Of Fears and Foes

Security and Insecurity in an Evolving Global Political Economy

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CHAPTER 3

Power in the Information Age

JEFFREY A. HART AND SANG-BAE KIM

INTRODUCTION

Power and technology are closely related to one another. The assessment or measurement of power generally takes into account this interdependence. In *The Peloponnesian Wars*, Thucydides was careful to tell us how many *hoplites* (armored foot soldiers) and ships each side had prior to an important battle. After the end of World War II, most of the attempts to assess relative national strengths had to take into account the possession of nuclear weapons and nuclear weapon delivery systems.

We want to go beyond the more limited question of assessing military power in terms of military technology, to discuss the cognitive and conceptual underpinnings of power. Our interest is not in the mere measurement of the military/strategic power of nation-states at the international level but also in the factors, which may be affecting the distribution of all types of power, within and across nations, in the information age. In this chapter, however, we will focus primarily on the impact of information technologies on the conceptualization of technology itself, and we will discuss some important implications of the changed conceptualization regarding the assessment of power.

It is necessary first to take a step back and ask about the relationship between information and knowledge. We assume that the creation and dissemination of knowledge require the analysis and restructuring of information; that information, by itself, does not constitute knowledge. In fact, too much information in the context of confusion leads to what some call "infoglut." One must possess some cognitive filtering and structuring mechanism to sort out what is relevant information from among what is not and to incorporate the new information productively into the old synthesis. However, without accurate and timely information, even the best conceptual structures are useless. Thus, there exists an interdependency between information and knowledge, just as there exists one between knowledge and power. Power can often enable actors to acquire both the information and the conceptual tools needed to devise effective strategies; knowledge helps actors to define goals and objectives in a more informed and, potentially, more rational manner.

Knowledge power, according to Francis Bacon, was the quest of science in its search to discover "the knowledge of Causes, and secret motions of things; and the enlarging of the bounds of Human Empire, to the effecting of all things possible" (Bacon, 1624: 36). This was a succinct, confident, ambitious statement of the nature and purpose of science; it brought together the previously separate notions of scientific knowledge, power, and progress. Bacon's two new aims of academic work were "control of nature" by means of science, and "advancement of learning." Bacon wanted scientists to pursue progress rather than individual fame, to cooperate with one another in order to bring about a speedier progress of civilization. In Bacon's conception, scientists were neither scholarly disputants nor literati greedy of glory. Until then, knowledge had been considered an end in itself, and the quiet contemplation of truth had been deemed the highest vocation to which man could aspire. Not so, Bacon suggested—the purpose of man was action and the aim of knowledge, utility—whereby he became known as an early champion of utilitarianism.

Since Bacon's time, the scientific/technological project, exemplified by the academic study of the natural sciences and engineering, has triumphed. Most contemporary governmental R&D programs share the premises in Bacon's writings that science and technology are useful for the betterment of the human condition, but also for the advancement of the interests of the nation-state in which technology is invented. Bacon's idea of knowledge power is, therefore, a useful starting point when seeking to understand power in the information age. But Bacon's formulation needs some updating when accounting for the altered nature of the processes by which knowledge is created and embedded in technology, in view of the shifts in the conceptualization of technology and the many changes in the acquisition of technological knowledge that have taken place since the recent beginnings of the information age.

TOWARD A NEW CONCEPTUALIZATION OF TECHNOLOGY

The word "technology" was first used in the seventeenth century, when it began to replace the more elementary idea of "technics." According to the *Oxford English Dictionary*, its original English meaning, dating back to

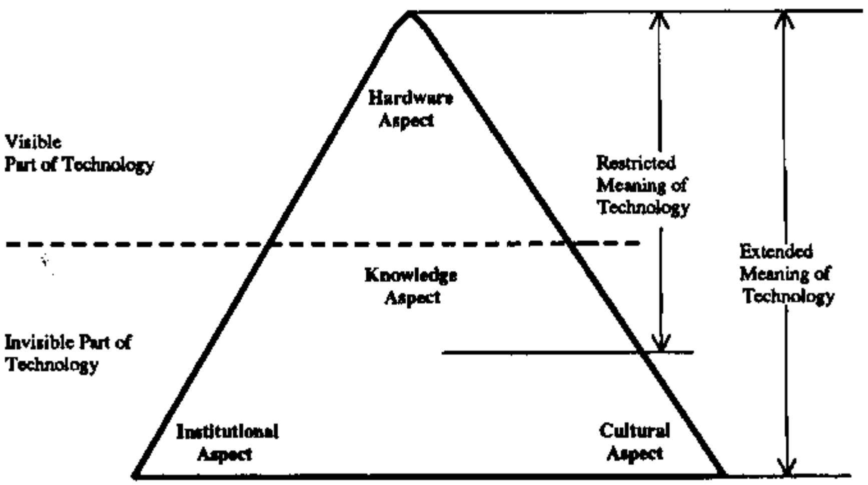
the early seventeenth century, was "a discourse or treatise (a *logos*) on art or the arts"; and "the scientific study (a *logos*) of the practical or industrial arts." Yet another meaning identifies technology as "technical nomenclature"—the very terminology or vernacular—*logos*—of a particular art. Only in the second half of the nineteenth century would the meaning begin to refer to the practical arts themselves, in transformational terms ("his technology consists of weaving, cutting canoes, making rude weapons"). Etymologically, "technology" comes from the Greek root *techne*, or art—not the finer arts but the useful crafts, rather carpentry and shoemaking than poetry and dance—and from *logos*, articulate speech or discursive reason. But the Greeks did not ideate the compound *techno-logos*. The closest they came to any such notion would have had the emphasis reversed: not an account about art (a *logos* of *techne*) but an art of speaking. Rhetoric, the art of persuasive speech, was indeed a *techne* of *logos*, and in the view of the sophists, a means for rationalizing political life free of the need for force (Melzer, Weinberger, and Zinman, 1993: 3).

