The last two chapters have referred to various technologies used in old and emerging organizational forms. This chapter will explicitly examine the role of technology, both in theories of organization and as a harbinger of organizational transformation. With the digital revolution and the proliferation of new information technologies, one must ask whether these new technologies are playing a qualitatively different role in shaping organizational structure and process.

In the organizational literature, technology has been defined as the means, activities, and knowledge used to transform materials and inputs into organizational outputs (Scott 1987:18). This definition is deliberately wordy because so many different technologies might be employed by any organization.

As a simple example of organizational technology, take the case of a raw material, say a piece of wood, entering an organization in the form of a log (the input) and leaving the organization as two-by-fours (the output). The technology includes the machinery and knowledge applied to the task of transforming the log into pieces of smooth lumber. This is the core technology of a lumber mill. Other forms of technology are likely to be employed by the organization that would be peripheral to the central core transformation process. For example, those working in the accounting, billing, and shipping offices of the organization might use computers and spreadsheet software to process information about inventory, sales, and suppliers. Technology is applied to these activities but they do not represent the core activity of the organization.
Technology and Organization Theory

The classic works on technology and organization have attempted to correlate the form of core technology with other organizational characteristics. Thus, an initial task was to delineate the significant variations in technologies across organizations (see Table 8–1). Some of the most influential contributions were made by Joan Woodward, Robert Blauner, James Thompson, Charles Perrow, and members of the Tavistock Institute.

Joan Woodward

Joan Woodward (1958) distinguished three types of core technology and associated labor processes. Small batch and unit production technologies produce items one unit at a time, in small numbers, in response to a restricted number of orders for the product. This kind of technology is associated with a labor process in which a worker is involved at every stage from start to finish. This technology is also regarded as the least technologically complex.

Large batch and mass production technologies produce a large number of the same items at the same time for an undifferentiated mass market. The labor process under this technology typically involves a more rigid division of labor along the lines of the Fordist assembly line. The level of complexity in this case is moderate.

Continuous process production is a technology that takes a raw material and subjects it to a continuous transformation process that cannot be divided into distinct and separate operations. A chemical plant, for example, will feed various chemical ingredients into a flowing liquid and apply different physical conditions (e.g., mixing, heating, cooling) as the ingredients move from the beginning to the end of the manufacturing process. Labor activity involves oversight of the technology, which automatically regulates and monitors the production process. There is no direct physical human contact with the manufactured materials. This form of technology represents the highest form of technical complexity.

Woodward correlated these organizational technologies with different management structures. She concluded that mass production technologies tend to be associated with centralized and bureaucratic forms of management while small batch and continuous processing technologies are most successful when coupled with decentralized management structures (Table 8–1A).

In linking technology with management systems, Woodward’s analysis suggests that the technology employed determines the degree of latitude and autonomy exercised by workers. Of the technological types identified by Woodward, those with the greatest levels of autonomy would coexist with batch and continuous processing technologies. Mass production, on the other hand, would tend to exist with a labor process that restricts the exercise of worker autonomy.
### Table 8-1 Perspectives on Types of Technology and Organizational Characteristics

<table>
<thead>
<tr>
<th>Technology Type</th>
<th>Associated Organizational Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit and batch production</td>
<td>Decentralized decision-making structure</td>
</tr>
<tr>
<td>Large batch and mass production</td>
<td>Centralized bureaucratic decision-making structure</td>
</tr>
<tr>
<td>Continuous processing</td>
<td>Decentralized decision-making structure</td>
</tr>
</tbody>
</table>

#### B. Blauner’s Model

![Inverted U-curve](attachment:inverted_u_curve.png)

<table>
<thead>
<tr>
<th>Technology:</th>
<th>craft</th>
<th>machine</th>
<th>assembly-line</th>
<th>process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry:</td>
<td>printing</td>
<td>textiles</td>
<td>automobiles</td>
<td>chemical</td>
</tr>
</tbody>
</table>

#### C. Thompson’s Model

<table>
<thead>
<tr>
<th>Technology Type</th>
<th>Associated Organizational Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-linked technology</td>
<td>Standardized sequentially interdependent linear process</td>
</tr>
<tr>
<td>Mediating technology</td>
<td>Standardized procedures mediating transactions</td>
</tr>
<tr>
<td>Intensive technology</td>
<td>Unstandardized applications of machines and knowledge</td>
</tr>
</tbody>
</table>

#### D. Perrow’s Model

<table>
<thead>
<tr>
<th>Technology Type</th>
<th>Associated Organizational Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine technologies</td>
<td>Low task variability–high task analyzability</td>
</tr>
<tr>
<td>Craft technologies</td>
<td>Low task variability–low task analyzability</td>
</tr>
<tr>
<td>Engineering technologies</td>
<td>High task variability–high task analyzability</td>
</tr>
<tr>
<td>Nonroutine technologies</td>
<td>High task variability–low task analyzability</td>
</tr>
</tbody>
</table>

### Robert Blauner

Robert Blauner’s well-known study, *Alienation and Freedom* (1964), advanced a hypothesis based on the logic derived from Woodward’s analysis. In examining the relationship between types of technology and the degree of worker alienation (defined as a combination of powerlessness, meaninglessness, isolation and estrangement), Blauner advanced the inverted U-curve pattern shown in Table 8-1B. His research of different industries indicated low levels of alienation under
the simple craft technology employed in the printing industry, higher levels of alienation in the textile industry where workers tend the machines, the highest level of alienation in the auto industry using the assembly line technology, and low levels of alienation in the continuous process chemical industry. Together, Woodward and Blauner suggested that the core technology used by an organization determines and shapes the management and authority structure.

