COMPUTERS, NETWORKS, AND THE CORPORATION

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ABSTRACT

This article, written for a general audience, discusses the effects that information technologies are likely to have on corporate structure and management approaches. By dramatically reducing the costs of coordination and increasing its speed and quality, these new technologies will enable people to coordinate more effectively, to do much more coordination, and to form new, coordination-intensive business structures.

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About 150 years ago the economy in the U.S. and Europe began to undergo a period of change more profound than any experienced since the end of the Middle Ages. We call that change the Industrial Revolution. The industrial economies are now in the early stages of another transformation that may ultimately be at least as significant.

There is a critical difference this time, however. Changes in the economies of production and transportation drove the revolution of the last century. The revolution under way today will be driven not by changes in production but by changes in coordination. Whenever people work together, they must somehow communicate, make decisions, allocate resources and get products and services to the right place at the right time. Managers, clerks, salespeople, buyers, brokers, accountants -- in fact, almost everyone who works -- must perform coordination activities.

It is in these heavily information-based activities that information technologies have some of their most important uses, and it is here that they will have their most profound effects. By dramatically reducing the costs of coordination and increasing its speed and quality, these new technologies will enable people to coordinate more effectively, to do much more coordination and to form new, coordination-intensive business structures.

The core of the new technologies is the networked computer. The very name "computer" suggests how one usually thinks of the device -- as a machine for computing, that is, for taking in information, performing calculations and then presenting the results. But this image of computing does not capture the essence of how computers are used now and how they will be used even more in the future. Many of the most important uses of computers today are for coordination tasks, such as keeping track of orders, inventory and accounts. Furthermore, as computers become increasingly connected to one another, people will find many more ways to coordinate their work. In short, computers and computer networks may well be remembered not as technology used primarily to compute but as coordination technology.

To understand what is likely to happen as information technology improves and its

costs decline, consider an analogy with a different technology: transportation. A first-order effect of transportation technology was simply the substitution of new transportation technologies for the old. People began to ride in trains and automobiles rather than on horses and in horse-drawn carriages.

As transportation technology continued to improve, people did not use it just to substitute for the transportation they had been using all along. Instead a second-order effect emerged: people began to travel more. They commuted farther to work each day. They were more likely to attend distant business meetings and to visit faraway friends and relatives.

Then, as people used more and more transportation, a third-order effect eventually occurred: the emergence of new "transportation-intensive" social and economic structures. These structures, such as suburbs and shopping malls, would not have been possible without the wide availability of cheap and convenient transportation.

Improved coordination technology has analogous effects. A first-order effect of reducing coordination costs is the substitution of information technology for human coordination. For example, data-processing systems helped to eliminate thousands of clerks from the back offices of insurance companies and banks. Similarly, computer-based systems have replaced scores of factory "expediters." Today computers track the priority of each job in the factory and indicate the most critical ones at each workstation. More generally, the long-standing prediction that computers will lead to the demise of middle management finally seems to be coming true. In the 1980s many companies flattened their managerial hierarchy by eliminating layers of middle managers.

A second-order effect of reducing coordination costs is an increase in the overall amount of coordination used. For instance, contemporary airline reservation systems enable travel agents to consider more flight possibilities for a given customer more easily. These systems have led to an explosion of special fares and price adjustments. American Airlines and United Air Lines, which provide the largest systems, have benefitted significantly from the fees they charge for this service. For instance, in 1988 American made about $134 million from its reservation system -- almost 15 percent of its total income. In addition, access to up-to-the-minute information about ticket sales on all airlines enables American

and United to adjust their fare schedules to maximize profits.

Otis Elevator Company also increased the amount of its coordination -- primarily to improve maintenance service for its customers. With its Otisline system, highly trained multilingual operators receive trouble calls through a national toll-free number. The operators record the problems in a computer data base and then electronically dispatch local repair people.

This real-time availability of data has vastly improved the management of repair activities. For instance, if a particular type of part has failed during the past week on eight of 100 elevators, Otis can preemptively replace that part on the other 92 elevators. Although this kind of nationwide correlation of data was possible before, the degree of communication and coordination required was impractical. These capabilities have played a major role in reducing maintenance calls by nearly 20 percent.

