ELECTRONIC MARKETS AND ELECTRONIC HIERARCHIES

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.

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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 are 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 may be more fundamental changes in how firms and markets organize the flow of goods and services through their value-added chains (e.g., see [34]). In this paper we address the more basic issue of how advances in information technology are affecting firm and market structures and discuss the options these changes present for corporate strategies.

New information technologies are allowing closer integration of adjacent steps on the value-added chain through the development of electronic markets and electronic hierarchies. Although 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. Others 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 from the possibilities for closer coordination provided by electronic hierarchies.

The analytic framework on which our argument is based is useful in explaining several major historical changes in American market structures, as well as in predicting the consequences that changing information technologies should have for our current market structures. Since we are attempting to predict changes that have not yet occurred on a large scale, our forecasts are based on a simple conceptual analysis rather than on systematic empirical studies. A conclusive test of our model and our predictions will, therefore, require further empirical and analytical work. Nevertheless, in many cases, we are able to identify early examples of the predicted changes that have already occurred in some industries and to suggest implications of the predicted 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 article. The examples we describe, however, illustrate the importance of changes in information technology, even in cases where other forces are involved as well.

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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 [14] and [40]). *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: The buyer of the good or service compares its many possible sources and makes a choice based on 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. 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 buyers do not select a supplier from a group of potential suppliers; they simply work with a single predetermined one. In many cases the hierarchy is simply a firm, while in others it may span two legally separate firms in a close, perhaps electronically mediated, 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, predetermined supplier, rather than choosing from a number of suppliers. On the other hand, the relationship between a single buyer and multiple suppliers serving only that buyer is governed by market forces, since the buyer is choosing between a number of possible suppliers. As the number of suppliers is reduced toward one, relationships that have characteristics of both types may exist.

Factors Favoring Markets or Hierarchies

A number of theorists (e.g., [14, 40, 41, 43, 44]) have analyzed the relative advantages of hierarchical and market methods of organizing economic activity in terms of various kinds of coordination or transaction costs. These coordination costs take into account the costs of gathering information, negotiating contracts, and protecting against the risks of "opportunistic" bargaining. Building on this and other work, Malone and Smith [27, 28] have summarized several of the fundamental trade-offs between markets and hierarchies in terms of costs for activities such as production and coordination. Table I summarizes the part of their analysis that is most relevant to our argument here.[1]

TABLE I. Relative Costs for Markets and Hierarchies

Organizational form	Production costs	Coordination costs
Markets	Low	High
Hierarchies	High	Low

In the table the designations "Low" and "High" refer only to relative comparisons within columns, not to absolute values. Production costs include the physical or other primary processes necessary to create and distribute the goods or services being produced. Coordination costs include the transaction (or governance) costs of all the information processing necessary to coordinate the work of people and machines that perform the primary processes (e.g., see [23], [30], and [40]). For example, coordination costs include determining 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. The classification of a specific task as a production or a coordination task can depend on the level and purpose of analysis, but at an intuitive level, the distinction is clear.

Table I is consistent with an analysis of both the simple costs involved in information search and load sharing [27] and the costs resulting from "opportunistic" behavior by trading partners with "bounded rationality" [40]. As Williamson [43, p. 558] summarizes, "tradeoffs between production cost economies (in which the market may be presumed to enjoy certain advantages) and governance cost economies (in which the advantages may shift to internal organization) need to be recognized."

In a pure market, with many buyers and sellers,

[1] In the terms used by Malone and Smith [27, 28], 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 [27, Table 2]). As noted by Malone [27, pp. 18–19], this comparison is equivalent to a comparison of coordination by separate hierarchical firms and coordination by a market.

the buyer can compare different possible suppliers 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 for pooling the demands of numerous buyers to take advantage of economies of scale and load leveling. The market 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 costs must also include additional negotiating or risk-covering costs that arise from dealing with "opportunistic" trading partners.