*James Thompson*

James Thompson (1967) also proposed a method for classifying the types of technology used by both manufacturing and service organizations (Table 8–1C). *Long-linked technologies* are most common in manufacturing and involve a linear process that begins with raw materials and proceeds toward a finished product. Both mass production and continuous process qualify as long-linked technologies.

*Mediating technologies* are those used by organizations that link clients or customers interested in engaging in a transaction. For example, employment agencies bring together employers and job seekers; banks join investors and borrowers. These organizations develop procedures and services for, and process information about, producer and consumer needs. The Internet has greatly expanded the role of this technology as the global computer network generates entry points, or “portals,” that link Internet users and consumers with every conceivable kind of supplier and service (see Hagel and Singer 1999).

Thompson’s third type, *intensive technologies*, are those forms of hardware and knowledge used to change some specific object. For example, medical technology is used to diagnose and treat a patient’s disease; laboratory technology is used in university research to conduct experiments; software is used in computer-mediated instruction to train and educate people.

*Charles Perrow*

Another widely used framework for the analysis of organizational technology was proposed by Charles Perrow (1967). His model has the advantage of being applicable to a wide variety of tasks and activities beyond the core technologies. Perrow used two dimensions—task variability and task analyzability—to classify organizational technologies. *Task variability* refers to the degree to which the labor process involves routinized standardized procedures (nonvariable) or whether it includes a wide range of exceptions (variability) that must be managed. *Task analyzability* refers to the degree to which formal procedures are required for handling the nonstandardized exceptional cases (analyzability) or whether exceptions require workers to improvise (non-analyzability). In typology form, these two dimensions yield four kinds of organizational technology (see Table 8–1D).
Routine technologies involve standard operating procedures coupled with systematic procedures for dealing with exceptions; thus low variability and high analyzability. Assembly line production fits this pattern.

Nonroutine technologies possess the opposite characteristics. There are no standardized routines used to approach the work (high variability) and no formal procedures to deal with uncertainty (low analyzability). Research and development work fits this pattern.

Craft technologies entail standard procedures for most tasks, but when exceptions and problems occur workers must innovate and invent solutions due to the inability to formalize all possible contingencies. Carpentry fits this pattern.

Last, engineering technology is characterized by high variability because the work cannot be reduced to a standardized protocol, yet the range of problems have predetermined and formalized solutions (high analyzability). Financial accounting work fits this pattern. The variety of cases confronted are managed with a set of specific rules, procedures, and forms.

Perrow's model conceptualizes task-related technologies in the context of rational bureaucratic (or what he calls neo-Weberian) principles. A highly bureaucratized organization seeks to standardize task activities (low variability) so that they can be managed with formalized procedures; even the small number of exceptions should have a formal protocol. This kind of organizational technology is designed to reduce or eliminate human discretion. It represents a high level of formal control.

While organizations would prefer to have predictable standardized inputs and demands, most face some degree of uncertainty. Therefore, at the other end of the spectrum where tasks involve a wide variety of tasks and, consequently, many exceptions, it is unlikely that formal bureaucratic controls will suffice. Task-related technologies may therefore involve low variability and high analyzability. Action in this situation must be based on informal emergent decision making and inventiveness. Such tasks are carried out by those who are socialized to select the appropriate strategies independent of formal constraint. Perrow (1986:22) has described the role of professionals as "personnel who have complex rules built into them." The strength of Perrow's technology framework lies in its inherent connection to broader organizational principles—formalization, decision making, social control, environmental pressures—and its application to a range of different tasks within a single organization.

Tavistock Institute

A final tradition in the literature of organization theory comes under the heading of sociotechnical systems and is based on the work of Eric Trist and his associates at the Tavistock Institute. In describing organizations as both technical and social systems, Trist (1981) recognized the associated tension that
resulted from the "core interface... between a nonhuman and human system." The technical side of the organization involves the application of instrumentally logical methods for the completion of tasks. The social side of the organization involves the needs of and relationships among humans.

The sociotechnical approach stemmed from a study by Trist and Kenneth Bamforth (1951) of technological innovations in British coal mines. In an effort to rationalize the mining process, mine owners introduced mechanization to enhance the extraction of coal from the mines. The increased technical complexity resulted in a reorganization of social relations and job tasks (through what was known as the longwall method). Prior to mechanization, the organizational structure involved small groups working as teams (using the shortwall method). After the introduction of the new technology, the organization of production resembled the factory model with greater specialization and segregation of work tasks and reduced autonomy. Instead of enhancing the productivity of the enterprise, the new system created an assortment of problems.

The social integration of the previous small groups having been disrupted, and little attempt made to achieve any new integration, many symptoms of social stress occur. Informal cliques which develop to help each other can only occur over small parts of the face, inevitably leaving some isolated; individuals react defensively... they compete for allocation to the best workplaces, there is mutual scapegoating across shifts... Absenteeism becomes a way of the miner compensating himself for the difficulties of the job (Pugh, Hickson, and Hinings. 1985:85).

Theoretically, Trist and his colleagues argued that the technical and social (or nonhuman and human) features of organization require an optimization of the relationship between technical imperatives and the social and psychological needs of workers. Practically, this insight was reflected in the implementation of a "composite longwall method" that reintroduced the autonomous work groups while still utilizing the new technologies for the extraction of coal. Thus, the tension created by the introduction of technology and the associated reorganization of production prompted human-generated consequences that challenged both technologically deterministic organization theory and the managerial efforts to institute technical forms of social control.

