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The Changing *Scope* of *Power and Governance*

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Hafner, Katie, and Matthew Lyon- 1996. Where Wizards Stay Up Late: The Origins *of the* Internet. New York: Simon and Schuster.

Hart, Jeffrey, Robert R. Reed, and Francois Bar. 1992. The Building of the Internet. Telecommunications Policy. (November) 16: 666-689.

Held, David. 1987. Models of Democracy. Stanford: Stanford University Press.

Helleiner, Eric. 1998. Electronic Money: A Challenge to the Sovereign State? Journal *of* International *Affairs.* 51(2): 387-409.

Herz, John. 1957. Rise and Demise of Territorial States. World Politics. 9: 473-493.

Huysmans, Jef. 1998. Security! What do you mean? From concept to thick signifier. *Euro*pean Journal *of* International *Relations. 4(2):* 226-255.

Innis, Harold. 1952. The Bias *of* Communications. Toronto: University of Toronto Press.

Krause, Keith, and Michael Williams. 1996. Critical Security Studies. Minneapolis: University of Minnesota Press-

Liphshutz, Ronnie. 1995. On Security- New York: Columbia University Press.

Luke, Timothy. 1991. The Discipline of Security Studies and the Codes of Containment. Alternatives- 16: 320-344

Lyon, David. 1994. The Electronic *Eye:* The Rise *of Surveillance* Society- Minneapolis: University of Minnesota Press.

Martin, David. 1991. Geographic Information Systems and *their* Socioeconomic Applications. London: Routledge Press.

McLuhan, Marshal. 1964. Understanding Media: The Extensions *of* Man. New York: McGraw-Hill.

Migdal, Joel. 1988. Strong Societies and Weak States: State-Society Relations and State Capabilities in the Third World. Princeton: Princeton University Press.

Strassman, Paul A., and William Marlow. 1996. Risk-Free Access Into the Global Information Infrastructure Via Anonymous Re-Mailers. Paper delivered to the Symposium on the Global Information Infrastructure: Information, Policy, and International Initiatives. Harvard University, Cambridge Mass, USA. (January 28-30)

Swett, Charles. July 1995. Strategic Assessment: the Internet. Office of the Assistant Secretary of Defense for Special Operations and Low-Intensity Conflict (Policy Planning).

Williams, Michael. 1998. Identity and the Politics of Security. *European* Journal of International *Relations. 4(2):* 204-255.

CHAPTER SIX

THE GLOBAL POLITICAL ECONOMY OF WINTELISM: A NEW MODE OF POWER AND GOVERNANCE IN THE GLOBAL COMPUTER INDUSTRY

SANGBAE KIM AND JEFFREY A. HART

INTRODUCTION

Technological competition in the global information industries—the leading sector in the contemporary global political economy—is currently moving beyond competition over technological innovation per se. The technological winner is now the one who manages to control de facto market standards while at the same time protecting intellectual property rights. Moreover, the new mode of technological competition puts pressure on firms and governments everywhere not only to adjust to the new principles of competition, but also to adopt new forms of industrial governance and state-societal arrangements.

In the global personal computer (PC) industry, two American companies, Microsoft and Intel, typify this new mode of technological competition. Together, Microsoft and Intel have defined the architecture for IBM-compatible PCs by setting and controlling de facto market standards and protecting those standards as the world's most valuable form of intellectual property. Scholars in International Political Economy (IPE) understand that the resurgence of the U.S. international competitiveness is closely related to its relative strength in this new leading sector. This is in a sharp contrast to the debates of the 1980s and early 1990s over the relative decline of the U.S. international competitiveness in previous leading sectors—steel, autos, consumer electronics, and semiconductors.

Building on Borrus and Zysman's work (1997), we attempt to understand the new mode of technological competition and subsequent changes in industrial governance and state-societal arrangements by using the concept of *Wintelism. Wintelism* writ small is a new mode of competition mainly in the personal computer industry, in which the Wintel (Windows + Intel) coalition represents the combined power of Microsoft and Intel over the architectural standards of PCs. In the PC industry, Microsoft's operating system and Intel's microprocessors are not just superior pieces of equipment that the competition might hope to match or surpass with a reasonable effort. Rather, for some years now, they have served as structural constraints—the rules of the game—that every firm entering the industry has had to accept.