Since hierarchies, on the other hand, restrict the procurer's choice of suppliers to one predetermined supplier, production costs are, in general, higher than in the market arrangement. The hierarchical arrangement, however, reduces coordination costs over those incurred in a market by eliminating the buyer's need to gather and analyze a great deal of information about different suppliers.

Various factors affect the relative importance of production and coordination costs, and thus the relative desirability of markets and hierarchies (e.g., see [40], [41], [43], and [44]). We focus here, however, on those that are particularly susceptible to change by the new information technologies [13]. 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 [27]). 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., [43, 44]), but the importance of the complexity of product descriptions has not, we believe, been satisfactorily analyzed.

Asset Specificity. An input used by a firm (or individual consumer) is highly asset specific, according to Williamson's definition [43, 44], 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 movable 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. An asset is time specific if its value is highly dependent on its reaching the user within a specified, relatively limited period of time. For example, a perishable product that will spoil unless it arrives at its destination and is used (or sold) within a short time after its production is time specific. Similarly, any input to a manufacturing process that must arrive at a specific time in relation to the manufacturing process to avoid great costs or losses is also time specific.

There are several reasons why a highly specific asset is more likely to be acquired through hierarchical coordination than through market coordination [41, 43, 44]. Transactions involving asset-specific products often involve a long process of development and adjustments for the supplier to meet the needs of the procurer, a process that favors the continuity of relationships found in a hierarchy. Moreover, since there are, by definition, few alternative procurers or suppliers of a product high in physical or human asset specificity, both parties in a given transaction are vulnerable. If either one goes out of business or changes its need for (or production of) the product, the other may suffer sizable losses. The greater control and closer coordination allowed by a hierarchical relationship are thus more desirable to both.

Complexity of Product Description. Complexity of product description refers to the amount of information needed to specify the attributes of a product in enough detail to allow potential buyers (whether producers acquiring production inputs or consumers acquiring goods) to make a selection. Stocks and commodities, for example, have simple, standardized descriptions, while those of business insurance policies or large and complicated computer systems are much more complex. This factor is frequently, but not always, related to asset specificity; that is, in many cases a highly specific asset, such as a specialized machine tool, will require a more complex product description than a less specific asset. The two factors are logically independent, however, despite this frequent correlation. Coal produced by a coal mine located adjacent to a manufacturing plant is highly site specific, though the product description is quite simple. Conversely, an automobile is low in asset specificity, since most cars can be used by many possible consumers, but the potential car buyer requires an extensive and complex description of the car's attributes in order to make a purchasing decision.

Other things being equal, products with complex descriptions are more likely to be obtained through hierarchical than through market coordination for reasons centering on the cost of communication about a product. We have already noted that coordination costs are higher for markets than for hierarchies, in part because market transactions require contacting more possible suppliers to gather information and negotiate contracts. Because highly complex product descriptions require more information exchange, they also increase the coordination cost advantage of hierarchies over markets. Thus buyers of products with complex descriptions are more likely to work with a single supplier in a close, hierarchical relationship (whether in-house or external), while buyers of simply described products (such as stocks or graded commodities) can more easily compare many alternative suppliers in a market.

As Figure 1 shows, then, items that are both highly asset specific and highly complex in product description are more likely to be obtained through a hierarchical relationship, while items that are not very asset specific and have simple product descriptions are more often acquired through a market relationship. The organizational form likely for items in the other two cells of the table will depend on which factor dominates.

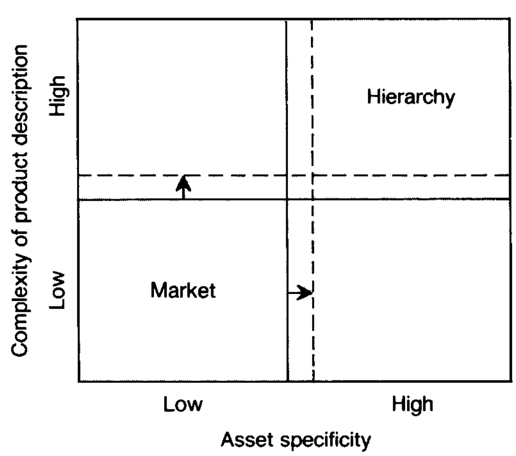

FIGURE 1. Product Attributes Affect Forms of Organization

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 [12], Williamson [43, 44], Malone and Smith [28], Malone [27], and DuBoff [16]. Yates [45] develops this application in more detail.)