Taken together, the classic technology typologies of Woodward, Thompson, Blauner, and Perrow, and the work of the Tavistock Institute, provide a means to classify and differentiate organizational technologies. However, they all predate the implementation of qualitatively unique forms of information technology that have infiltrated in varying degrees almost every organization. These technologies have forced theorists to rethink the old typologies and to develop new ways to conceptualize the transformative impact of technology (DeSanctis and Fulk 1999).
**Entering the Age of the Smart Machine**

In her book *In the Age of the Smart Machine* (1984), Shoshana Zuboff posed profound and defining questions about the relationship between information technology, work, and organization. Most generally, she asked how and in whose interest would technologies be used and how would they affect the human factor of production? She outlined several alternative visions which continue to frame the debate over the consequences and appropriate application of organizational technology (see Table 8–2).

<table>
<thead>
<tr>
<th>Organizational Dimension</th>
<th>Positive Vision</th>
<th>Negative Vision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conception and distribution of knowledge</td>
<td>New forms of skill and knowledge are generated to exploit the new technology; workers exercise greater critical judgment in applying technology to tasks; new forms of mastery, meaning, and opportunity pervade organizations</td>
<td>Intelligence lodged in the machine; humans exercise no critical judgment and are dependent and passive; human senses no longer generate knowledge; results in disorientation, meaninglessness, apathy, and alienation</td>
</tr>
<tr>
<td>Relations of authority</td>
<td>Organizational behavior is transformed in the direction of greater collaboration and mutual responsibility; managers and workers break out of their functional and vertical relationships and create new roles which blur the lines of authority and decision making</td>
<td>Managers use the technology to reinforce, reestablish, and reproduce their legitimacy; hierarchical distinctions are erected between those who can use and understand the abstract scientific principles of the smart machines and those who cannot</td>
</tr>
<tr>
<td>Methods of coordination</td>
<td>The technology becomes a rich resource that permits innovative methods of information sharing, exchange, and collaboration; the wide and open access to information allows a climate of collective responsibility, mutual ownership, and team problem solving</td>
<td>The new technology is used as a potent method for controlling and monitoring workers; management becomes a form of remote and automated surveillance and administration; a climate of distrust pervades the organization as workers seek new forms of resistance</td>
</tr>
</tbody>
</table>

Among the central questions: Will technology prevent workers from translating their experiences into skill and knowledge and shift all intelligence to the machine, or will technology reduce physical labor while expanding mental and conceptual job skills? Will technology create greater divisions between conception and execution, or will technology break down the vertical divisions and generate new multiskilled roles for managers and workers that reduce the need for authoritative control? Will smart machines be used as a more advanced and sophisticated form of technical control to monitor work effort and compliance, or will they become a resource permitting all workers to share and exchange information, collaborate, and solve problems collectively?

Zuboff argued that the smart machines used in today’s organizations are qualitatively distinct from earlier forms of machine technology, as is their impact on the organization and its workforce. Information technologies do not just automate; they also informate.

**Automating machines** are designed to replace the physical motions and actions of human labor with an automated process subject to greater continuity and control. For example, an assembly line automates the movement of a product from one workstation to another. **Informating machines**, in contrast, “generate information about the underlying productive and administrative processes through which an organization accomplishes its work” (Zuboff 1984:9). Information technology machines can be programmed to carry out not only physical tasks (automate) but also to record and store information and data (informate) on the production process. This represents a major advance over earlier forms of organizational technology. Any analysis of the organizational impact of technology must consider this qualitatively new dimension. Together, automated and informated tasks weaken or eliminate a physical hands-on labor process and shift work activities toward the comprehension and interpretation of information. An example from the furniture industry:

Plant 12, Pulaski Furniture Corp.’s new $20 million factory in Pulaski, VA, is a gleaming testament to technology’s capacity for reordering work. Computerized equipment shapes wood with spurts of laser beams; an automated machine instantaneously cuts eight pieces. Each would take a craftsman 30 minutes by hand.

This is labor-eliminating automation at its most severe: Plant 12’s 125 workers manufacture more furniture than five times as many people at Pulaski’s much larger Dublin (VA) operation . . . It also leaves 60-year-old Howard Frazier strangely out of place. Having fashioned furniture by hand for 40 years, he now advises a new breed of machine operators, 90 percent of them computer-literate. “They have good educations and they know about computers, but they don’t know a lot about building furniture,” Frazier says. (“Rethinking Work: Special Report,” *Business Week*, October 17, 1994, p. 80.)
One of Zuboff’s major insights is her subtle analysis of the de-skilling and re-skilling process in organizations. For most production workers, skill is developed out of hands-on, sensory-involvement with the labor process. Knowledge is based on a sentient relationship with materials and machines. The furniture maker who claims that the machine operators don’t know much about building furniture does so because their computer knowledge is divorced from the physical process of holding, measuring, and directly cutting wood. These are what Zuboff calls the action-centered skills which are forms of competence based on physical activities and performed in response to sensory cues (Zuboff 1984:61).

In the pulp and paper mills she studied, Zuboff found that the introduction of new technology eliminated the workers’ direct connection with the production process. Mediated by computers, the action-centered skills were no longer relevant. Judgments and decisions once based on a worker’s experience, feel, and intuition were programmed into the machines. Action-centered skill was replaced with intellectual skill involving the interpretation of abstract symbols that are remote from but still representative of a physical production process. This entails, for example, reading dials and interpreting messages on a computer screen. For many workers this transition created “epistemological distress.” “Computer mediation seems to bathe action in a more conditional light: perhaps it happened; perhaps it didn’t. Without the layered richness of direct sensory engagement, the symbolic medium seems thin, flat, and fragile” (Zuboff 1984:81). The concepts of de-skilling and re-skilling take on a deeper meaning in this context.