We have inherited conceptual tools from the past, many of which are not adequate for acquiring an understanding of social transformations caused by important technological changes. And although we have seen a rise in the number of new terminologies for describing social and technological changes since the 1950s—postindustrial, post-Fordist, postcapitalist society, Information Revolution, knowledge industry, the Third Wave, the microelectronics market, the postmodern era—concepts of the sort do not, in our view, capture the essence of the changes that we have been experiencing. Thus, the best way to proceed is to characterize as accurately as possible the impact of modern information and of the communications technologies on the conceptualization of technology itself.

Technology has often been understood as "hardware": whether a weapon, a production facility, or a piece of telecommunications equipment. In order to differentiate the conceptual structure of technology, however, we should note that technology, like Janus, has two faces: the hardware face (material product), and the software face (technological knowledge). Most technology is not merely a material product or solely technological knowledge, but usually a combination of both. Hardware is useless without the knowledge of usage. Moreover, technological knowledge alone often has no utility until it is embodied in tools, instruments, or machines. The hardware face of technology is generally easier to grasp because of its tangibility, which is why we tend to think about technology in terms of "doing"—of hardware only.

Technology is "the systematic application of scientific or other organized knowledge to practical tasks by ordered systems that involve people, organizations, living things, and machines" (Pacey, 1983: 4–7). Technology has four *aspects*: machines, knowledge, organizations, and people. In this chapter, we identify four related aspects of technology, each with its very own

Figure 3.1
The Conceptual Structure of Technology (A Simile of an Iceberg)



policy implications for technological development: (1) material products, (2) knowledge, (3) institutions, and (4) culture. Only the first two of these can fall within the "restricted" meaning of technology. In order to grasp the whole picture, therefore, we also need an "extended" meaning of the concept of technology, which may include all four aspects.

In the restricted meaning of technology, the adoption of new technologies is purely pragmatic in nature. It does not consider the possible impact of technology on institutions and culture. In the extended meaning of technology, technology policy is closely related to an assessment of the immediate and potential impacts of new technologies on social institutions and culture.

We know from empirical study of the process of technological adaptation and diffusion that technological change does not occur in isolation from institutional and cultural considerations; and that institutional and cultural factors have an important impact on the development and diffusion of new technologies. To a certain extent, each new technology "encodes" a set of institutional and cultural practices in itself as a conditional part of the process of its acceptability in different societies. And that is exactly why countries technologically trying to "catch up" often become involved in intense internal debates about which technologies to pursue and how to reconcile these technologies with their culture and institutions.

Figure 3.1 implies that technology is like an iceberg—with a visible part above the water line and a larger, invisible part below the surface. The visible part of technology is often embodied in hardware, whereas the invisible is embodied in supporting "software" that includes the knowledge that made

the technology possible in the first place. The emphasis on the visible versus the invisible elements of technology may depend on the conceptualization of technology in a particular society or culture. For example, in the nineteenth century, China's outlook was different from Japan's: The Chinese were more hardware-oriented, focusing on the visible tips of the iceberg, uninclined to paying attention to the invisible part of technology, especially in the early stages of modernization. In contrast, the Japanese were willing to accept the invisible as well as the visible part of Western technology. This is the point from which Chinese and Japanese responses sharply diverged at the initial stages of their modernization. This divergence in conceptualizing is evident in almost every aspect of their modernization processes (Kim, 1995).

The conceptual core of technology involves the knowledge aspect—"the semi-visible part." Three characteristics of technological knowledge are noteworthy in the information age: appropriability, codifiability, and compatibility. The first of these deals with the credibility and enforceability of claims of ownership. Codifiability means the ability of people to write down in some reproducible form the essence of a given technology. And compatibility implies the possibility of transferring usage rights for a technology that has the capability of being used in a system without need for special modification to accommodate it.

Three types of appropriability of technological knowledge have been proposed (Krugman, 1987): (1) largely appropriable knowledge, such as production-process knowledge reflected in firm-specific learning curves; knowledge, assimilable within a firm and therefore broadly appropriable; (2) semi-appropriable knowledge, say, of product design, which—once generated—often can be captured by competitors through "reverse engineering"; and (3) spreadable ("footloose") but non-appropriable knowledge that can spread beyond the innovating firm, although not necessarily as easily so, beyond national or sometimes even regional boundaries. It is often embodied in people and is likely to spread through social and academic networks.

The ability of firms or nations to reverse-engineer the new technologies developed elsewhere speeds international diffusion but at some cost. True, both the speed and the expense of copying the technologies of others are lower for spreadable technologies than for appropriable technologies. For national governments, an interesting tension exists between the desire to promote the development of spreadable technologies in the public interest and to promote the development of largely appropriable technologies as a way of creating at least short-term advantages for domestic private industry and for military capability. The governments of major industrialized nations recognize this tension by splitting bureaucratic responsibility for the funding of basic and applied research among different agencies. Thus, basic research funding is generally administered by Ministries of Education and Research and usually is spent by universities and government laboratories in the form of mostly outright grants. Applied research funding is generally administered by Ministries of Commerce, Industry, and Defense and generally is spent by private firms under contract to the government. Similarly, almost all governments recognize the desire of private actors to appropriate new technologies and to exploit them for financial gain, and in the process to foster technological innovation. This recognition materializes primarily through intellectual property protection: patents, copyrights, and the like (Long, 1991). This raises the question of the extent to which a given technology can be codified in order for it to be able to qualify for intellectual property protection.