Wintelism writ large is a new form of industrial governance that originated from the computer industry, but can be applied to all information industries. It is our view that there is a close fit between Wintelism writ large and horizontal industrial governance. In the Wintelist era, large firms that are vertically integrated no longer dominate because they cannot compete adequately with horizontally focused, specialized firms. We will be arguing below that recent changes in U.S. state-societal arrangements are well suited to an era of architectural competition.' We use the term modified regulatory state to refer to U.S. government policies and institutional arrangements. Other countries have not been so fortunate in this regard, including the country that was the main source of foreign competition for U.S. high technology firms in the 1980s, i.e., Japan.

THE TECHNOLOGICAL BASIS OF WINTELISM

The rise of Wintelism is connected with the growing prominence of a technological sector that we call software electronics technology. Software electronics technology includes computer software, microcode, semiconductor chip designs, and technical standards in products and services. Software electronics does not include the hardware aspects of electronics or information technologies. We will call these excluded technologies *hardware electronics.* Although both hardware and software electronics belong to the broader category of information technology, our definition of Wintelism begins with the distinction between the two technological sectors.

COMPUTER ARCHITECTURE TECHNOLOGIES

Among software electronics technologies, we will focus on technologies associated with *computer* architecture. Computer technology is comprised of hardware (all the physical equipment of computers), firmware (embedded software in programmable microchips) and software (a set of instructions that tells the electronics system how to perform tasks). There are also published and unpublished standards and interface protocols that allow designers to make sure that hardware and software work together. As Morris and Ferguson hold,

> The standards define how programs and commands will *work* and how data will move around the system—the communication protocols and formats that hardware components must adhere to, the rules for exchanging signals between applications software and the operating system, the processor's command structure, the allowable font descriptions for a printer, and so forth. (Morris and Ferguson 1993, 88)

Morris and Ferguson call this complex of standards and rules *architecture.* The architecture is mainly defined by microprocessor, basic input output system (BIOS), data bus, and operating system software. All elements are usually referred to together as *a platform.* Technologies concerning the computer architecture are the core of PC technology; among them, the most critical parts are microprocessors and operating system software.

Personal computer systems are generally designed around **microprocessors,** which embody most of the central processing unit of a computer within a single chip. The microprocessor chip is embedded in a printed circuit board with helper chips to form what is called *a motherboard.* The motherboard generally includes a separate chip for the BIOS, a digital clock, the data bus, and a bank of chip sockets for dynamic random access memory (DRAM). The motherboard is connected via the data bus and other input/output interfaces to PC peripherals such as the monitor, the keyboard, the floppy disk drives, the hard drives, and whatever else the customer wants to have connected. IBM-compatible PCs use Intel's x86 series of microprocessors or microprocessors designed to emulate those devices. Apple's Macintosh uses Motorola or IBM (Power PC) microprocessors.

Operating systems translate the software written in higher-level languages, like BASIC, Fortran, or C++ into machine language instructions that are understood by the computer's central processing unit. It also manages data flows into and out of the central processing unit and may also manage the way in which data is handled in data storage devices. In terms of the functional level of software, the operating system is most closely related to the hardware and to design a good one requires sophisticated knowledge of computer science, but does not require much knowledge in the application domain or real-world problems that end users confront. For application software to perform well, the designer must start from a good understanding of the problems that users are trying to solve.

TECHNOLOGICAL PROPERTIES OF SOFTWARE ELECTRONICS

There is a restricted meaning of technology as knowledge, and an extended meaning of technology in relation to embedded institutions (Hart and Kim 2000). In the restricted meaning, technology is technological knowledge embodied in material products. Here we note that there are at least three distinct aspects of technological knowledge in software electronics: technical standards, intellectual property and product innovation.'