In some instances, the second-order effect of an increase in demand may overwhelm the first-order effect of substitution. For example, in one case we studied, a computer conferencing system helped to remove a layer of middle managers. Several years later, however, almost the same number of new positions (for different people at the same grade level) had been created. According to people in the company, the new specialists took on projects not considered before. Evidently, managerial resources no longer needed for simple communication could now be focused on more complex coordination tasks.

A third-order effect of reducing coordination costs is a shift toward the use of more coordination-intensive structures. A prime example is Frito-Lay, Inc., studied by Lynda M. Applegate of Harvard Business School and others. At Frito-Lay, some 10,000 route salespeople record all sales of each of 200 grocery products on hand-held computers as they deliver goods to customers on their route. Each night, the stored information is transmitted to a central computer. In turn, the central computer sends information on changes in pricing and product promotions to the hand-held computers for use the next day. Each week, the main computer summarizes the centrally stored information and combines it with external data about the sales of competitive brands. Some 40 senior executives and others can then gain access to this information through an executive information system (EIS).

The availability of these data has enabled Frito-Lay to push key decisions down from corporate headquarters to four area heads and several dozen district managers. The managers can use the data not only to compare actual sales to sales targets but also to recommend changes in sales strategy to top management. This entire coordination-intensive structure has become possible only in the past few years because of the improved capability and reduced costs of hand-held computers, EIS software, computer cycles and telecommunications equipment.

Coordination-intensive structures do not just link different people in the same companies. Many of the most interesting new structures involve links among different companies. For example, the U.S. textile industry has begun implementing a series of electronic connections among companies as part of the Quick Response program. As described by Janice H. Hammond of Harvard Business School and others, these electronic connections link companies all along the production chain, from suppliers of fibers (such as wool and cotton) to the mills that weave these fibers into fabric, to the factories that sew garments and, ultimately, to the stores that sell the garments to consumers.

When such networks are fully implemented, they will help companies respond quickly to demand. For instance, when a sweater is sold in New York City, a scanner reading the bar-coded label may automatically trigger ordering, shipping and production activities all the way back to the wool warehouse in South Carolina. This new, multiorganizational structure will reduce inventory costs throughout the value chain. The textile-apparel retail industry spends about $25 billion in inventory costs every year; the Quick Response approach may save half that amount.

Wal-Mart has already established parts of a similar system that links the retailer to Procter & Gamble Company and several of its other major suppliers. In doing so, Wal-Mart has eliminated significant parts of its own purchasing groups and contracted with its suppliers to replace products as they are sold. In one such experiment, both unit sales and inventory turnover increased by about 30 percent.

Sometimes technology helps to create interorganizational networks -- not just among buyers and suppliers but also among potential competitors. For example, Eric K. Clemons of the University of Pennsylvania has studied the Rosenbluth International Alliance, a

consortium of travel agencies around the world that share customer records, services and software. The alliance also provides clients with toll-free English-language help lines in every major country. This consortium of independent agencies, led by Rosenbluth Travel in Philadelphia, can therefore manage all travel arrangements for international trips and for meetings of people from many parts of the globe.

The textile firms near Prato, Italy, illustrate a related kind of interorganizational alliance. As described by Michael J. Piore and Charles F. Sabel of the Massachusetts Institute of Technology, the operation of a few large textile mills was broken into many small firms, coordinated in part by electronic connections among them. This network can flexibly adjust to changes in demand, sometimes shifting orders from an overloaded mill to one with spare capacity. The structure also takes advantage of the entrepreneurial motivation of the owners: in small mills, the owners' rewards are more closely linked to their own efforts than is the case in large ones.

As these examples show, information technology is already facilitating the emergence of new, coordination-intensive structures. What do these changes mean for the organizations of the near future?