Until the mid-nineteenth century, small-scale local and regional markets, not hierarchies, coordinated adjacent stages of American industrial activity. The three major functions of manufacturing—procurement, production, and distribution—were generally handled by different parties. By mid-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 larger and more efficient markets in some cases, and larger, multifunctional hierarchies in others. On the one hand, as Table I illustrates, markets are more communication intensive than hierarchies. Therefore, reducing the time and cost of communication favored—and thus encouraged—the growth of markets. On the other hand, the growth in market area increased the number of economic actors potentially involved in transactions as well as the total amount of communication necessary for efficient markets to operate, thus favoring hierarchies (see [27] and [28]). The net effect of the telegraph in different industries depended largely on the other factors from our framework.

Just as our framework would lead us to expect, nationwide markets mediated by telegraph developed for products such as stocks and commodities futures. These products were nonspecific assets with many potential buyers. In addition, they were easily describable and consequently susceptible to standardized designations that reduced telegraph costs further. The commodities futures market, for example, only emerged on a national scale after a uniform grading scheme that simplified product description was adopted [16].

The detailed evolutionary path of large integrated hierarchies was more complex than that of national markets and 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, according to Chandler [12], encouraged manufacturers to increase their output, frequently by developing new techniques of mass production that offered economies of scale. Such firms, however, often found that existing procurement and distribution mechanisms did not support the high-volume throughput necessary to realize the economies, especially when specialized equipment or human expertise were required.

As Williamson [44] has pointed out, the companies that Chandler identifies as the first to vertically integrate procurement, production, and distribution within a hierarchy were those 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. In the first case, high time specificity outweighed low complexity of product description. In the second case, the product description was complex, and the sales process was high in human specificity. For these firms, the telegraph provided a mechanism by which close hierarchical coordination could be wielded over great distances. Although the economies of scale were the major factor driving this integration, asset specificity and complexity of product description played a role in determining which firms were likely to integrate, using the telegraph as a mechanism of hierarchical coordination rather than of market communication.

Thus our analytic framework is useful in interpreting the impact of communication technology on past changes in organizational form, even when noncommunication factors also played 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 toward electronic markets.

Emergence of Electronic Interconnection

Let us begin by looking briefly at the technological developments that make electronic interconnection 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, the use of computer and telecommunications technology for transferring information gives rise to what we term the *electronic communication effect.* This means that information technology 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 may 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 one party to the other. A broker substantially reduces the need for buyers and suppliers to contact a large number of alternative partners individually (see [1] and [27] 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 database, 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 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.* This effect occurs when information technology is used not just to speed communication, but to change—and lead to tighter coupling of—the processes that create and use the information. 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 and manufacturing engineers to access and manipulate their respective data to test 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 use in the procurer's manufacturing process, enable the latter to eliminate inventory holding costs, thus reducing total inventory costs for the linked companies. 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.

Electronic interconnections provide substantial benefits. The recipients of these benefits—either buyers or suppliers (or both)—should be willing to pay, either directly or indirectly, for them. The providers of electronic markets and electronic hierarchies should, in many cases, be able to realize significant revenues from providing these services.

The 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.

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

General Argument Favoring Shift toward Markets. Our initial argument for the overall shift from hierarchies to markets is a simple one, based primarily on two components. The first is the assumption that the widespread use of information technology is likely to decrease the "unit costs" of coordination. As noted above, "coordination" refers to the information processing involved in tasks such as selecting suppliers, establishing contracts, scheduling activities, budgeting resources, and tracking financial flows. 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., [15, 23, 38]).

