentralized market (see Malone, 1985, Table 2). As Malone (1985, pp. 18-19) notes, this comparison is equivalent to a comparison between coordination by separate hierarchical firms and coordination by a market.

[2] Time specificity, as well as site specificity, could be viewed as special types of physical asset specificity.

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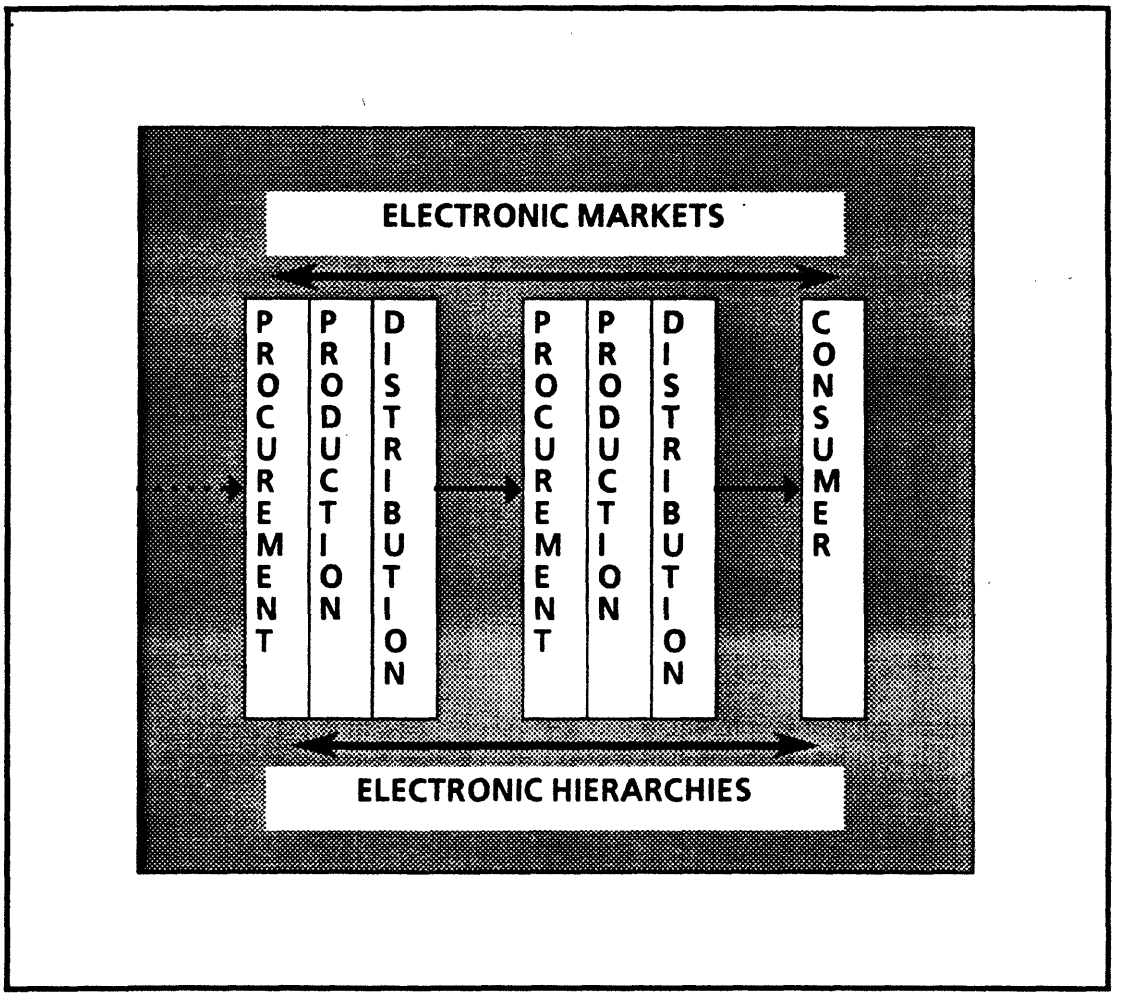

Figure 1

ELECTRONIC INTEGRATION

Information Technology can be used to integrate adjacent steps on a value-added chain through two mechanisms: more efficient electronic markets and more tightly coupled electronic hierarchies