The appropriability of technological knowledge is closely related to codifiability. An uncodifiable technology is more appropriable than a codifiable one in that it is usually less transferable; a codifiable technology is less appropriable than an uncodifiable one in that it is usually more transferable. In the information age, however, codifiable technologies have become largely appropriable in both technological and legal terms. One of the more important features of this age is the very effort now being exerted on codifying by electronic hardware and software many of the previously uncodified human practices. Thus, for example, it is not unusual to find filtering programs for E-mail software that help weed out unwanted messages from untrusted sources. The software, sometimes called an intelligent agent, learns how to do this by emulating human filtering behavior. Until recently, it was a secretary's job or the boss's task to do this—the filtering of knowledge was human-embodied and not codified. After filtering agents do their job, the knowledge becomes software—embodied in computer hardware and codified.

The increasing trend toward codifying knowledge in software has raised the salience of intellectual property laws and of law enforcement in the perception of national governments. To promote the software industry as part of the larger task of promoting the computer industry, many of the governments of industrially advanced nations grant temporary monopoly privileges to the writers of new software through patent and copyright laws. Patenting/licensing fees paid to firms that make/sell software compensate the expense of developing the software in the first place. However, software is relatively easy to "pirate" (by selling illegal copies), and so software firms frequently turn to their home governments for help in enforcing intellectual property rights at home and abroad.

Often, it is not in the interest of the less industrialized countries to cooperate vigorously with the intellectual property regimes established by the industrialized countries because those regimes force them to pay a premium for new technologies, largely invented abroad. If they can use the technologies by copying them illegally and therefore enjoy much lower prices, then ordinarily they will do so. However, there are two major costs associated with this practice. First, if the country condoning piracy seeks to develop its

own domestic software industry, it will be highly handicapped in doing so because of lax or nonexistent enforcement of intellectual property rights. Second, the firms that control the development of valuable intellectual property, many of which are multinational enterprises, may be less willing to sell their most advanced products in countries that do not care to enforce intellectual property laws—if only due to the low likelihood of making a reasonable profit. So the country that chooses this path may thereby be unwittingly or otherwise also cutting itself off from the benefits of the latest innovations in hardware or software.

Along the issue of intellectual property, another important matter is the issue of codifiability. In the information age, the importance of human-embodied craft knowledge is rising. This is the technological knowledge embodied in the creators or users of technology rather than in software or hardware. Sometimes, it is called tacit knowledge, or uncodifiable knowledge, and is closely related to the creation and learning processes (such as learning-by-doing or learning-by-using) usually associated with the development and diffusion of new technologies. As a general rule, the more complex the technology, the more time and effort required to train a human to use it, and hence the higher value of human-embodiment of technological knowledge. If technological knowledge is tacit or uncodifiable, technological development is likely to be more dependent on historically determined skills and search routines. Often, technology cannot be easily transferred because of its dependence on the specific competence of localized individuals. The failure of many attempts elsewhere in the world to reproduce the Silicon Valley of northern California provides a good example. None of the rare limited successes has been able to equal, let alone duplicate, the size and breadth of activity in the original site.

Uncodifiable craft knowledge still plays an important role in industrial production—in fine machining or in laying out a design for a printed circuit board, for instance—despite efforts since the beginning of the Industrial Revolution, to root out the craft elements in order to reduce managers' dependence on craft workers and on their powerful unions (Piore and Sabel, 1984). The software business is rife with practitioners of craft knowledge, to the chagrin of the Japanese and others trying to create "software factories" (Cusumano, 1991). Especially able programmers are often called "wizards" and draw higher salaries and better perquisites, even stock options, compared to their fellow software employees, mainly to prolong their professional loyalty to the firm.

Compatibility is particularly important for technologies that become more useful to humans to the extent that they are widely shared. A good example would be a telegraph or telephone network. Network infrastructures become increasingly valuable to their users as the number of people who can be reached via the network increases. Economists identify this effect as ***network externality***. Languages work this way, too: The more those who share a given language, the greater the usefulness (at least in theory) for those who use that language. If a technology is hard to use, if it is priced unreasonably, or if ownership rights are difficult to guarantee, then compatibility problems might arise. A technology easily transmitted via existing transportation and telecommunications networks is potentially more shareable and compatible than one that cannot be diffused in that easy manner. The software side of information technology is highly dependent on compatibility, hence the relatively new high-speed networks of telecommunications currently being built. But such technology may prove difficult to appropriate, owing to the ease with which it can be pirated via illegal copying and transmission over the network.

Technological compatibility can serve as a useful strategic instrument for firms. "Nation-states are likely to use national and international infrastructures as instruments of competition in world affairs. There will always be some temptation to use incompatibilities in national infrastructures . . . [so as to shelter] domestic firms or workers from international competition" (Hart, 1989: 8.) In the setting or updating of technological standards for information technology industries, the politics of standards and compatibility have been remarkable in recent years. The U.S. decision to adopt a digital HDTV (high-definition television) standard incompatible with Japanese and European analogue standards, as well as the competition between two incompatible formats for home VCRs (videocassette recorders)—Beta versus VHS—provide two examples of the politics of standardization in the world at large as well as in the Japanese economy. The periodical standard updating of computer hardware and software by such major computer companies as Intel and Microsoft is also tainted by politics. The two firms are market leaders. IBM-compatible computers have Intel x86-family microprocessors and DOS/Windows operating systems. It is remarkable that, as Kenney (1996) suggests "(s)ome products such as personal computers are now on a three-month product cycle, demonstrating that even as value is being created more quickly, it is . . . destroyed more quickly. In the case of software, the quintessential product of the Information Economy, obsolescence is also extremely rapid. . . . the economy is obsolescence-based."