The second component of our argument is based on the trade-offs summarized in Table I. As we noted above, and as Williamson [43] and numerous others have observed, markets have certain production cost advantages over hierarchies as a means of coordinating economic activity. The primary disadvantage of markets is the cost of conducting the market transactions themselves, which, for a number of reasons (including the "opportunistic" ones emphasized by Williamson and the purely "informational" ones emphasized by Malone [27]), are generally higher in markets than in hierarchies. An overall reduction in the "unit costs" of coordination would reduce the importance of the coordination cost dimension (on which markets are weak) and thus lead to markets becoming more desirable in some situations where hierarchies were previously favored. In other words, the result of reducing coordination costs without changing anything else should be an increase in the proportion of economic activity coordinated by markets. This simple argument does not depend on the specific values of any of the costs involved, on the current relative importance of production and coordination costs, or on the current proportion of hierarchical and 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 Figure 1 illustrates, some of the new, computer-based information technologies have affected both of our key dimensions so as to create an overall shift from hierarchies to markets. Databases and high-bandwidth electronic communication can handle and communicate complex, multidimensional product descriptions much more readily than can traditional modes of communication. Thus the horizontal line between high and low complexity in Figure 1 has, in effect, shifted upward so that some product descriptions previously classified as highly complex, such as those of airline reservations, may now be considered low in complexity relative to the capabilities of the technology to communicate and manipulate them. 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 undergone a similar change. 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 switch-over costs. The vertical line in Figure 1 therefore moves slightly right 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 the Shift toward Electronic Markets. A dramatic example of the shift toward electronic markets has already occurred in the airline industry. When airline reservations are made by a customer calling the airline directly (and the commission is 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 the commission is received) by the travel agent acting as an external selling agent for the airline. In this case, the selling process 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 percent since the introduction of the American Airlines reservations system [33, 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 [10] and [35]). This kind of "vertical disintegration" of production activities into different firms has become more beneficial 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.

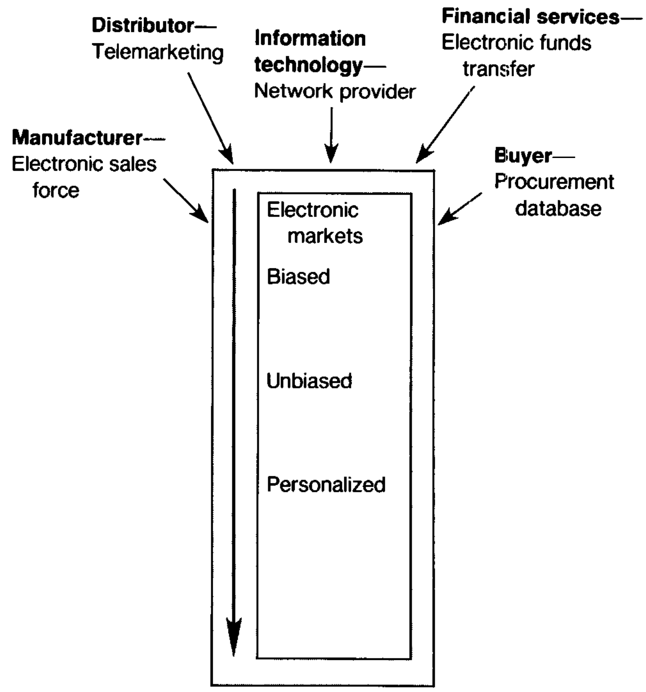

FIGURE 2. Evolution of Electronic Markets: Multiple Starting Points Lead to a Common Evolutionary Path