A surprising result of our research is a prediction that information technology should lead to an overall shift from internal decisions within firms toward the use of markets to coordinate economic activity. To see why, consider that all organizations must choose between making the goods or services they need and buying them from outside suppliers. For instance, General Motors Corporation must decide whether to make tires internally or purchase them from a tire manufacturer.

Each of these two forms of coordination -- internal and external -- has advantages and disadvantages. As Oliver Williamson of the University of California at Berkeley and others have argued, buying things from an outside supplier often requires more coordination than making them internally. To buy tires, General Motors may need to compare many potential suppliers, negotiate contracts and do formal accounting for the money that changes hands. Coordinating the production of tires internally, on the other hand, can often be done less formally and at lower cost, with telephone calls and meetings.

But improved information technology should reduce the costs of both internal and external coordination, much as transportation technology lowered the expense of traveling. When trains and automobiles reduced the difficulty of traveling, more people chose to live in the suburbs rather than in the cities to reap such benefits as extra living space. Similarly, when information technology reduces the costs of a given amount of coordination, companies will choose to buy more and make less. The additional coordination required in buying will no longer be as expensive, and buying has certain advantages. For instance, when General Motors buys tires, it can take advantage of the supplier's economies of scale and pick the best tires currently available from any supplier whenever its needs change. Thus, we expect networks to lead to less vertical integration -- more buying rather than making -- and to the proliferation of smaller firms. More electronically mediated alliances (such as the Rosenbluth International Alliance) and an increased use of electronic markets to pick suppliers (such as the airline reservation system) will result.

This argument implies that information technology will help make markets more efficient. Buyers will no longer have to exert great effort to compare products and prices from many different suppliers. Instead an electronic market can easily and inexpensively collect and distribute such information.

These more efficient markets threaten firms whose strategic advantages rest on market inefficiencies. For instance, as Clemons described, when the London International Stock Exchange installed an electronic trading system, the trading floor became virtually deserted within weeks. Trading moved to electronic terminals around the world. The system greatly reduced the costs of matching buyers and sellers. This change, in turn, dramatically reduced the profits of brokers and trading specialists, who previously had had a monopoly on performing this function. The potential decline in profit may explain why many other exchanges still resist electronic trading.

Many other kinds of intermediaries, such as distributors and retailers, are becoming vulnerable as well. For example, consumers can now bypass retail stores entirely by using computer-based systems such as Comp-U-Card and Comp-u-store to buy household goods and services at substantial savings. Electronic markets can also make evaluating product quality easier; we expect that it is only a matter of time before networks contain extensive

comments and evaluations from previous buyers, becoming a kind of instantaneous, on-line *Consumer Reports*.

Increasing market efficiency also implies that firms should focus more carefully on the few core competencies that give them strategic advantages in the marketplace. They should buy the additional, more peripheral products and services they need instead of making them. For instance, in the past few years, Ford Motor Company and Chrysler Corporation have significantly increased their proportion of externally purchased components, such as tires and batteries.

Even though information technology can be strategically important, single innovations in information technology are seldom in themselves a source of continuing competitive advantage. For example, American Hospital Supply (now Baxter Healthcare Corporation) won high praise for its early system that let customers place orders electronically without requiring a salesperson. This system made ordering from American Hospital easier than doing so from competitors and reduced the time salespeople had to spend on the clerical aspects of taking an order. But contrary to original expectations, systems like these do not "lock in" customers in the long run. Instead customers eventually seem to prefer electronic systems that provide a choice among several vendors. Similarly, an automatic teller machine system that may once have been a competitive advantage for a bank is now largely a competitive necessity.

One way to maintain an upper hand is to keep innovating so rapidly that other firms always lag a step behind. Another way, as Clemons has noted, is to use information technology to leverage some other structural advantage. For instance, Barclay deZoete Wedd, a British brokerage firm, continues to benefit from an electronic stock-trading system because the company already controlled the trading of far more stocks than did any of their competitors.