The most prominent feature of contemporary software electronics technology is the increasing importance of standards. This feature derives from the high value placed by consumers on compatibility between interrelated technological components. For example, the PC is a modular device assembled from a series of discrete components, each of which has its own discernable production chain. Thus, the existence of a dominant technical standard provides producers and consumers with the advantages of compatibility among subsystems while products are continually refined and reconfigured. Architectural standards enable rapid innovation to take place at the component level without sacrificing compatibility at the system level.

Despite these advantages, architectural standards may also result in barriers to entry that lead to the potential for particular firms to exercise market power because of imperfect competition. In fact, the operating system and microprocessor are perfect examples of subsystem markets with high barriers to entry because of the entrenchment of the IBM-compatible PC architecture. To utilize the biggest selection of software for personal computers, consumers have had little choice but to buy a machine containing an Intel-designed chip and loaded with Microsoft's operating systems.

The second feature of software electronics technology is that there are increasing demands for protecting proprietary knowledge as intellectual property rights. One of the major technological trends that brings about those demands is the rising cost of research and development and other innovation-related activities. Investment in R&D has accelerated worldwide; and product life cycles have become shorter. In order to recoup substantial investments in R&D, a company must be able to secure its investment in technology in the form of intellectual property.

Effective protection of intellectual property, however, has become more difficult as copying of digital technology has become easier. For example, computer software programs costing huge sums to develop can be copied quickly and cheaply by unscrupulous individuals with fairly rudimentary equipment. Moreover, "the information-intensive nature of software means that its exploitation by a number of parties does not degrade its quality" (Mowery 1996: 305). Semiconductor chips pose similar problems with respect to existing forms of intellectual property protection. As in computer software development, designing new chips and preparing masks for chip manufacturing is expensive, but copying chip designs and reproducing chip masks is relatively simple and inexpensive.

Therefore, it is no surprise that firms want more secure ways of protecting their intellectual property. Recent evidence shows that information technology firms are seeking greater intellectual property protection through legal mechanisms, such as patents and copyrights. Similarly, the number of patent and copyright infringement lawsuits is increasing. These current trends have raised the salience of intellectual property laws and their enforcement in the eyes of national governments (Clapes 1993; Moore 1997).

The final feature of computer architectural technologies is its unique pattern of product innovation. For computer architectures, functionality is more highly valued than quality. Software engineering is a highly knowledge-intensive process, more like a craft industry than like high-volume manufacturing. Japanese efforts to create software factories—by adapting methods from high-volume manufacturing that normally enhance productivity such as statistical quality control, standardized components, and speeded up assembly lines—have not succeeded. Instead, the most highly valued software is written by small teams of skilled engineers (Cusumano 1991).

New computer architectures are usually introduced by discontinuous breakthrough-type innovations rather than by incremental innovations or quality improvement. The development of a new generation of microprocessors and operating system software yields major innovations with little room for incremental improvement between major breakthroughs. Furthermore, this development of new products in microprocessors and operating systems is based on the obsolescence of old products; new products destroy the old generation (Kenney 1996).

One important question here is whether there is a set of identifiable institutional arrangements specific to a given technology or set of technologies that produces better long-term economic consequences overall for the political unit in which those institutions exist. Herbert Kitschelt (1991) argues that any technology has two important dimensions that influence the choice of industrial governance structures: one is the degree of coupling in the elements of a technological system, and the other is the complexity of causal interactions among production stages. He argues that each technological system—characterized by its position vis-a-vis the two dimensions—requires a distinct governance structure for maximum performance. For example, the more tightly technological elements are coupled, the more control needs to be centralized. The more complex the causal interaction between production stages is, the less control needs to be decentralized. Following Kitschelt, we argue that software electronics technology requires a distinct governance structure—or a particular set of institutional arrangement for maximum economic performance (Hart and Kim 1998).

Software electronics is a loosely coupled technological system. Each step or component of production in a software electronics system is separated from every other step in space and time. Thus the production steps can be done in any sequence at any location because loose coupling permits decentralized control, and errors in components do not easily affect the entire system. For example, the modularity of the PC system means that parts, subassemblies, components, and peripherals can be sourced in the open market from wherever the best price/performance can be garnered. The components from multiple vendors fit together because they are compatible enough to enable end-to-end interoperability among the components. Here, architectural standards serve as the lubricant that allows modular components to work together well.