THE EVOLUTION OF THE CONCEPT OF TECHNOLOGY

To conceptualize the current transformation of technology, we need to understand the origin and historical evolution of the idea. What is the modern concept of technology? What are the differences between the modern and premodern technologies? Are there any midrange or microlevel changes in the concept of technology in any given era? To answer these questions, we need to explore the conceptual history of technology at three levels: (1) technology as hardware, (2) technology as knowledge, and (3) technology as an institutionally and culturally embedded entity.

Hardware invention has been developed in four stages: in the primitive, premodern, modern, and information societies, as per Figure 3.2. Three criteria help distinguish them: the intention of the invention, its linkage to specific persons, and the knowledge applied. In primitive society, invention is just a discovery with rare if any human intention for invention. In premodern society, invention is often the intentional making of tools. Invention does not yet include the invention of machines. Tools serve as an extension of the craftsman's hands and cannot be understood on their own merit. In the modern world, invention becomes designing and making a machine—of active and direct action on the object being worked, albeit still under the command of a human operator. Man is master of machine, but—unlike craftsman's tools—machines make their own demands on the operator; and the organization that buys and operates the machines (usually not the operator-worker) may impose further restrictions on the worker's behavior. In the information age, invention becomes the making of intelligent (or at least programmable) machines with far greater autonomy from their human users than modern-era machines. Intelligent machines require software as well as hardware. The intelligent machine of the information age is now a "co-worker" or "assistant" of sorts.

Technology has implications for the destructive, productive, and communicative potential of human societies. And technological innovations tend to co-evolve in three sectors, as per Figure 3.2. Of interest here is the overlap between military (destructive) and industrial (productive) technologies, and the related issues of spinoff, spin-on, and the promotion of dual-use (military and civilian) technologies (Vogel, 1992). Of similar interest are the triple-use technologies that have military, industrial, and communications dimensions and implications simultaneously. This newer tendency of technologies to overlap may be an important and possibly distinctive feature of technological knowledge in the information age, even if some overlaps did exist even earlier on.

Of the many things written on the concept of technology as knowledge, the work of José Ortega y Gasset (1972) is probably the most famous. Ortega y Gasset outlines technological evolution by dividing it into three main periods: the technics of chance, the technics of the craftsman, and the technics of the technician. The difference among the three is in the mode of discovery, and in the means of realization elected—the "technicity" of technical thinking. We extend Ortega y Gasset's categorization by adding the technics of the information worker in Figure 3.3.

The Technics of Chance

In the first period, there are no methods or technics at all. A technic must be discovered simply by chance, and technics are regarded as a part of nature. It is a revelation of nature that uncovers them. Thus, technics belong

Figure 3.2
The Evolution of Technology as Hardware

		Pre-modern Society	Modern Society	Information Society
The Meaning of Invention		tool as passive hardware	machine as active hardware	intelligent machine as assistant
Military Technology	*(land)*	sword spear/bow	gun cannon; rifle; automatic gun; tank; missile nuclear weapon	laser weapons SDI
	(sea)	sail ship row ship	steamship; turbine ship submarine; nuclear ship aircraft carrier	
	(air)		hot air balloon; engine plane bomber; jet plane fighter	spaceship satellite/stealth
Industrial Technology			textile; iron/steel railroad; electrical equipment automobiles chemistry; electronics aerospace nuclear power	information industries biotech
Communication Technology		writing	telegraph; telephone; wireless telephone radio; satellite communications broadcasting	computer communication

Figure 3.3
The Evolution of Technology as Knowledge

	Primitive Society	Pre-modern Society	Modern Society	Information Society
the subject of technological behavior	the technics of chance	the technics of craftsmen	the technics of technicians	the technics of knowledge workers
the essence of technics	nature (discovery-based)	man (human-based)	knowledge (knowledge-based)	knowledge in a broad sense
the nature of technological behavior	practice = probability	practice = plan (the principle of similitude)	practice ≠ plan (beyond similitude searching for universality)	practice = planning (allows for custom solutions to universal problems)

to the sphere of probability. In this pre-technological concept, technics are integral to the mysteries of nature.

The Technics of the Craftsman

In this second period, certain kinds of technics become conscious, and they are passed from one generation to the next by a special class of individuals—the artisans. Still, there is no systematic study of technics worthy of the label "technology." A technic of this period is simply a skill, an art, or a craft embedded in individual, not scientific or systemic (socially shared), knowledge. Also, the technics of planning are not yet separated from the technics of practice as they are to become in the modern era. A craftsman is worker as well as technician. To acquire the technics of the craftsman, a person must enter one of the exclusive communities of craftsmen, whether guilds or workshops, and accumulate experiences within that community. These technics cannot be explained by words or writings alone, only by training. The aspiring artisan must learn through a long apprenticeship. There may be no concept of progress among craftsmen that are now imbued with notions of virtuosity. Most premodern Oriental technics belong in this category, as do also most Western technics before the Industrial Revolution.

The Technics of the Technician

It is only in this third period, with the development of the analytic way of thinking associated with the rise of modern science, that the technics of technicians or engineers—"scientific" technics—"technology" in our literal sense, comes into existence. The great document of this dramatic shift from skill to technology was the *Encylopédie*, edited in the period from 1751 to 1772 by Denis Diderot and Jean D'Alembert. This famous work attempted to bring together, in an organized and systematic form, the knowledge of all crafts in such a way that the non-apprentice could learn to be a "technician." In this new period, discovering the technical means for realizing any end has in itself become a self-conscious scientific discipline. Now, the "technicity" of modern technics is radically different from that which inspired all previous technics, because it manifests itself both in technics and in scientific theory. As Ortega y Gasset puts it, now humanity has "the technology" before "a technics." People can know how to realize any project they might elect, even before actually choosing it. Technology now has become a system of knowledge, emancipated from nature, specific to human acumen.