In addition to markets, another coordination-intensive organizational structure likely to become much more common is what some management theorists call a networked organization, or, more picturesquely, an "adhocracy", a term Alvin Toffler popularized in his book *Future Shock*. This form is already common in organizations such as law firms,

consulting companies and research universities. Such organizations and institutions must continually readjust to a changing array of projects, each requiring a somewhat different combination of skills and other resources. These organizations depend on many rapidly shifting project teams and much lateral communication among these relatively autonomous, entrepreneurial groups.

The adhocracy contrasts with the conventional business organization of today: the hierarchy. Hierarchies are common partly because they provide a very economical way of coordinating large numbers of people. In principle, decision makers in a hierarchy can consider all the information known to anyone in the group with much less communication than would be needed if each person communicated with everyone else.

In practice, however, hierarchies have severe limitations. Central decision making can become overloaded and therefore unable to cope effectively with rapidly changing environments or to consider enough information about complex issues. Furthermore, people at the bottom may feel left out of the decision making and as a result be less motivated to contribute their efforts.

As information technology reduces communication costs, the nonhierarchical structures (such as markets and adhocracies) may help overcome the limitations of hierarchies. For example, because of the large amount of unpredictable lateral communication, the adhocracy is extremely coordination intensive. New media, such as electronic mail, computer conferencing and electronic bulletin boards, can make the coordination easier and, therefore, enable the adhocracy to work much more effectively. Computer networks can help find and coordinate people with diverse knowledge and skills from many parts of an organization.

Moreover, computer-based technologies can transfer information not only faster and more cheaply but also more selectively. These capabilities help to mitigate information overload. Systems now exist to help people find, filter and sort their electronic mail based on topic, sender and other characteristics. Together these new coordination technologies can speed up the "information metabolism" of organizations -- the rate at which firms can take in, move, digest and respond to data.

Abundant information poses two potential difficulties for organizational power. Some people worry that managers may become "Big Brothers" who use the information to exert stronger centralized control over those who work for them. Others fear that if power is decentralized throughout the organization, workers might use their newfound power to serve their own narrow interests, leading to organizational chaos.

In fact, neither dark vision has been realized. Instead what appears to be happening is a paradoxical combination of centralization and decentralization. Because information can be distributed more easily, people lower in the organization can now become well enough informed to make more decisions more effectively. At the same time, upper-level managers can more easily review decisions made at lower levels. Thus, because lower-level decision makers know they are subject to spot-checking, senior managers can retain or even increase their central control over decisions.

The changes at Phillips Petroleum Company illustrate this process. Previously, senior managers decided what price to set for petroleum products. These critical decisions depended on the recommendations of staff analysts several levels down. When Phillips Petroleum developed an executive information system, senior managers began to make some of these decisions more directly based on the global information provided by the system. The senior executives soon realized, however, that they could pass on this global information directly to local terminal managers, who could take into account information such as competitors' prices. By decentralizing the pricing decision in this way, the company made sounder, more profitable pricing strategies in each area of the country.

Another way of understanding this paradoxical effect is to realize that new technology does not just redistribute power. It can provide a sense of more power for everyone. For example, the agents of several insurance companies currently carry laptop computers when they visit the homes of customers. The agents use the computers to fill out applications and to project premiums and benefits. But typically, underwriters at the corporate headquarters require several weeks to review the applications and to issue new policies.

Soon the underwriting rules for certain routine policies will be included in the laptop computer itself. The agent will be able to issue these policies immediately in the customers' homes.

These systems will thus "empower" the agents, who will control the time and place of the policy-acceptance decisions and can make sales immediately. The authority of the central underwriters will increase as well, because the rules they have created will be applied consistently. The underwriters will also be able to devote more time to analyzing interesting and potentially more profitable nonroutine cases.

Information technology not only changes power; it also changes time. On the one hand, time has expanded. Electronic mail, voice mail and facsimile transmissions can be sent or received at any time of day or night, almost anywhere around the globe. Similarly, customers of automatic teller machines and some stock markets can make transactions around the clock. The "work day" has much less meaning, and companies can compete by expanding the times their services are available.