Software electronics is also a complex interactive technological system. In other words, a software electronics system requires complex feedback between production stages to keep the whole process on track. Thus, its developmental processes have to take place in decentralized organizational units, because a centralized system of control would be quickly overloaded. For example, the whole process of software development including design, coding, testing, and integration entails a tremendous amount of feedback and informal communication within the firm. Thus, technological trajectories of advanced software are not readily predictable in time, cost, or in final results. The development of new computer software technology is usually the result of trial-and-error research. This is called learning by doing. Likewise, close interaction between producers and sophisticated users is critical in the software development process. For instance, the alpha and beta testing of new software generations provides invaluable feedback to software developers on the features desired by users and helps eliminate bugs before the product is shipped. This is called learning by using. (Rosenberg 1982).

In this context, technological properties of software electronics require a flexible institutional environment that encourages the rise of decentralized industrial governance structures. Software electronics technologies do not reward the organized capabilities of vertically integrated private or state-owned enterprises or the interventionist role of the state where architectural standards exist. Smaller sized start-up firms with cross-regional or cross-national networks emerge as the fittest industrial governance structure but, in cases where R&D uncertainties are substantial and knowledge intensity is high, appropriate industrial governance requires the coexistence of large and small firms. In this regard, Herbert Kitschelt points out that,

> ... corresponding governance structures [to software electronics] include mixed regulatory requirements and the exigencies of effective global marketing strategies give large corporations an advantage, unprecedented organizational decentralization nevertheless continues to prevail under the umbrella of the large corporation (1991, 474).

Large corporations with decentralized structures or horizontal intercorporate alliances among those corporations are required in order to provide necessary financial and technological supports. Appropriate state governance promotes this

kind of horizontal industrial governance. The regulatory state promotes small start-up firms while enforcing antitrust laws to prevent large firms from discouraging innovation. The regulatory state thus encourages value-chain specialization in the computer industry as discussed below.

THE SUCCESS OF WINTEL AND STRUCTURAL POWER

The case of computer architecture technology typifies a new mode of competition in the global computer industry. In this new competition, the cutting edge of industrial competition lies in the establishment of de facto technical standards. Since the introduction of the IBM PC in 1981, for example, Intel and Microsoft have defined the IBM-compatible PC architecture and established that architecture as a global standard. In this section, we discuss how Intel and Microsoft were able to dominate markets of microprocessors and operating systems for PCs, and will explain what their success means by using the conceptual framework of structural power.'

THE WINTEL COALITION IN THE PC INDUSTRY

Since 1981, Intel had supplied leading edge microprocessors for IBM-compatible PCs. It maintained its leadership position in this market **through** development and continual improvement of its x86 series of microprocessors. All IBM-compatible PC manufacturers buy Intel-designed microprocessors or clones of Intel microprocessors to build machines that run DOS/Windows operating systems. About 90 percent of all PCs sold in recent years are IBM-compatible PCs. There are several producers of x86 Intel clone chips, such as Advanced Micro Devices (AMD) and Cyrix. However, Intel has been successful in limiting the market share for cloned microprocessors by taking deep price cuts when necessary, making steep production ramp ups of new generatiws of products, and launching aggressive legal challenges to companies that simply copy Intel designs rather than engineering their own design improvements.

In 1992, the year when Intel became the world's largest semiconductor manufacturer, it held the overwhelming majority of the market for the then state-of-the-art 32-bit microprocessors. Intel's share was 73 percent of this market ($3.18 billion) compared with Motorola's 8.5 percent ($0.38 billion), AMD's 8.0 percent ($0.35 billion), Texas Instruments' 1.9 percent ($0.06 billion), and NEC's 1.1 percent ($0.05 billion) (Fransman 1995, 169).

Microsoft's great opportunity came when IBM chose it to be the supplier of the DOS operating system for the PC in 1981. This gave Microsoft the basis for growth, but its subsequent performance has depended on frequent improvements in operating systems. Microsoft's market position in PC operating system software resembles that of a pure monopolist even more than Intel's in microprocessors. For example, Microsoft's operating systems sit on about 90 percent of the world's personal computers (Microsoft, 89 percent; Apple, 8 percent; Unix, 2 percent; IBM OS/2, 1 percent), and PC customers have almost no choice but to purchase DOS/Windows to access the many compatible software applications currently available on the market.