Forms of Organization favored by Products with different characteristics

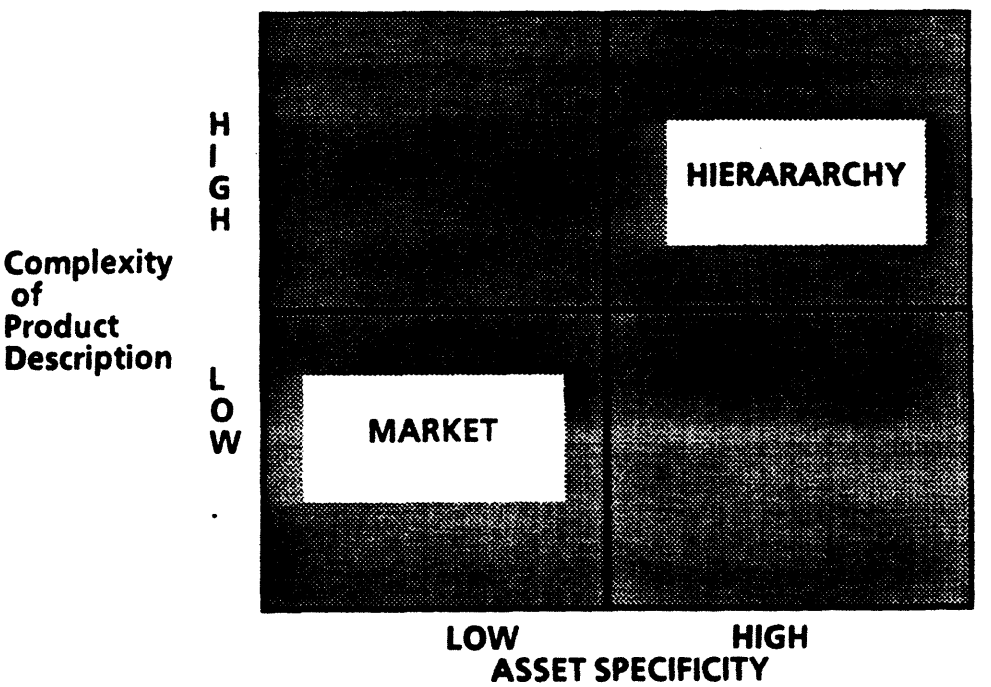

FIGURE 2A

Impact of Information Technology on Forms of Organization