THE EVOLUTION OF ELECTRONIC MARKETS AND ELECTRONIC HIERARCHIES

Motives for Establishing Electronic Markets: Possible Market Makers

An electronic market may develop either from a nonelectronic market or from an electronic hierarchy spanning firm boundaries. As Figure 2 indicates, any of several participants in an emerging electronic market may be its initiator or market maker, each with different motives. For a market to emerge 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 will continue to use these three terms as well as 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 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 market participants has different motivations and possibilities for helping to form electronic markets. Our framework suggests how these motivations and other forces such as the electronic brokering, electronic communication, and electronic integration effects may influence the evolution of 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. In the airline industry, such electronic systems were originally established to encourage travelers to buy tickets from the airline providing the service; they were thus initially electronic hierarchies. Now, however, the travel agents' systems provide access to tickets from all airlines, thus creating electronic markets with an electronic brokering effect [9, 11, 33]. Another example of an electronic interconnection established by a producer is American Hospital Supply's (AHS's) ASAP system, by which several thousand hospitals are provided with on-site terminals that allow them to automatically enter orders for AHS's products [21, 33]. 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 wants 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 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, thus creating an electronic market. 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 [11]. These systems can then be used to speed order processing and implement innovations such as "just-in-time" inventory management [7]. Groups of buyers are currently developing similar electronic markets in the grocery, chemical, and aluminum industries as well [7]. 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 pharmaceutical industry, for example, wholesale distributors such as McKesson have followed the lead of producers such as AHS in setting up electronic connections with their customers [8]. Like AHS, such distributors established the electronic links in an attempt 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. Although the benefits to the distributor may initially have had their source in the bias, distributors may soon find that the greater efficiency offered by the electronic market allows adequate compensation 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, offer their credit card holders a telephone shopping service for a wide variety of consumer goods [37]. 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, and have them delivered to their door. In a similar spirit, Citicorp and McGraw-Hill have formed a joint venture to make information about alternative prices for crude oil and to match buyers and sellers [5]. Similarly, Louie [26] describes the evolution of the PRONTO home banking system at Chemical Bank in New York, 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 supplier'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 the software necessary to create computer-based markets are provided by information technology vendors. Even though these examples illustrate how the line between these 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 verifying that the latter have the necessary legal authorization and insurance coverage [20, p. 1199]. It is easy to imagine other examples of information technology vendors making markets. For example, a natural extension of telephone companies' classified directories would be "electronic yellow pages," which might include capabilities for actually placing orders as well as locating suppliers. (A directory-only service of this type is already offered by Automated Directory Services [25].)

Stages in the Evolution of Electronic Markets

The evolution of electronic markets from nonelectronic markets or from electronic or nonelectronic hierarchies frequently 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 initial providers of electronic markets have attempted to exploit the benefits of the electronic communication effect to capture customers in a system biased toward 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 [9, 11, 33]. The United system was originally 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 for 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 adopted the same strategy, and by 1983 travel agencies that used automated reservation systems used one of these two systems for 65 percent of the reservations they made [11, p. 139]. These systems' significant bias in favor of their suppliers' flights eventually led other airlines to protest, and recent rules from the Civil Aeronautics Board eliminated much of the bias in the systems. The systems now provide unbiased reservation service to other airlines for a significant fee.

A similar evolution may result in the case of the ASAP order entry system. AHS is apparently trying to prevent that outcome by making the shared processes themselves more asset specific. For instance, Jackson [21, p. 137] describes 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, 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 an electronic hierarchy or 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 buyers might be overwhelmed with more alternatives than they 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. The problem will be particularly acute, however, 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 many consumer products, for example, would fall in this category.

In these cases, a final stage may be the development of electronic markets that provide personalized decision aids to help individual buyers select from the alternatives available, what we call "personalized markets." For example, at least one such system has been developed for airline reservations [6, p. 21]. Using this system, travel agencies and corporate travel departments can receive information about available flights with each flight automatically ranked on a scale from 1 to 100. The rankings take into account "fares, departure times, and even the value of an executive's time."

It is easy to imagine even more sophisticated systems that use artificial intelligence (AI) techniques to screen advertising messages and product descriptions according to precisely the criteria that are important to a given buyer (e.g., see [29] for a similar system that filters electronic messages of all kinds). Air travelers, for instance, might specify rules with which their own "automated buyers' agents" could compare a wide range of possible flights and select the ones that best match that particular traveler's preferences. A fairly simple set of such rules could, in many cases, do a better job of matching travelers' preferences than all but the most conscientious and knowledgeable travel agents.