After succeeding in computer languages and operating systems, Microsoft invested in developing applications software. Its first major success in this area was a spreadsheet program called Excel, displacing Lotus, which until then had dominated the market with its 1-2-3 product. Microsoft then successfully created and marketed a word processor, Microsoft Word, for both the Apple Macintosh and the IBM PC, which managed to displace earlier programs like Word Perfect as the market leader. Microsoft now controls 60 percent of the Windows spreadsheet market, and 47 percent of the Windows word processing market. Microsoft's revenues from applications software rose from $1.4 billion in 1992 to $2.2 billion in 1993, an increase of 58 percent. Microsoft was the world's largest independent software producer in 1998, with annual revenues of $14.5 billion and 27,320 employees (Cusumano and Selby 1995, 3; Chang 1994: 15-16; http://www.microsoft.com/presspass/fastfacts.htm).

Much of Intel's and Microsoft's strength in the marketplace is the result of a special relationship they have developed over time with each other. In order to keep their share of their respective markets, Intel and Microsoft had to coordinate their strategies whenever a new microprocessor or a new version of the operating system was introduced to the market.

An introduction of a faster and more powerful microprocessor requires a new operating system to perform its tasks at higher speeds (or to perform new tasks) in order for the user to benefit from the improved chip. Similarly, the successful introduction of an operating system newly developed by Microsoft depends on the replacement of older machines that occurs whenever a new and faster Intel microprocessor is released. Independent software developers tend to focus their efforts on operating systems and hardware platforms that have the largest user base.

In a circular fashion, both Intel and Microsoft have benefited from the great variety of software applications and computer peripherals that have been developed to serve this installed base. The mutually reinforcing power of Intel's microprocessors and Microsoft's DOS/Windows products over the PC architecture gave rise to the idea of the Wintel (Windows and Intel) coalition. While there are some tensions in the Microsoft/Intel partnership, so far the two firms have managed to continue their successful collaboration.

WINTELIST STRATEGIES AND STRUCTURAL POWER

The question arising here is how the combined power of Wintel—or the success of Microsoft and Intel separately—was established in the PC architecture in the first place. Microeconomic theories can be used to explain Wintel's' success within the conceptual frameworks of network externalities, lock-in *effects,* dominant *design* and *first-mover* advantages. Of particular interest is how first-mover advantages in industries subject to network externalities can be used by innovating firms to deter entry by potential market entrants and to lock in customers. These economic approaches, however, cannot predict or explain the international power implications of Wintelism.

In this section, we draw upon the concept of *structural power* to examine the power implications of Wintelism. We argue that there are basically two different ways of understanding power—material *power,* which confers the material capabilities to control over others in relational dimensions, and structural power, which confers the power to reconstitute the rules of the game (including the surrounding structure and even actor's identity) by which actors constrain other actors (Hart 1976, 1989; Hart and Kim 2000).

With this conceptual framework, we understand that, in the new mode of technological competition, an industrial winner should be able to establish the material base of manufacturing and technological innovations as usually understood. However, it should also be better able to manipulate the rules of the game of technological competition. Three aspects of Microsoft's and Intel's business strategies—control over technical standards, intellectual property protection and continuous product innovations—clearly show that the structural power dimension—interacting with the material power dimension—was working explicitly so that Wintel has remained at the center of the evolution of the PC business.

First of all, the success of Wintel should be understood within the context of the increasing importance of technical standards. Currently, competitive success flows to the company that manages to establish die facto market standards control over a broad, fast-moving, competitive product market (Gabel 1987, 1991; Grindley 1995).

The most typical example of standards competition is found in the success of IBM-compatible PCs in contrast with Apple's Macintosh series. Although some experts argue that the Macintosh architecture is technically superior to that of the IBM-PC, the latter has nevertheless stubbornly held on to its dominant market position. The IBM-compatible PC makers, by adopting an open standards strategy, effectively locked in the customer base and created a market with a much more diverse set of products with generally lower prices than comparable Apple products (Yoffie ed. 1997; Grindley 1995).