On the other hand, time has contracted. Companies can also compete on speed. For instance, effective coordination can reduce the time needed to develop new products, deliver orders or react to customer requests. Management teams, such as the one at Phillips Petroleum, have information available throughout the management hierarchy, which enables them to react to market conditions much more quickly. Decisions that might have taken days in the past can now be made within hours or minutes.

The changes discussed so far require no great predictive leaps; they are already happening. What will happen as information technology improves even more? What other kinds of organizations might emerge in the globally interconnected world that the technologies make feasible?

One possibility is the increasing importance of "answer networks," networks of experts available to answer questions in different areas. One might go to these services with questions such as "How many bars of soap were sold in Guatemala last year?" or "What are the prospects of room-temperature superconductivity in consumer products by 1995?" The services would include massive data bases and layers of human experts in many different topic areas. Some questions will be easily answerable from information in a data base. Others will be referred to progressively more knowledgeable human experts. Depending on how much one is willing to spend and how quickly one wants the answer, the response might

range from a newspaper clipping to a personal reply from a Nobel laureate scientist. Similar but limited services exist today -- product hot lines and library reference desks are examples -- but computer networks and data bases will make such services much less expensive, much more valuable and, therefore, much more widely used.

Electronically mediated markets can also assemble armies of "intellectual mercenaries" virtually overnight. For instance, there may be a large number of consultants who make their living doing short-term projects over the network. If a manager has a job to be done, such as evaluating a loan or designing a lawnmower, he or she could quickly assemble a team by advertising electronically or by consulting a data base of available people. The data base might contain not only the skills and billing rates of prospective workers but also unedited comments from others who had used their services before. Although consulting firms and advertising agencies sometimes work like this now, pervasive networks will allow teams to be assembled much more quickly, for shorter projects and from many different organizations.

This kind of market for services might be used inside an organization as well. Instead of always relying on supervisors to allocate the time of people who work for them, extensive internal markets for the services of people and groups may exist. Murray Turoff of the New Jersey Institute of Technology has suggested how such a system might work. Someone with a short programming project to be done, for instance, might advertise internally for a programmer. Bids and payments for this internal market could be in real dollars or some kind of point system. The bids from programmers would indicate their skill and availability. The payments that programmers receive would reflect how valuable they had been to other parts of the organization.

Improved technology can also help create decision-making structures that integrate qualitative input from many people. For instance, in making complex decisions, such as where to locate a new plant, the amassing of many facts and opinions is critical. Today companies often make such decisions after incomplete discussions with only a few of the people whose knowledge or point of view might be valuable. In the future, companies may use computer networks to organize and record the issues, alternatives, arguments and counterarguments in graphical form. Then many different people can review and critique

the parts of the argument about which they know or care.

For instance, someone in a remote part of the firm might know about plans for a new highway that completely change the desirability of a proposed plant location. As such information accumulates, people can vote on the plausibility of different claims. Then, using all the information displayed in the system, a single person or group can ultimately make the decision.

What will happen as the globally networked society leads to a world in which vast amounts of information are freely available or easily purchased? Clearly, this world will require services, both automated and human, to filter the tremendous amount of information available. In general, as the amount of information increases, people who can creatively analyze, edit and act on information in ways that cannot be automated will become even more valuable.

But what else people will do will depend on the values that are important to them. When trains and automobiles reduced the constraints of travel time, other values became more significant in determining working and living patterns. As Kenneth T. Jackson of Columbia University has documented, for example, American values about the importance of owning one's home and the moral superiority of rural life played a large role in determining the nature of suburbs in the U.S.

Similarly, when the costs of information and coordination are not a barrier to fulfilling people's needs and wants, other values may emerge to shape the workplace and society. The new information technologies will almost certainly help gratify some obvious wants, such as the desire for money. Some of the emerging corporate structures may be especially good at satisfying nonmaterial needs, such as those for challenge and autonomy.

But perhaps these desires are themselves manifestations of some still deeper needs. Psychologists sometimes refer to a need for self-actualization. Others might call this a desire for spiritual fulfillment. To use the new technology wisely, we will need to think more carefully about what we truly value and how the technology can help us reach our deeper goals.