The introduction of computer technology translates the action-centered skills into explicit data. For this translation to produce a parallel shift toward worker empowerment will depend, according to Zuboff, on the training and nurturing of intellectual skills in the workforce and the requisite opportunity to exercise and perform these skills in a nonhierarchical environment. Traditional authority structures must be transformed if the workers are to apply the new technology to the labor process effectively. As Zuboff explained, “The informing process sets knowledge and authority on a collision course. In the absence of a strategy to synthesize this force, neither can emerge a clear victor, but neither can emerge unscathed” (1984:310).

A third question about the application of informative technology concerns its use as a means to control and monitor the labor process. Zuboff used the term information panopticon to raise the specter of a form of surveillance capable of automatically and continuously recording, as hard objective data, all organizational activities. From a managerial perspective, this capacity might provide a final solution to the “agency problem”; that is, the accountability and responsibility of employees can be empirically validated; inefficiency and
shirking can be detected and sanctioned. In practice, Zuboff observed that many managers used the electronic recording system as a substitute for the more direct and personal modes of interaction and evaluation formerly used. Instead of impressionistic, subjective, qualitative data, managers could base their evaluations on systematic, objective, and quantitative data. "There was a distinctive shift toward less interaction, less engagement, and more impersonally administered relationships" (1984:334). Paradoxically, this objective and systematic accounting system replaced the interactive modes of supervision and assessment on which productivity-enhancing human relations principles are based. Again, the action-centered skills that might be associated with human relations management techniques are supplanted by intellective skills directed toward managing through the interpretation of hard data.

Alternatively, the electronic workplace accounting system has the potential to be used as an information gathering mechanism devoted to worker instruction, training, and quality improvement. Workers could also use objective data to evaluate and validate their own performance independent of the potentially subjective and arbitrary managers. In this way, the information provides workers with both a language and an objective record to confront their managers (1984:356). Under this form of empowerment, rationality triumphs over authority, but this can only be realized in an organization that allows free and equal access to the empirical record. As Zuboff put it, "Because rationality has no guile, it can also work to limit authority."

Information Technology and Organizational Change

Let's now turn to an examination of the relationship between the developing information technologies and the emergence of new organizational forms. The question of cause and effect should be considered here; that is, have new information technologies determined the trajectory and shape of organizational structures and change? Or has the effort to restructure and develop a more flexible organizational form stimulated innovations in information technology? Another possibility is that the two processes of organizational transformation and information technology have progressed independently but are now tightly connected and interdependent.

In a chronological sense, the crisis of Fordist-style organizational forms preceded what is now thought of as the information technology revolution. Microelectronics, digital computing, telecommunications, and virtual networks emerged in a comprehensive fashion in the mid-1980s and the pace of development has increased exponentially since that time. Thus, the search for flexibility and the existence of flexible organizational forms (e.g., the Japanese models) preceded the technology revolution. Today, however, they
are closely linked and seem to be mutually stimulative. Information technologies now seem to enhance the prospect of flexibility

The information technology paradigm is based on flexibility. Not only processes are reversible, but organizations and institutions can be modified, and even fundamentally altered, by rearranging their components . . . Turning the rules upside down without destroying the organization has become a possibility, because the material basis of the organization can be reprogrammed and retooled (Castells 1996:62).

**The Organizational Impact of Information Technology**

Emerging information technologies give rise to production processes characterized by several critical features. First, value added is generated by innovations in both production process and product development activities. The application of information can improve the production process and enhance the versatility of the actual product or service delivered. This is a defining element of the new organizational paradigm (Castells 1996).

Second, efficiency rests on the ability to automate standard procedures and routines while at the same time devoting human energy to analysis, decision making, reprogramming, and system feedback activities “that only the human brain can master.” Manuel Castells believed that the application of information technology “increases dramatically the importance of human brain input into the work process” and also stimulates a “greater need for an autonomous educated worker able and willing to program and decide entire sequences of work” (1996: 241).

Third, the potential for the greater application of human brain power is represented by the employment of “open processes” that “manage rather than reduce complexity” (Kolodny et al. 1996). The greater use of open processes represents a shift from the bureaucratic effort to create formal rules and procedures that limit worker discretion, to those that emphasize innovation, brainstorming, creative problem solving, and responsible engagement. These become an increasing part of the labor process as routine and standardizable procedures are automated.

This need to manage uncertainty, rather than reduce or eliminate it (Kolodny et al. 1996), is due to the ineffectiveness in a rapidly changing environment of the rigid formal procedures once used to eliminate uncertainty. Information technologies provide a means to better manage the inevitable uncertainties by providing workers with the necessary information to construct knowledge-based methods for handling a variety of contingencies.

Fourth, information technologies, such as groupware, allow information and databases to be shared and accessed by functionally differentiated departments and units. This advances the objective of integrating functionally
distinct but highly interdependent organizational activities in a nonlinear, rugby-style, interaction pattern. The study of a variety of firms by Harvey Kolodny and his associates found that "new integrative approaches include: shared use of common databases; computer integrated manufacturing practices; simultaneous or concurrent engineering to expedite the design-to-manufacture transition; flatter organizational structures with more horizontal communication; self-regulating work teams; and some not-so-new coordinating mechanisms such as project management teams" (Kolodny et al. 1996:1472).

A final observation of the research by Kolodny's associates concerns the notion of enlarged rationalities—"that organizations may be able to entertain different and even conflicting outcomes simultaneously." The dilemma of trade-offs (Aram 1976) that faces most organizational choices—such as high quality or lower costs, differentiation or integration—can be better managed, balanced, and anticipated with the application of information technologies that allow simulations, feedback, and advanced forecasting. The ability to consider and pursue several potentially contradictory objectives simultaneously may prove to be a significant asset in the "age of paradox" (Handy 1994).