In addition to AI techniques for specifying complex qualitative reasoning processes, there are also a number of normative mathematical models [24] and descriptive behavioral models [22, 32, 36] 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 nonspecific) 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 obviously cases where protecting the privacy of buyers should preclude making this information available. In other cases, however, making buyer preferences automatically available (perhaps anonymously) to suppliers could dramatically improve the efficiency of certain kinds of market research as well as the responsiveness of suppliers. Instead of having to painstakingly infer consumer decision rules from surveys or experiments, suppliers might be able to simply observe the actual rules consumers had specified.

Motives for Establishing Electronic Hierarchies

There are still many cases of high asset specificity and complex product descriptions for which electronic hierarchies will be desirable. In particular, as Figure 3 suggests, electronic hierarchies will be established to improve product development or prod-

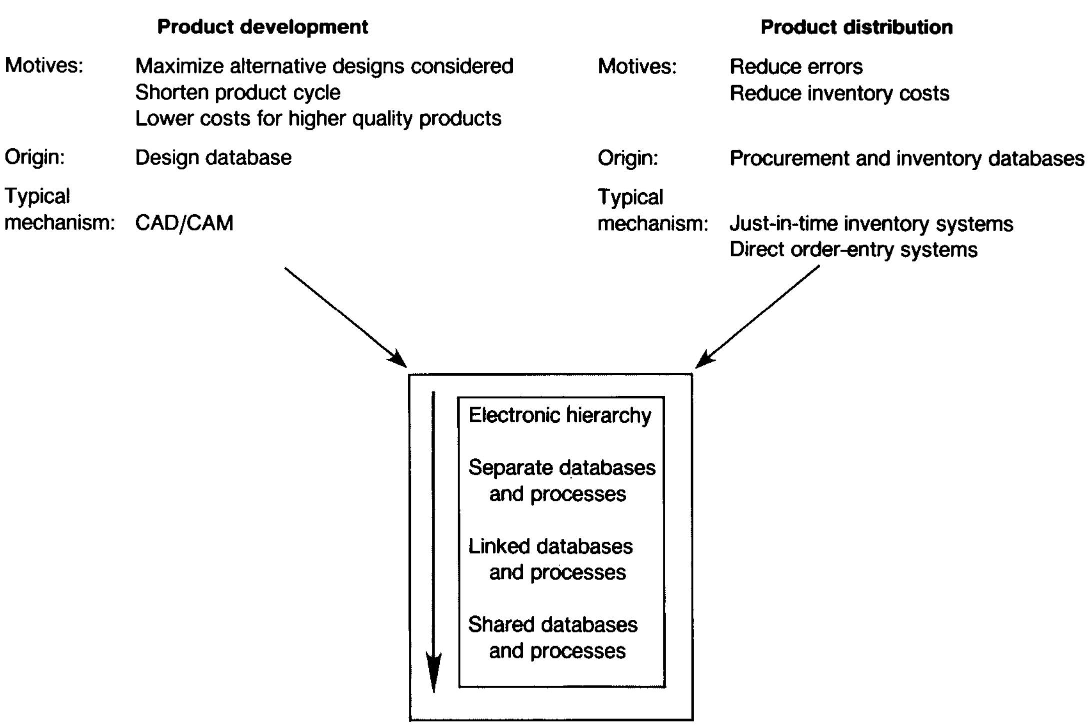

FIGURE 3. Evolution of Electronic Hierarchies: From Separate to Shared Databases

uct distribution. In this section we discuss why and how companies may establish electronic hierarchies for each of these functions.

Product Development. CAD/CAM, electronic mail, and other information technologies can be used in product development 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 that such integration "is the key to faster and less costly development, to lower manufacturing costs, and to better products" [19, p. 12].

The key data that must be shared in the product development process are engineering drawings, parts descriptions, bills of materials, engineering change notices (ECNs), machine tool configurations, and so forth. For example, in many companies the ECN process is considered a people-intensive, time-consuming, and error-prone administrative activity. Because the shared database 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 (e.g., [30]).