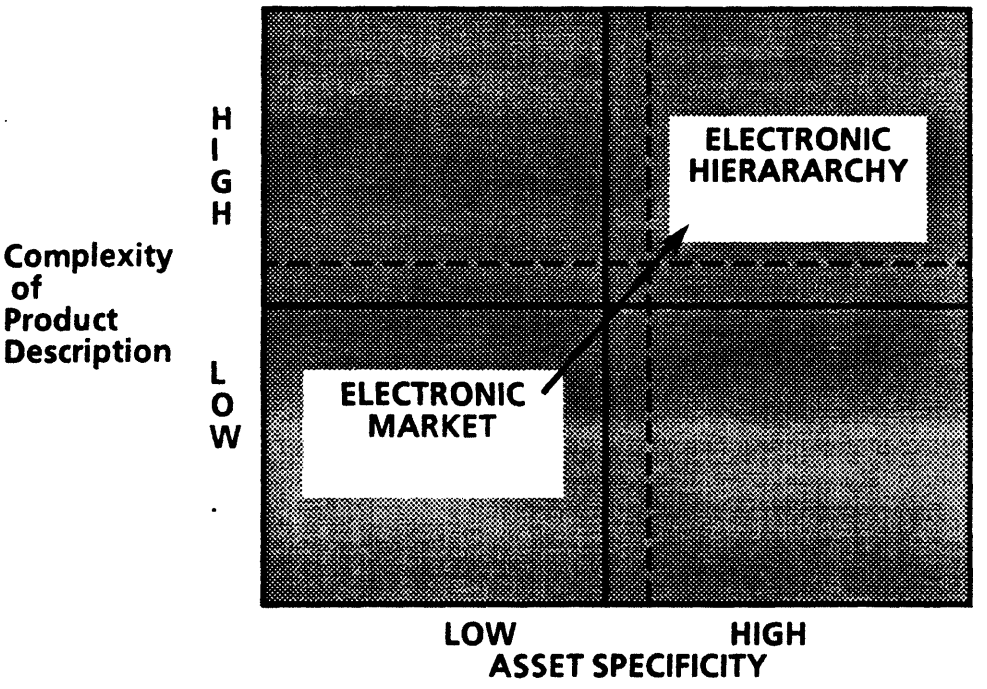

FIGURE 2B

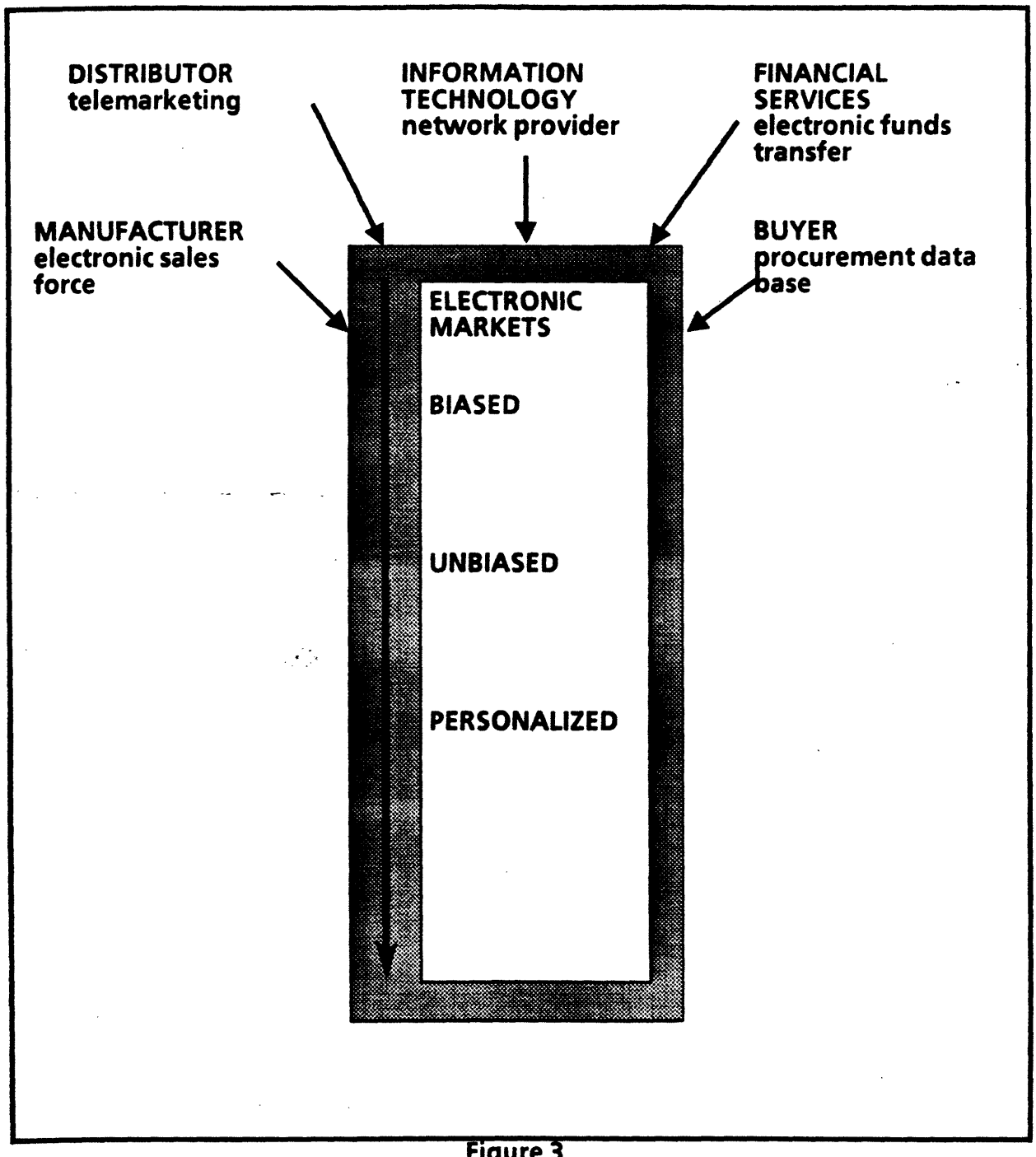

Figure 3
EVOLUTION OF ELECTRONIC MARKET MAKERS
Multiple starting points lead to a common evolutionary path