The Wintel coalition established de facto standards for each successive generation of the PC architecture by maintaining a subtle balance between aggressive diffusion and limited licensing of architectural standards—by adopting an open but owned standards strategy (Borrus and Zysman 1997). Open standards may mean a loss of market share for developers of new technology as a result of the ability of other firms to market compatible cloned products. By means of limited dissemination of standards, however, Intel and Microsoft were able to maximize the effect of network externalities and gain competitive leverage in the PC industry. Cloning may even give a systematic advantage to the initial developer if it helps it to maintain its status as first mover in successive product generations.

The competition between IBM and the clone makers led to an explosion in demand for IBM-compatible PCs. The more IBM PC clone makers used Intel chips and Microsoft operating systems and the more software developers developed products that were compatible with Wintel standards, the greater was Intel's and Microsoft's competitive advantage over potential rivals in the microprocessor and operating systems businesses. Indeed, Intel's microprocessors and Microsoft's operating systems represent a structural constraint that every firm entering the industry has had to accept in the PC business. In short, Wintel has controlled the rules of the game in the PC industry.

Theoretical works in international political economy can help us better understand the importance of technical standards for the international system as a whole. Susan Strange's concept of structural power is particularly useful. Strange argues, "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" (Strange 1988: 25). According to Strange, structural power in the arena of knowledge is the most important among the four main structural arenas—security, trade, finance, and knowledge. She argues,

> ... 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. . . . 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 (1988, 31).

In spite of Strange's silence about technical standards, control over technical standards in the PC industry clearly qualifies as an example of structural power.

The sophisticated management of intellectual property was the second essential ingredient in the success of Wintel. While the diffusion of technical standards was a part of the offensive dimension of Wintelist strategies, the protection of intellectual property was part of its defensive dimension. Indeed, a fine balance between liberal dissemination of open standards and stringent protection of intellectual property rights emerged as a central issue for Intel and Microsoft. Choosing the right degree of openness and the right amount of intellectual property rights enforcement was a problem that had to be solved, as it was, with open but owned standards (Borrus and Zysman 1997).

To protect their interests, Intel and Microsoft were active in policing infringements and taking legal action in their home markets. Interfirm level lawsuits against alleged cases of intellectual property infringement have played an important role in protecting the intellectual property of Wintel. Examples include computer-related infringement lawsuits, such as *NEC vs Intel, Intel vs AMD, Intel vs* Cyrix and *Microsoft vs* Shuuwa (Clapes 1993). Without such a defense, the two firms would not have been able to remain leaders in their respective markets, because they would not have been able to afford investments in new technologies and new production facilities.

Successful intellectual property rights enforcement ultimately requires a commitment on the part of national governments to enact strong copyright and patent laws in the first place and then to develop credible enforcement procedures. Intellectual property protection has primarily been a matter of national (territorial) jurisdiction in the sense that "each national government determines the scope of protection and rights subject only to bilateral and multilateral agreements... . Within each system, countries established regimes of protection that were economically and philosophically compatible with their cultures" (Hansen 1997 265-6). In recent years, Intel and Microsoft have lobbied the U.S. government for stronger intellectual property laws, and persuaded the U.S. government to pressure foreign governments to enforce intellectual property rights. In this way, the developers of the Wintel PC platform have been able to maintain control over those technologies by restricting access to companies unwilling to pay the price and follow the dictates of technology licensing agreements (Gabel 1991 11-4).

Indeed, the U.S. government has played an indirect but important role in the international success of the Wintelist firms by advocating a strengthened international regime for protecting intellectual property. The U.S. government has taken a trade-oriented approach to international intellectual property issues. Intellectual property protection became a major trade issue in the Uruguay Round of the GATT and later in the World Trade Organization (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) (Ryan 1998).