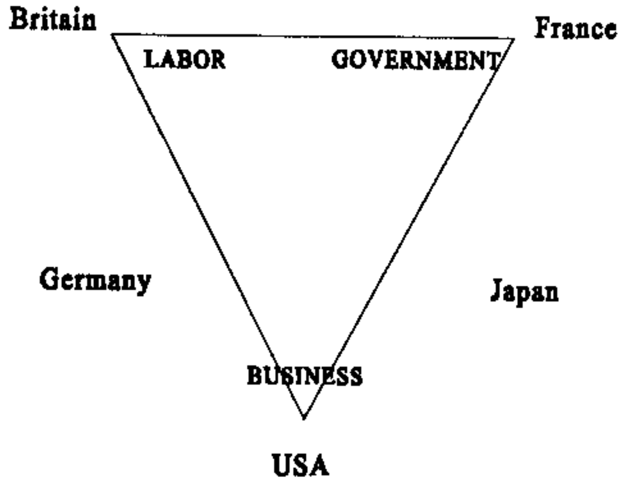
The Technics of the Information Worker

In the continuum of the above categorization, we would like to introduce here the idea of the technics of information workers and a provisional new term, *technoledge*—compounding technology and knowledge—to communicate the new meaning of technology in the information age. It is our hypothesis that another fundamental transformation of the concept of technology is now taking place with the introduction of new information technologies, particularly of computer software and telecommunications technology, into the processes of technical innovation. The "technicity" of the current technics is radically different from that of previous technics. Now, there is knowledge of how to take a general systems approach and apply such flexibility toward solving problems for specific users of a given technology. "Technoledge" combines knowledge about machines with knowledge about humans using those machines. Thus, in the information age, technological discourse becomes much more open to participation by users of technology (often the general public) and includes many of the factors excluded in the earlier, narrower discourses among technologists. Most importantly perhaps, both diversity and universality permeate the goals of technological activity in the information age.

THE FIT BETWEEN PREEXISTING INSTITUTIONS AND NEW TECHNOLOGIES

Since the emergence of the modern concept of technology, our technologies and institutions have tended ever more to co-evolve. It has therefore become increasingly important to understand the embedding of cultural and institutional elements within the newer technologies. One issue raised by

Figure 3.4
Types of State-Societal Arrangements



Source: Hart (1992), p. 281.

the foregoing is the ease with which new information technologies can be adapted and diffused within different societies. This is obviously important if—as we assume—power, just like international economic competitiveness, pivots on the rapid adaptation and diffusion of new technologies. Since new technologies embed cultural and institutional practices into the technology itself, there may be new types of impediments to the transfer of these technologies across national boundaries that did not exist in earlier periods.

Two approaches in the literature can provide some answers here. The first deals with the major differences in institutional arrangements among leading industrialized countries and relates those differences to important economic outcomes. The second deals with the possible institutional requisites of the new technologies. Both are useful and can be summarized on the basis of two references: Hart, 1992, and Kitschelt, 1991.

Which types of state-societal arrangements are conducive to the diffusion of new technologies? In *Rival Capitalists* (Hart, 1992), the relative power held by government, business, and labor is the crucial issue (see Figure 3.4). The five countries in Hart's study divide into two groups: (1) dominance of one factor; and (2) the sharing of power by two factors. The three factor-dominant patterns are either government-centered, business-centered, or labor-centered. France, the United States, and Britain belong in the one-factor dominance category: strong government in France, strong business in the United States, strong labor in Britain. Shared-power patterns consist of three types: government and business, government and labor, and business and labor. Japan and Germany belong to the shared-power category: coalitions of strong government and strong business in Japan, and coalitions of strong business and strong labor in Germany.

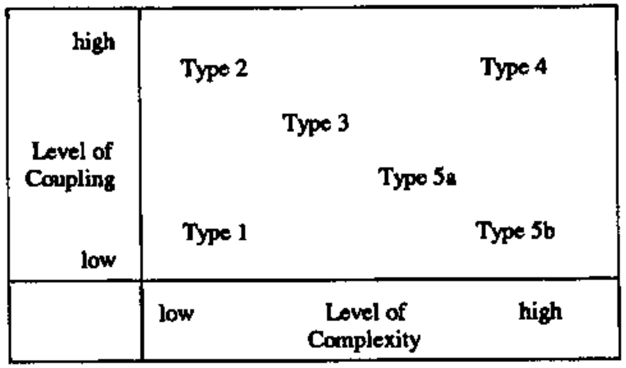
Based on his empirical study, Hart can hypothesize that in the last two decades, countries with shared-power configurations have experienced increased competitiveness relative to those with factor dominance. Shared-power arrangements are more flexible. They provide a favorable environment for the rapid introduction of technological innovations. Countries with factor dominance are relatively less flexible because the dominated factors resist technological change (see Chapter 9). The competitiveness of Britain and the United States in major industries, such as steel, automobiles, and semiconductors, has declined, whereas that of Germany and Japan in those industries has increased and the performance of France has been somewhere in between.