**Information Technology and Social Organization**

Each of these emerging organizational principles and practices have been associated with the application of information technologies. More accurately however, these technologies enhance and facilitate the shift toward alternative, flexible, nonbureaucratic, organizational forms. They do not determine these changes. Kolodny's analysis indicated that the realization of an "emerging organizational paradigm" employing these practices is contingent on the beliefs and ideas of engineers and managers (the design principles) and the implementation strategies employed (the design implementation). Team-based design principles coupled with participatory implementation strategies were found to be the necessary conditions for the efficacious application of information technologies. This confirms the importance of the social organization in shaping the impact of technology.

Further support for the importance of the social dimension is provided by several studies that have examined the organizational consequences of introducing groupware technologies such as Lotus Notes. These software technologies require a hardware network that links organizational members and allows them to communicate, collaborate, share information, asynchronously develop and complete projects, and access information databases. The purchase and application of this collaborative software does not automatically transform the organization into a flexible collaborative enterprise. This transformation depends on the prevailing mental
models about the relationship between technology and work, and the structural properties (such as policies and reward systems) of the organization (Orlikowski 1992).

This study found an unsuccessful application of groupware technology owing to the use of the dominant mental model of software as a stand-alone application rather than as a collaborative communication tool. For this reason, the groupware was neither widely used nor correctly employed. The organization did little to change these conceptions or communicate the purpose and potential of the groupware. Structurally, this particular organization also allocated rewards on the basis of billable hours charged to clients. Using the groupware was not viewed as a client-related activity and was therefore deemed a “waste of time” in terms of a renumerated activity. Furthermore, the promotion system in this organization fostered an individualistic and competitive culture that served to discourage the collaborative or information-sharing objectives of groupware. Together, the prevailing mental models and the reward and promotion structure rendered the information technology ineffective.

Similar patterns of inattention to the social dimension have been reported in other industries. David Upton and Andrew McAfee (1997) conducted a quantitative analysis of the impact of computer-integrated manufacturing (CIM) technology in the fine-paper industry. They noted that strong pressure had been exerted to build plants that can switch between products quickly and reliably, and respond to growing market volatility and product proliferation. Upton and McAfee were interested in examining whether the computer-integrated methods implemented in many plants in this industry would advance these goals of quick response with little penalty. The ultimate penalty in this industry is “catastrophic failure rate.” This means a “paper break” requiring the production process to be shut down, repaired, and restarted at great expense.

The two-year study of 61 paper plants concluded that “the computer automation of the production process increased the rate of catastrophic failure in the paper plants.” The explanation for this finding is revealing:

The use of computer integration to provide this flexibility is an example of a structural solution to the development of the capability. Such solutions are attractive, since the costs are definable and “once-off” (even if the benefits must be justified partly on faith). However, there is growing evidence . . . that flexibility is best facilitated through infrastructural solutions—that is through solutions which rely on dismantling inappropriate measurement systems, nurturing the right skills in the workforce, and focusing managerial attention on the development of flexible capabilities. This is unfortunate, since it implies that flexibility cannot simply be bought, but must be built through a painstaking process of skill-building and organizational development (Upton and McAfee 1997:31).
The researchers do not argue that flexible technology is ineffective, only that it cannot be inserted into an organization as a "structure" in isolation from the broader social processes or "infrastructure" of the enterprise.

Another study in the same industry by Steven Vallas and John Beck (1996) examined how the shift toward greater flexibility—particularly the application of computerized Distributed Control Systems, quality standards assessment, and advanced information systems—affect ed the transformation of work. The new technology was designed to gain greater control over all aspects of the production process and monitor the flow and quality of each production stage. This required worker training and the upgrading of skills. It also resulted in the "disproportionate growth in the number of process engineers involved in each mill's production process" (1996:349). The introduction of the technology and the growing presence of process engineers had the net effect, according to Vallas and Beck, of devaluing the traditional craft knowledge previously employed by the workers and increasing the constraints on the workplace discretion of manual workers.

These are not the kinds of changes normally associated with the transition toward a more flexible organizational form, yet they represent one example of the kinds of contradictions, or limits, that emerge in the effort to transform different but related aspects of the production process. In this case, the technology brought expert personnel, a new production vocabulary and knowledge, and a shift from human discretion to distributed control. This may enhance the flexibility of the production process without expanding worker discretion and autonomy. In this environment, the familiar contradictions emerge:

On the one hand, mill managers want operators to maintain high levels of commitment to the quality of output, and thus to scan their process controls with the utmost patience. On the other hand, mill managers have embraced a conception of work that places growing limits on craft workers' traditional discretion and demands that production settings be defined in accordance with the logic of technical expertise. Thus, even as they take some halting steps in the direction of greater flexibility, these mills are pulled even more decisively in the direction of a technocratic operational regime (Vallas and Beck 1996:356).

Vallas and Beck's observation provides a nice complement to the findings reported by Upton and McAfee. The performance results of the new integrated technology were less than satisfactory because of a disregard for the larger "infrastructural" or, more accurately, human social processes related to skill building and organizational development. The shop floor relations examined by Vallas and Beck point to one obvious area for further managerial attention.

More generally, these cases reinforce the central organizational theme regarding unintended consequences and paradoxical effects (see also Victor and Stephens 1999; Poole 1999). As it applies to technology, this point is well
illustrated in Edward Tenner’s book, Why Things Bite Back (1976), which provides an answer to the question posed by the title:

Revenge effects happen because new structures, devices, and organisms react with real people in real situations in ways we could not foresee. There are occasional reverse revenge effects: unexpected benefits of technology adopted for another reason. Like revenge effects themselves, reverse revenge effects are a rough but useful guide metaphor: in one case, for the way reality seems to strike back at our efforts, and in the other, for the equally unexpected ways in which we benefit from the complexity of the world’s mechanisms (1976:9–10).