However, because of the vagueness of both domestic and international intellectual property regimes, many bilateral disputes over intellectual property have occurred in recent years. For this reason, the U.S. government has concluded a number of bilateral reciprocity agreements with other countries that protect software programming and chip mask works on substantially the same basis as in U.S. domestic law (Leaffer 1991; West 1995). Such U.S. initiatives, because of their essentially unilateral nature and the claims of target governments that the United States is violating their sovereign right to decide for themselves what intellectual property laws to enact and enforce, lead inevitably to clashes between systems—system friction as Sylvia Ostry calls it (Ostry 1996; Bergsten and Noland 1993; Tyson 1992).

A combination of economic and power political theories helps us understand the power implications of intellectual property protection. Intellectual property disputes have sometimes become the basis for power struggles between national governments. For example, the U.S. government has been pressuring the government of the People's Republic of China to adopt stricter intellectual property laws and to enforce them. The U.S. government has tried to persuade the Chinese government to change its legal regime for reasons of Chinese self-interest (e.g., to promote the growth of indigenous software firms), but it also has used coercion to the extent that it made stricter enforcement a condition for continuing most favored nation (MFN) trade status and U.S. support for Chinese entry into the WTO.

Beyond the relational power dimension, however, we would like to call attention to a deeper structural dimension of intellectual property issues (what Stephen Krasner calls "meta-power issues"). According to Krasner, ". . . relational power behavior refers to efforts to maximize values within a given set of institutional structures; meta-power behavior refers to efforts to change the institutions themselves ... [and] ... the ability to change the rules of the game" (1985: 14). International intellectual property regimes are not a given but rather must be periodically redefined by the actors themselves, while interpreting their material interests and circumstances. In her recent work, Susan K. Sell pays attention to the role of ideas—in relation to power—in helping actors to define their material interests within intellectual property regimes (1998).

In a similar vein, Joseph S. Nye's concept of *soft* power also provides a useful framework for understanding the structural dimension of intellectual property disputes (1990). Soft power is the ability to achieve desired outcomes in international affairs through attraction rather than coercion. It works by convincing others to follow, or getting them to agree to, norms and institutions that produce a desired behavior. Soft power can rest on the appeal of ideas themselves or on the ability of certain actors to set the agenda in ways that shape the preferences of others. In a related vein, Susan Strange argues 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" (1988, 123). International intellectual property regimes are concerned with protecting the ability of individuals and private firms to influence the values and beliefs of others by means of ideas rather than tangible products—that is to say ideational power—and therefore must be a component of any discussion of either soft power or structural power in the contemporary international system.

Along with standards initiatives and intellectual property protection, the success of Wintel has also been based on its ability to introduce successive product innovations—the third ingredient of Wintel's success. Architectural leaders can perpetuate their market positions only if they continually offer new improved products that are compatible with older subsystems. In fact, Intel and Microsoft continuously renew their products in order to sustain their control over the PC industry. Intel's ability to maintain its leadership in the microprocessor industry lies in its ability to maintain continuity across successive product generation while at the same time greatly increasing the processing speed of its microprocessors. Microsoft has also frequently made incremental improvements and occasionally introduces major advances in its products.

A fundamental root cause of this dramatic speeding in product change has been the astonishing rate of improvement in the performance of semiconductors and software. For example, according to Moore's Law, the capacity of microprocessors and memory devices doubles roughly every eighteen months while the price per operation stays the same (Moore 1996; Schaller 1997). As a result of this steady and rapid technical progress, a seemingly endless stream of new personal computers is constantly being introduced. Each new introduction seems to bring greater functionality for roughly the equivalent prices of its predecessor, while the value of earlier models drops dramatically. As Martin Kenney argues, "as value is being created more quickly, it is also being destroyed more quickly . . . the economy is obsolescence-based" (Kenney 1996). The rapid obsolescence of successful knowledge-intensive products, often accelerated by the new products developed and introduced to the market by the original innovators, is often cited as a contemporary example of Schumpeterian *creative destruction* (Schumpeter 1950).

Microsoft and Intel have managed to subtly balance the three strategies of being aggressive in diffusing standards, innovative in periodic improvement of products, and fiercely protective of intellectual property rights. There is an unavoidable trade-off among these three strategies, since, for example, too aggressive protection of intellectual property can result in slower diffusion of standards. We will argue below that one important role for public policy is to make sure that aggressive protection of intellectual property does not become an impediment to market growth or market entry by potential competitors.