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 its entry in the spare parts ordering process; the manufacturing engineer, who designs the actual manufacturing process; and the manufacturing analyst, who updates the necessary manufacturing databases 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 were 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 database permits significant reduction in administrative coordination costs and, more importantly, increases the quality and timeliness of the product development process as well.

Although the above example 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 [11, 35]. In the design of semiconductor circuits, for instance, over 100 different processes and over 30–40 separate organizations have traditionally been involved [17, 38]. Use of the Mead Conway method for VLSI design and electronic integration between organizations has dramatically reduced these numbers. Designers in remote organizations use standardized languages in functionally rich workstations and then send their standardized design databases over a network to a supplier fabrication facility where they are linked to the supplier's manufacturing process databases. The end result is that the test circuits are delivered to the procurer more cheaply and quickly.

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

Product Distribution. The two primary participants in product distribution systems are 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 inventory [31]. That is, to lower inventory costs, procurers may raise the time specificity of the process. Firestone, for example, as part of the physical and electronic inventory system of two major car manufacturers, carries the tire inventories of both firms. The large battery manufacturer that supplies Firestone's retail stores is similarly tied into its distribution system and maintains the battery inventory for Firestone.

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., [35]). 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 [35, 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. Suppliers, however, may also perceive other advantages to an electronic arrangement. Jackson [21, 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 databases and physical and electronic processes may become physically, humanly, and time specific, increasing the likelihood of a hierarchical rather than market relationship. This is clearly a consideration in early systems such as that developed by AHS. As noted earlier, however, such electronic hierarchies frequently develop into biased, then unbiased electronic markets when the products themselves are not asset specific and are easily described in standardized terms.

In addition to these separate motives, both procurer and 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 reentries of information between paper and computer systems of both parties. For the auto makers and component suppliers, for example, this costly process results in errors in approximately 5 percent of all procurer/supplier documents [7]. The Automotive Industry Action Group is now establishing standard forms and processes for the major 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 preexisting 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. In the insurance industry, for example, both the independent agents and the major commercial and property carriers are hotly contesting the control of standards [3]. 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

Shared databases, 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 [4].

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 3 indicates a plausible trajectory that this observation suggests: Stand-alone but mutually accessible databases should appear first, then be replaced by electronically linked databases and, eventually, by fully shared databases. We are not aware of good examples of all three stages of this trajectory occurring in a single system, but we can describe examples of systems at each of the three stages.

Stand-Alone Databases. In this stage one or both parties make their databases accessible to the other party in the electronic hierarchy. This often requires the other party to use a separate workstation. The early versions of the AHS order entry system, for example, required customers to use a separate workstation to access the AHS order entry programs and purchasing history databases [18]. 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 customer's accounting and other application systems, so we classify it as a stand-alone database.

Linked Databases. In this stage supplier and buyer databases are still separate, but a formal on-line mechanism passes information from one to the other. The most recent version of the AHS order entry system (see [18]) allows this kind of direct computer-to-computer communication. Orders are prepared by the customer's internal computer system and transmitted electronically to AHS, and 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 Databases. In this final stage, one database contains information of value for both parties in the electronic hierarchy. The ECN 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 database environment successfully (e.g., [39]).

CONCLUSIONS AND STRATEGIC IMPLICATIONS

A casual reading of the business press confirms that electronic connections within and between organizations are becoming increasingly important (e.g., [2, 9, 11, 33]). The framework we have developed here helps illuminate 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 occurring 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 the potential advantages of providing 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 likely that biased electronic sales channels (whether electronic hierarchies or biased electronic markets) for nonspecific, 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) Information systems groups in most firms should begin to plan the network infrastructure that will be necessary to support the kinds of internal and external interconnections we have described.

(6) 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 intel-

ligent 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.

In short, if our predictions are correct, we should not expect the electronically interconnected world of tomorrow to be simply a faster and more efficient version of the world we know today. Instead, we should expect fundamental changes in how firms and markets organize the flow of goods and services in our economy. Clearly more systematic empirical study and more detailed formal analyses are needed to confirm these predictions, and we hope the conceptual framework presented here will help guide this research.

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