**Additional Consequences**

Some further examples show how the application of the information technologies, alongside the reorganization of tasks and positions, can produce qualitatively new forms of organization. These trends suggest a horizontal or network-based organizational structure (Castells 1996; Powell).

The corporation has changed its organizational model . . . *The main shift can be characterized as the shift from vertical bureaucracies to the horizontal corporation.* The horizontal corporation seems to be characterized by seven main trends: organization around process, not task; a flat hierarchy; team management; measuring performance by customer satisfaction; rewards based on team performance; maximization of contacts with suppliers and customers; information, training, and retraining of employees at all levels (Castells 1996:164).

Some of these patterns of organizing have already been suggested in our discussion of flexible, lean, and postbureaucratic forms. Other aspects, particularly those concerned with the interorganizational relations between firms, will be considered in Chapter 10. What is worth elaborating here are other internal organizational transformations associated with what is variously called the network enterprise, network capitalism, the horizontal corporation, or the horizontal firm. The widespread use of network and horizontal conceptions indicate the perceived importance of and trend toward greater interactive, collaborative, and nonbureaucratic work arrangements. One of the central features of this transformation within the firm can be seen in the shift from the job to the project.

*Work* today is evolving in terms of how it is conducted, and it is changing into short-term projects often performed by teams. Consequently, the organization of work is likely to be much less frequently honeycombed into a pattern of highly specified jobs . . . This form of production integrates conception and execution, with design and production running on parallel tracks . . . These new arrangements are deeply corrosive of the old system of sequential steps, linear design, and vertical integration that provided worker and manager alike with security (Powell).
The demise of jobs, in this scenario, represents a monumental transformation. Jobs, job titles, and job descriptions have been central principles shaping human identity and the definition of formal organizational activities. When individuals no longer have a job linked to a career, but are instead members of a team working on a project, individual security and performance are replaced by rapidly shifting demands and collective accomplishments. When work is organized in this fashion, centralized hierarchy and strict functional differentiation must also be abandoned. Further, forms of information technology, such as groupware, can then play a role in facilitating communication and the exchange of information among project team members. Again, the information must be joined with structural reorganization in order to avoid what Walter Powell described as the "mismatch" between the technologies designed to level hierarchy and the centralized structures that reinforce status orders.

Lynda Applegate's (1995) extensive analysis of information technology and organizational change suggests that current and increasingly available information and communication systems will allow a truly qualitative transformation of organizational structure and process. Earlier efforts at organizational reform attempted to reduce decentralized control and provide managers with greater decision-making power. However, this created problems because the information processing infrastructure revolved around mainframe computer systems based on centralization and hierarchy. This thwarted efforts to truly reorganize the decision-making and communication structure. According to Applegate (1995:36), a gap remained between the "information process and communication demands of the matrix" and the "technology to support both lateral and vertical information sharing and communication." She believed this extended challenge combining centralization and autonomy could be resolved with the introduction of state-of-the-art systems of information technology. She wrote:

The "networked IT revolution" of the 1990s—reflected in the emergence of distributed, client-server systems, electronic data interchange with customers, suppliers, and business partners, and the growing interest in electronic commerce—provides an information processing and communication infrastructure that matches the information and communication requirements of a firm wishing to operate as if it were both big and small (1995:36).

In this rendition of the informational technology-organizational structure interface, technology does not determine the outcome but enhances the realization of intended objectives.

Public-sector organizations are also employing information technologies as a means to enhance and extend their operations (Ghere and Young 1998; Percy-Smith 1996; Alexander and Grubbs 1998). Richard Ghere and Brian Young (1998) pointed to the five critical organizational functions advanced by the new technologies: access engineering, substantive policy communication,
record keeping, decision-making support, and vehicles of informal communication. Access engineering refers to the infrastructure designed to "extend network access between government and citizens." Citizens now have easier access to government documents and services, and the technology in turn has facilitated a greater consumer orientation in government. Substantive policy communication is also presumably expanded as a wide range of constituents can access policy proposals and communicate reactions and opinions. Record keeping has been brought up-to-date as well. Records can now be stored more efficiently, disseminated electronically, and accessed remotely. Decision-making support is enhanced to the degree that decision makers are able to access all the necessary information on which to base policy decisions. Again, electronic storage and retrieval can contribute to this function. Finally, a greater proportion of the informal communication within public organizations is conducted electronically. While this may increase organizational interaction, Ghere and Young pointed to the emerging issue of whether electronic forms of communication are subject to the same "open records" provision as conventional intra-agency mail. In short, what is private and what is public?

Related to the last point, Ghere and Young raised the important and persistent question about the unintended organizational consequences of these technologies. With the advent of electronic record keeping and access, long-standing operating procedures will have to be reassessed or replaced. This has a destabilizing effect on the entire organization. Further, the greater access to public policies and actions can increase the challenges and criticisms by antigovernment and taxpayer forces. Lastly, managing and dealing with the array of technological applications, consequences, and safeguards may result in the proverbial "displacement of goals" as public administrators become obsessed with the technological means rather than the public service ends of government operations.

The Virtual Organization

Any discussion combining the topics of information technology and new organizational forms will inevitably raise the issue of the virtual organization. The literature on the virtual organization has proliferated over the past 10 years along with the number of definitions and applications of the concept.