Can these results be generalized to all technologies? Hart raises this question in discussing variations within countries. For example, even though becoming internationally more competitive overall in the 1980s and 1990s, German industry remains markedly weaker than that of the United States and Japan in "hi-tech" electronics. Similarly, Japan seems to have had trouble catching up with the United States in microprocessor and software technology. Thus, the question: Is there a set of feasibly desirable institutional arrangements specific to a particular technology?

Kitschelt (1991) says that any technology has two important dimensions—coupling and complexity. First, we are to distinguish whether the elements of a technological system are loosely or tightly coupled. The extent of coupling refers to the requirement for spatial or temporal links between different production steps. If the steps must be executed at the same location or at the same time, they are tightly coupled. If they can be undertaken in any sequence, at any location, they are loosely coupled. In loosely coupled systems, each step or component of production is separate from every other step in space and time. Tight coupling requires close supervision, so as to contain problems that otherwise might quickly spread to other processes. Loose coupling permits less centralized control. The more tightly the technological elements are coupled, the more centralized the controls are required to be. The concept of coupling is closely related to the level of capital investment and to the size of the economy. If a technological system is tightly coupled, it generally requires a large economy with high levels of capital investment for local firms to be successful. Loosely coupled, the technological system does not require a large economy or high levels of capital investment for its local firms to be successful.

Second, we must assess the complexity of causal interactions among production stages. Complexity refers to the overall extent of interactive feedback among the production stages on which will depend the smooth run of the whole process. Linear systems that proceed from one stage to the next without feedback are uncomplex, whereas those that are iterative and inter-

Figure 3.5
Types of Technology



Sources: Kitschelt (1991): 468–475; Golden (1994): 129.

active are, in degrees, relatively more complex. Complex systems have large information requirements to manage the intricate flow of connections across processes, but large communications flows also can overload the capacity of centralized governance structures. Consequently, complex systems favor decentralized production units coordinated through network connections. Technological processes that are more sequential, and less interactive, have fewer information requirements. They are therefore more amenable to centralized control. If the technology is not complex, its trajectories are predictable, and production advances in continuous, incremental steps. If the technology is complex, technological innovations have to be explored by trial and error. They yield fast-paced technological change with major breakthroughs followed by small incremental improvements.

Based on these two dimensions, Kitschelt distinguishes five technological clusters from Mark I to Mark V technology. In this chapter, we intend to modify his categorization slightly—by reinterpreting his Mark III category and by dividing his Mark V into two distinct technological clusters, thereby creating six types in all. Like Kitschelt, we hypothesize that each technology will require a distinct governance structure for its maximum performance. Although the combinations of coupling and complexity of a technology do not determine a uniquely optimal governance structure, they do somehow constrain the efficient possibilities (see Figure 3.5). The possible efficient governance structures, or the favored institutional arrangements, for Type 1 to Type 5b are as follows.

Type 1 Technology (1770–1840)

A loosely coupled technological system endowed with linear interaction among its components characterizes this category. Concentrated ownership is not necessary, nor are there important economies of scale. Because knowledge intensity is quite low, technological trajectories in this case are readily predictable. Thus, new technologies are incrementally innovated. Consumer goods, light machine tools, and textiles belong to this type. In the case of Type 1 technology, a decentralized, market-oriented system with weak government and strong business is the way to exploit most energetically the opportunities offered by the new technological trajectory. Innovation in these systems stems from the incremental process of "learning by doing," not by the organization of systematic research.

Type 2 Technology (1830–1890)

This is a tightly coupled technological system with linear causal complexity. Because knowledge intensity remains fairly low, the advance of products is still made incrementally along predictable trajectories. But this type of technology requires large capital investments, and economies of scale increase rapidly. The heavy industries, such as iron/steel and railroads, belong here. The efficient governance structures for Type 2 technology shift from small to large corporations, from competitive to oligopolistic markets. The domestic structures that succeed in innovations are business-oriented arrangements, which facilitate industrial centralization, but incremental innovations are propelled above all by large corporations through systematic research in private laboratories. In the late-industrializing countries, the state-societal arrangements that deeply involve government across the stages of industrial development also belong in this category.

Type 3 Technology (1880–1940)

This is a highly-to-moderately coupled technological system of low-to-moderate causal complexity. This type of technological system involves moderate knowledge intensity; the technological trajectories are readily predictable. Hence, product advancements are made incrementally. Requirements of capital are relatively high. Economies of scale are quite large. Chemical production, electrical engineering, consumer-/durable-goods, and automobiles fit into this category. Centralized institutional arrangements are required to develop Type 3 technology—and especially so, in monopolistic markets. Historically, this technology was practiced in the "Fordist" mass production of consumer goods. It permitted the rise of the large multinational corporation.

Type 4 Technology (1930–1980)

A tightly coupled technological system of high causal complexity, this type of activity requires intensive knowledge. The trajectory is quite unpredictable. The advancement of its product occurs in leaps and bounds—not incrementally. The scale of economy is very large, and investment risks are very elevated. Representatives of this type include nuclear power and aerospace. In Type 4 technology, it is appropriate and common to have highly centralized governance structures, capable of placing the burden of investment risks on public agencies, even in cases where the technologies are meant to be developed or produced in privately owned facilities. Historically, two categories of countries have excelled in these technologies: economies governed by states with well-developed, centralized capabilities, often before the new technologies even surfaced; and countries, which acquired such capabilities in connection with the military competitions of World War II and the exigencies of the Cold War that followed. Note that, while the victors of World War II all ventured into the development of these Type 4 "state technologies," the losers and small neutral countries were forced to stay on the sidelines.