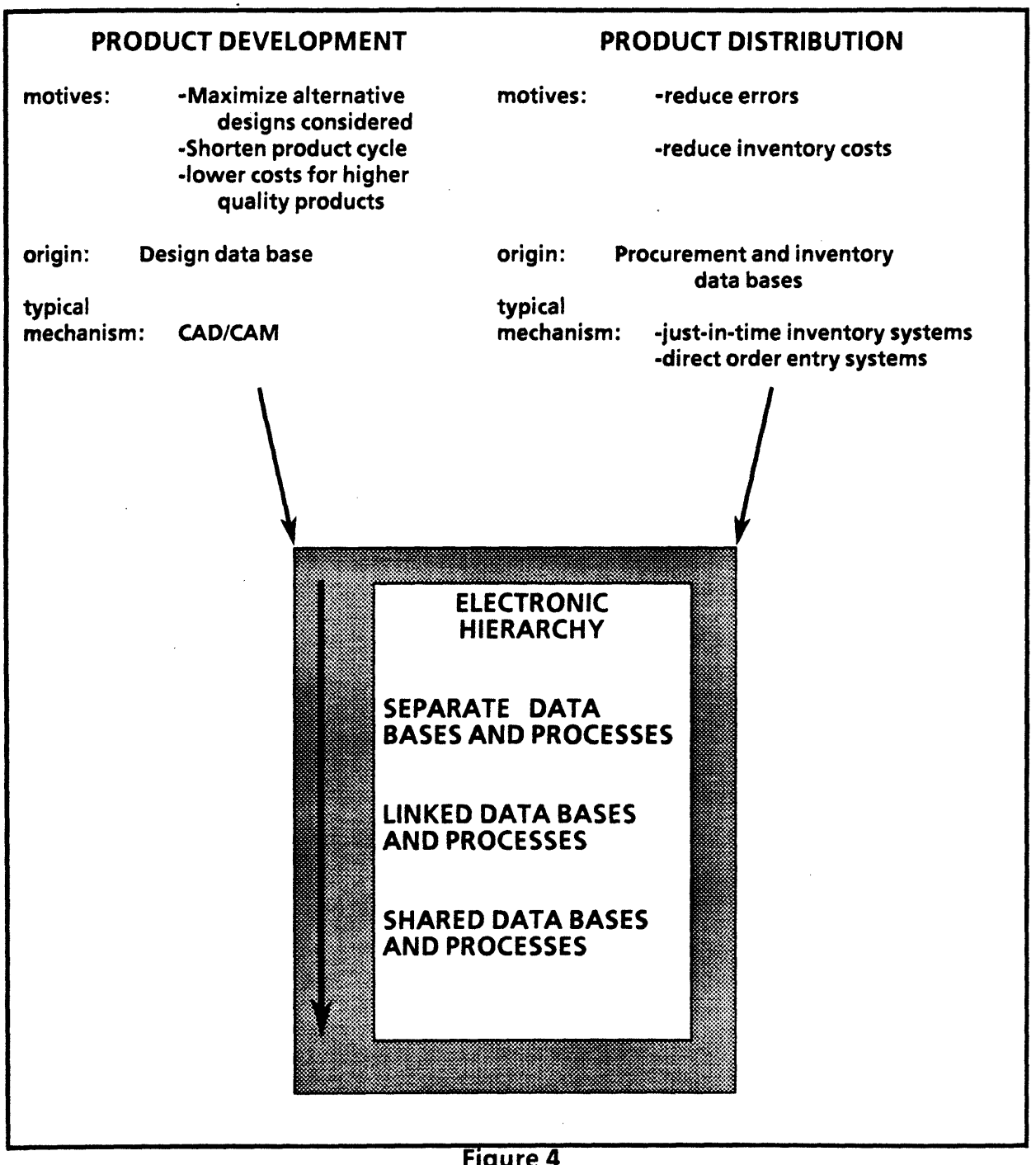

Figure 4
EVOLUTION OF ELECTRONIC HIERARCHIES
From separate to shared data bases