Definitions and Characteristics

One of the earliest forays into the topic was undertaken by William Davidow and Michael Malone in The Virtual Corporation (1993) which, as is common in much of the popular management literature, defined the virtual corporation as an organization that has adopted any and every trendy management idea and
buzzword. Thus, the virtual corporation employs computer design in the product development process; collects and analyzes information on and shares information with customers, suppliers, and distributors; utilizes flexible, team-oriented, quality-conscious, lean production processes; and allows employees to exercise autonomy, responsibility, and continuous learning.

More recent works have identified some of the key and distinctive features of the virtual organization that are related to the interaction of information technology with alternative structural arrangements. Although the term virtual is often applied to any application of digital technology, it was originally used to describe the way a computer can generate virtual memory. This referred to the ability of the hard disk to simulate additional memory or random access memory (RAM) that exceeded the physical technical specifications and capacity of the machine. As applied to the organization, virtual memory suggests that a virtual organization possesses abilities and capacities beyond what would be expected from mere appearances (Goldman, Preiss, and Nagel 1997).

For example, we often confine our image of an organization to the physical location of a building, office, or factory made up of departments and units in which people work. A virtual organization would possess an operating capacity that could not be represented by, and that would extend beyond, these familiar organizational traits. More specifically, there might be no physical location for the organization; the units, departments, and offices might not exist under or within a single, clearly defined, organization; there may be no physically copresent human labor process in the virtual organization requiring people to assemble in a single location. In this sense, the structure and capacity of the organization defies the conventional notion of a bounded and physically situated organizational entity.

The question then arises: How is the virtual organization able to expand its capacity? Here the interaction of the technological and structural features of the virtual organization must be considered. Technologically, virtual organizations are enabled by information technologies that allow interaction, communication, and collaboration to take place without face-to-face contact in a common physical location. A computer network that links teams and employees, and distributes information anytime and anyplace, facilitates the realization of the virtual form (Lipnack and Stamps 1997). For these reasons, information technologies are closely associated with the rise of the virtual organization. People can work without physically locating themselves in an organized workplace. It can be accomplished through "homeworking" or telecommuting; "hot desking," which involves the use of shared work space just when needed; and "hoteling" which allows workers to set up a temporary work space in the facility of another firm (Barnatt 1995; Snizek 1995).

While these virtual office practices are associated with the larger objective of flexibility and customer support, they are also driven by an effort to reduce costs. Siemens Communications Ltd., a subsidiary of the transnational
information technology company, encourages these new work practices in its online "Flexible Working Guide" (Siemens Communications Ltd. 1998) and emphasizes that “office space is one of the most significant fixed costs. For a business to work effectively, building management must be controlled... By introducing hot-desking you can reduce the total number of desks required in your company whilst providing users with all the services associated with a permanent office desk.” These forms of consulting advice are a useful reminder that a significant portion of what falls under the glamorous title of the virtual organization or "alternative officing" is driven by some very basic bottom-line considerations.

However, a major component of the virtual organization is the communication and information networks that preclude the need for the centralized or agglomerated location of employees. If this trend continues, it will be increasingly the case that, as Charles Handy expressed it, “work is what you do, not where you go” (Handy 1995a:42). As with other technological applications, the virtual office will likely yield some unintended human consequences. Interaction dynamics, sense of community, and organizational connectedness through “ownership” of physical office space may be negatively impacted under the virtual organizational arrangement (Snizek 1995).

As the association of work with a physical workplace location and environment slowly erodes under the virtual organization system, the notion of organizational borders begins to be challenged. The new system has promoted the related phenomenon of the borderless organization (Jarillo 1995; Ashkenas et al. 1996).

The borderlessness of the virtual organization refers to a key structural element of this organizational form: temporary collaboration, networking, and alliances between firms. These interorganizational arrangements (discussed further in Chapter 10) again give the virtual organization a reach that extends beyond its apparent capacity. What we have previously described as the "network enterprise" or the "horizontal corporation" is a fundamental element of the virtual corporation. Just as there is a greater emphasis on teams and projects within the organization, there is now a growing trend toward partnerships and joint ventures across organizational borders. A major consequence of this trend for intraorganizational structure is the elimination of departments and units that do not represent a core competency, or value-added link in the production chain. If other firms that are more adept or experienced with these peripheral activities can provide these resources when needed, the organization itself is more flexible and lean. It also means that those workers who are retained will increasingly be interacting with a wider range of unfamiliar personnel from other firms.

A particularly powerful example of a virtual organization is Verifone, Inc. Verifone designs, manufactures, markets, and services electronic credit card
payment systems. It is the global leader in credit card “swiping” machines used to authorize Visa and MasterCard payments. It also represents a virtual organizational model (Taylor 1995). Verifone has no corporate headquarters or recognized national origin. The company employs 3,300 people worldwide and operates continuously without regard to the limitations of time and place. This is made possible by a worldwide computer network that provides immediate online access to all company information and data. Driven by a “culture of urgency,” software projects involve the input of programmers and engineers in Bangalore, Dallas, and Hawaii who write a computer code, test it, and eventually integrate it into the products and software. The activities proceed in a parallel rather than serial fashion. There is no “downtime.” As Verifone’s CEO emphasizes, the competitive edge rests on the fact that “people are distributed around the world” and the company is “insensitive to distance and time” (Taylor 1995).

Further Consequences

The various characteristics of the virtual organization—physical decentralization, telecommuting, teams and projects, partnerships and alliances—are likely to produce some significant unintended consequences for organizations. Several can be considered here.