Type 5a Technology (1970–)

This is a low-to-moderately coupled technological system with high-to-moderate causal complexity. Because this type of technological system involves a very considerable intensity of knowledge, the technological trajectories are not readily predictable. Product advances are made in incremental steps with some breakthroughs. The economies of scale, initially moderate, increase over time. An example is a type of integrated circuit, the Dynamic Random Access Memory (DRAM). DRAMs are used in computers and now increasingly in consumer electronics. For Type 5a technology, countries with power-sharing institutions are better able to take advantage of such conditions. Cooperative networks between state-societal actors impart flexibility into production systems and reduce investment risks for firms.

Type 5b Technology (1970–)

This is a loosely coupled technological system with high causal complexity in which problem solving is difficult and complicated. Type 5b's technological trajectories are not readily predictable. The economies of scale, moderate in the beginning, increase over time. This type of technology incorporates computer software, microprocessors, and biotechnology. Type 5b technology requires more sophisticated institutional arrangements than all other types. Here, the technologies no longer reward the organized capabilities of highly integrated private or government-run enterprises. Corresponding governance structures include mixed private and public research and development consortia as well as national and international intercorporate alliances of all sorts. Because of the high technological uncertainties, organizational decentralization has to be combined with a certain dose of public funding, to stimulate requisite private investments (Kim, 1994).

To summarize, Hart's and Kitschelt's theories together give us some insight as to which institutional arrangements are most likely to promote technological innovation for different types of technologies. A question left unanswered is whether institutional arrangements already existing in various countries can be changed as needed in order to pave the way for innovative successes. The reader needs to refer to the theory of "technological paradigms," which covers "national innovation systems"—the network of public and private institutions that affect the creation and adoption of technologies within an economy (Freeman, 1987; Dosi, 1988). This theory asserts that relatively infrequent changes in technological paradigms require changes in products, processes, and organizations. Based on the aforegoing, it is now possible to address the query of how to observe power in the information age.

OBSERVING POWER IN THE INFORMATION AGE

There are basically three different ways of empirically observing power: (1) as a resource, (2) as a relationship, and (3) as a structure (Hart, 1976). We hypothesize that as a result of the growing importance of information technologies: (1) the main locus of power as resource has been shifting from the military to the economic and now to the informational purview, and (2) the main mechanisms for exercising power have also been shifting: from relational power to structural power.

"In the power as resources approach, power is measured in terms of control over a resource (potential power) which can be converted . . . into control over others or over outcomes (actual power). These resources, also called capabilities, may be connected with measurable phenomena such as economic wealth or population" (Hart, 1989: 3). Realist theories of international relations and works on geopolitics often rely on power-as-resource approaches. Power is measured or assessed in terms of certain capabilities—functions of control over specific types of resources—land area, population, GNP, energy production, and so on.

In recent years, besides the usual set of capabilities used to measure power, technological capabilities have begun to count for power resources. In the early 1990s, world production shares of semiconductors appeared as one of the indicators monitored by the Central Intelligence Agency in its annual publication, the *Handbook of International Economic Statistics.* It is foreseeable that future issues of that publication will contain tables on the number of server computers linked to the Internet or the number of World Wide Web sites extant in major countries. As information technology grows in importance in international relations, these sorts of changes in conventional power assessment are likely.

It has been suggested that the development of information technologies shifts the basis of power from violence to wealth on to knowledge through a phenomenon described as the "powershift" (Toffler, 1990). While we do not necessarily agree with Toffler on this score, there is evidence for such a shift in the recent works of realists and students of geopolitics. A key unresolved issue for us, however, is whether it is really necessary to try to reconceive the inherited notion of national security, to seek to redefine the international power game, and to re-situate its players as a result of the rise of information technologies.

The new technologies clearly have had an impact on both power and power assessment. If a country possesses high-tech communications equipment, then it can all the more easily access information resources. If a country has developed an information superhighway system, then citizens of that country can ever more easily access important information resources, and the country thus gains an informational edge over those without such system.

The information age is producing a blurring of boundaries between power resources. In the information age, there appears to be greater concern than in previous eras about the importance of dual-use (military and civilian) technologies, the role of the media in society, the importance of having the means to project one's culture abroad, and the vulnerability of communications networks to disruptions by hostile forces. These are not entirely new concerns, of course. Iron-clad ships also combined dual-use technologies; the telegraph and telegraph cables, too, played an important role in preserving British hegemony during the nineteenth century; and there was obviously not lesser concern about the integrity of radio and telegraph communications networks in both world wars. Still, the intensity of concern has shifted in these directions to an extent that now makes it possible to assert that a noticeable qualitative change has taken place.

The information age has made intangible forms of power more important. Control over knowledge, over beliefs and ideas, is now increasingly regarded to be a complementary control over tangible resources, including military forces, raw materials, and economic productive capability. In this context, the extent to which the politics of ideas complements power politics is becoming larger than before. Thus, "whoever is able to develop or acquire and to deny the access of others to a kind of knowledge respected and sought by others; and whoever can control the channels by which it is communicated to those given access to it, will exercise a very special kind of structural power" (Strange, 1988: 30).

Information is a flexible power resource that is less constrained by time and place than any other power resource. It is in many ways more fungible—transferable from one actor to another—than other forms of power. It is much more like money and other economic resources than it is like any military power resource in that regard. This commodification of information is not new. It has simply accelerated with the growth of high-speed telecommunications technologies and following the digitalization of information. The deployment of these new technologies has made it easier to package, sell, and distribute information than ever before (Giese, 1994). However, one could never overstate the fact that information without knowledge is not very useful and that information about technology is especially difficult to transfer to others unless there exists a solid cognitive and institutional basis for doing so. An example would be the dubious utility of supplying raw digital data from a spy satellite to a friendly country that did not have the capability of turning the data into images or did not have experts capable of interpreting the images for security purposes. Another example would be the sharing of a secret microchip design with a friendly country that had no semiconductor production facilities.