First, the emergence of these horizontal, network, and virtual organizations raises the fundamental issue of social control. As hierarchical control systems are dismantled, as employees are able to exercise greater discretion, as a greater proportion of work is performed away from the physical workplace, and as the ability to physically supervise and monitor employees is diminished, alternative modes of social control must be devised and implemented. The “agency problem” in the virtual organization is increasingly addressed through normative strategies of labor control, or what some have called “infor-normative” control (Frenkel et al. 1995). The CEO of a virtual organization explained it this way:

Given that the key objective of virtual corporation is to provide for ultimate adaptability and flexibility, monitoring may not be of much use. The key emphasis is on empowerment and self-control of the employees . . . This issue is related to the company’s broad vision and strategic goals which are communicated through the shared culture and common corporate values.

I am not suggesting that the virtual corporation cannot use technology for “monitoring” employees’ work . . . The traditional “monitoring” by means of “observing” every move of the employee may not be necessarily conducive to the agility that is the key objective of the virtual corporation. (“Virtual Corporations, Human Issues and Information Technology,” Training and Development, May 1997, p. 30.)
The transition toward virtual-style organizational forms also raises a second issue: How will organizational members make sense of and interpret their work-related activities. Karl Weick's (1995) notion of organizational sense-making refers to the frame of reference people use to make sense of organizational stimuli and how this process influences action. The most common frame of reference, labeled the generic subjective, entails the elements of formal social structure, such as roles and rules, that shape organizational understanding and behavior. The "generic subjects" are the interchangeable people that can be slotted into the formal positions in an organizational structure. As these formal controls associated with rational bureaucratic organization subside, the sense-making process is also transformed. Weick (1995:174) addressed this change:

Consider, for example, the current movement away from hierarchy and vertical organization toward projects, horizontal structuring, and self-managed teams . . . The routines, roles, and expectations that allow for generic subjectivity and interchangeability seem to be giving way to intimacy, discretion, close proximity, and smaller sized collectivities where people work primarily as collaborators rather than as experts. If units keep changing their mission, size, and composition, then generic descriptions become meaningless. This suggests that intersubjective sensemaking—or perhaps some new social form—may be a new defining property of organizations . . .

The greater prevalence of multifunctional teams that form and re-form around different projects may produce this new organizational mode of intersubjective sensemaking. It seems less structural and more emergent. It develops out of the close interaction among team members. However, if the number of team projects increases while the duration decreases, and there is an increasingly likelihood that teams will be composed of unknown personnel from one's own firm as well as other firms, there will be far less time to develop the intersubjective sense and trust usually required for effective group process.

This raises a third potential problem for the virtual and network organizations. One of the most familiar forms of trust is "knowledge-based trust" (Shapiro, Sheppard, and Cheraskin 1992; Lewicki and Bunker 1996). This is founded on knowledge about other people that is accumulated over extended periods of interaction, communication, and "courtship." In the emerging work organization, this form of trust will be more difficult to establish.

Different forms of trust, such as what Debra Meyerson, Karl Weick, and Roderick Kramer (1996) described as "swift trust," might be discovered. Swift trust is established in the "temporary groups" that (1) work on tasks with a high degree of complexity; (2) depend on the diverse skills of relative strangers; (3) are involved in high-risk, high-stakes outcomes; but (4) lack a formal or normative structure to coordinate behavior and interaction. "In many respects, such groups constitute an interesting organizational analog of a 'one night stand':
they have a finite life span, form around a shared and relatively clear goal or purpose, and their success depends on a tight and coordinated coupling or activity" (Meyerson, Weick, and Kramer 1996:167). Under such conditions, trust must be established rapidly, using the available sense-making information. "Category-driven information" is used in such situations. This involves a set of role expectations based on the type of organization one represents, the specific occupational specialty one practices, or the stereotypes associated with people who practice a particular craft. Swift trust is reinforced when team members live up to these expectations and behave in a manner consistent with the stereotypification. Thus, people interact with roles rather than personalities.

Trust is also established more easily if members of a group possess resources that will be required for future projects. Members will then be driven to act responsibly in order to maintain a good reputation. The assumed desire of all team members to be included in future projects serves to encourage competence and conscientious dedication to the task at hand. The mutual knowledge of the importance of reputation for inclusion in partnerships and projects is both a controlling and reassuring force in temporary groups. The increasing use of temporary teams "suggests a rather rich and complex phenomenology—what may be most distinctive about swift trust in temporary systems is that it is not so much an interpersonal form as it is a cognitive and action form...swift trust is less about relating than doing" (Meyerson, Weick, and Kramer 1996:191).

The discussion of the dynamics surrounding social control, sensemaking, and swift trust is just one reminder of how the radical transformation of organizations can have large consequences for fundamental human organizational processes (see also Victor and Stephens 1999).

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**Summary**

1. Much of the study of technology in organization theory has been devoted to determining the relationship between technological applications and organizational structures and processes. Some accounts assume that particular production processes require a particular technology which then determines the organization of production. Others are based on the notion that the technologies are not neutral but employed for the purpose of controlling workers or reinforcing class divisions.

2. The emergence of highly sophisticated information technologies has further complicated the analysis of the relationship between technology and organization. These technologies allow organizational processes to be both automated and informated. They
also facilitate organizational flexibility, decentralization, information sharing, collaboration, and communication. Again, these technologies can be used either to expand human involvement and brain power in the organization or to monitor and penetrate every aspect of the labor process.

3. Regardless of the intended purpose, technology can “bite back” with unintended consequences. The obsession with technological applications can produce a displacement of goals; technology can disrupt and cripple production systems; the technology can devalue traditional skills and create alienation and disaffection; it can decentralize and enhance autonomy while at the same time undermining a sense of community and organizational attachment.

4. Technology is a major force fueling and reinforcing the new organizational forms. While technology has always been a central focus of organizational theory, the explosive proliferation of information technology and computer networks has had a profound influence on the organization of the labor process. Notions of virtual organization challenge traditional conceptions of the organization as a tangible and bounded entity.