In the power-as-relationship approach, power is measured or assessed in terms of interactions between pairs of social actors. A has power over B when A and B have conflicting views about the desirable outcome of a specific situation but B acts as if it had adopted the preferences of A. Relational power can result either from coercion or persuasion. In a coercive power relationship, A threatens B in order to get B to act on A's preferences. In a persuasive relationship, A communicates with B in a non-threatening manner, to convince B to adopt A's preferences. This category of power is difficult to measure because it requires knowing A's and B's preferences both before and after their interaction. Relational approaches to power are based on empiricist conceptions of power.

With the end of the Cold War, power relationships hitherto based on bipolar enmity or alliances are being redefined to take into account the absence (with the noteworthy exception of the People's Republic of China) of a communist bloc. Integral to that adjustment is an increased interest in avoiding the commitment of military resources in attempts to influence specific other actors in the international system. Thus, there is greater interest in economic sanctions as an alternative response to various forms of bad behavior. We predict that sanctions involving deprivation of access to informational resources will become a likely substitute for military threats, as the information economy develops.

Joseph S. Nye's concept of soft power may be one way of understanding power in the information age, at least from the relational perspective. Soft power is the ability to achieve a desired outcome through attraction rather than coercion. It works by convincing others to comply with norms and institutions that produce a particular desired behavior. Soft power depends on the appeal of ideas and an actor's ability to set the agenda in ways that shape the preferences of others. If a state can legitimize its power by establishing and supporting new regimes, then it may be able to economize on its expenditure of traditional military and economic resources (Nye, 1990).

More important, international actors seem to be thinking more about the larger set of norms, rules, and procedures that govern the world's political and economic systems now that the Cold War is over. They are thus more interested in exercising structural power.

Susan Strange says that

> structural power . . . confers the power to decide how things shall be done, the power to shape frameworks within which states relate to each other, relate to people, or relate to corporate enterprises. The relative power of each party in a relationship is more, or less, if one party is also determining the surrounding structure of the relationship . . . What is common to all four kinds of structural power is that the possessor is able to change the range of choices open to others, without apparently putting pressure directly on them to take one decision or to make one choice rather than others. Such power is less "visible." Today the knowledge most sought after the acquisition of relational power and to reinforce other kinds of structural power (i.e. in security matters, in production and in finance) is technology. The advanced technologies of new materials, new products, new systems of changing plants and animals, new systems of collecting, storing and retrieving information—all these open doors to both structural power and relational power. (Strange, 1988: 25–31)

Later in the same work, however, she goes on to emphasize that "Structural analysis suggests that technological changes do not necessarily change power structures. They do so only if accompanied by changes in the basic belief systems which underpin or support the political and economic arrangements acceptable to society" (Strange, 1988: 123).

This emphasis is consistent with our argument about the cultural and institutional impediments to the transfer of technology in the information age. Information technologies embed institutional and cultural practices into the technology itself. A certain amount of structural power is implicit in the transfer of information technologies across national boundaries. The country which is the source of new key technologies—microprocessors, fast digital switches, operating system software, and the like—frequently gets to impose its institutional and cultural arrangements on others. For example, Microsoft now dominates the personal computer market with the Windows operating systems on computers that use Intel's microprocessors. Computer companies and users in Europe and Asia have tried unsuccessfully to compete directly with these firms and now are forced to adapt to the technological solutions that the dominant firms have imposed on them as well as on the rest of the world. This generates a certain amount of resentment, even of irritation, that sometimes percolates up to the level of national governments. Yet it is arguably an outcome of the success of both Microsoft's and Intel's ability to anticipate the demands of the marketplace, and to some extent also of their ability to extend sufficient incentives to overseas users to accept and buy products not of domestic origin.

CONCLUSIONS

Technological change clearly influences the distribution of power in the international system. If a country wields advanced technology, it can that much better produce military weapons and that much more competitively manufacture civilian products. This is why politicians and business leaders pay so much attention to acquiring new technological knowledge. Historically, and at least since Bacon, technological innovation has been seen to offer a way of making a society strong and wealthy. Success in acquiring or adapting to a new technology produces winners; lack of success produces losers. In recent years, the development of information technology has increasingly linked power of technology to power of information in a form of power that we call technoledge.

Information-based technological power is different from earlier forms of technologically based power in a number of important ways. It is connected with the successful creation or adaptation of new technologies which contain a great deal of institutional and cultural information embedded in them. As a consequence, these new technologies do not flow across national boundaries as easily as the technologies of previous eras. Also, information technologies have forced the governments of nation-states to rearticulate their internal structures in order to cope with the trend toward globalization of international business—a trend made possible by faster and cheaper computing and advanced telecommunications (Douglas, 1996: 7; Hart and Prakash, 1997).

Third, the development of information technology has greatly reduced the difficulty and expense of surveillance, and has given greater surveillance power both to states and to the citizens of contemporary nation-states (Hewson, 1994). The ability of the citizenry to use its new surveillance powers will depend on its ability to force the state to permit access to information that was previously jealously guarded. It will also depend on the creation and diffusion of new encryption technologies, which are increasingly used by commercial enterprises and individuals, and thus are no longer under the stringent control of national governments.

Finally, information technologies have created a new frontier for exploration, in ways analogous to the creation of new frontiers when wind power was harnessed and sail-ships could be launched into an age of exploration. The challenge here is that these new frontiers are more than actual (territorial or geographic)—they are virtual. It is these virtual boundaries that may yet divide an otherwise actually uniting world in unusually profound ways.

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