The dynamics of technological competition are not determined solely by the actors' material capabilities in production and innovation. The competition is as much about structural power as it is about material power. This new form of structural power also changes the nature of competition over material resources by privileging certain types of technological knowledge in the broader international competition for resources.

Stefano Guzzini's recent work on power, which implicitly assumes a constructivist stance, provides a useful framework for synthesizing our discussion of material power vs. structural power.' Guzzini focuses on the interaction between agent *power* and structural *governance,* saying that "power lies both in the relational interaction of agents and in the systematic rule that results from the consequences of their actions.... power analysis, as the comprehensive account of power phenomena, must call into question the relationship between the different forms of power and of governance" (1993, 471-4).

Obtaining control over key material resources is a primal reason for exercising power. Any cultural, institutional, or normative developments that improve the efficacy of those resources should logically also become targets for attempts to acquire power. As Guzzini suggests, therefore, "two strategies are possible to improve one's potential power in a given situation: to cause either a quantitative improvement of the relevant situational power resources or a change in the environment that defines the situationally relevant power resources" (1993, 455-6). The question arising here is how to improve both resources and environment material power as well as structural power in our terms—in a specific issue area, for example the global computer industry. To answer this question, we turn now to the role of industrial and governmental institutions.

THE RISE OF WINTELISM AND DECENTRALIZED GOVERNANCE

The rise of architectural competition pressures firms and governments everywhere not only to adjust to the new principles of competition, but also to reconsider their institutional environment to adjust better to technological and competitive changes. We will argue that modifications in American institutions in response to increased competition from other industrialized countries (especially Japan) helped to assure the success of Wintelism and the resurgence of the U.S. industrial competitiveness. In this section, we focus on two levels of governance: industrial governance structures and state-societal arrangements.

HORIZONTAL INDUSTRIAL GOVERNANCE

Industrial *governance* is defined mainly in terms of corporate and industry structure. Types of corporate governance can be distinguished by observing the characteristics of firms and industries: for example, whether coordinating networks are

organized vertically or horizontally. Those characteristics include the size of the industry, the organizational structure of firms, the degree of concentration of ownership, the level of inter-firm coordination, the degree to which user-producer (or manufacturer-supplier) links are utilized by firms in the industry, and the presence of national or cross-national production and distribution networks.

The pattern of integration among industrial units in the U.S. computer industry is horizontal. The so-called Silicon Valley model typifies the horizontal governance structure (Ferguson and Morris 1994). The Silicon Valley model encourages horizontally focused and non-bureaucratic corporate structures. In architecturally contending companies like Microsoft, for example, architectural competition permits many systems and organizations to be developed independently and still work together gracefully. It also permits dean separation between centralized general-purpose functions and decentralized or specialized functions, and enables management of unpredictability and change (Ferguson and Morris 1994; Cusumano and Selby 1995; Cusumano and Smith 1997).

The competitive structure of the U.S. computer industry is also being transformed from one of an oligopoly dominated by large vertically integrated firms to something else. The PC industry from its earliest beginnings adopted a horizontal supplier structure, consisting of competing PC assembler firms. Companies such as Intel, Microsoft, Novell, Lotus, Compaq, Seagate, Oracle, 3Com, Electronic Data Systems, and many others all thrived by being specialists in particular layers of a newly emerging information technology industry value chain. All these firms were integrated in a horizontal way—not vertically as the older mainframe computer companies were—and formed regional production networks in Silicon Valley (Borrus and Zysman 1997; Cringely 1993; Saxenian 1994).

In the horizontal industrial structure, a handful of companies supplying components to PC assemblers came to define and control the system's critical architectures, each for a specific layer of the system. For example, Borrus and Zysman hold,

> Market power has shifted from the assemblers—such as Compaq, Gateway, IBM, or Toshiba—to key producers of components (e.g., Intel); operating systems (e.g., Microsoft); applications (e.g., SAP, Adobe); interfaces (e.g., Netscape); languages (e.g., Sun with Java); and to pure product definition companies like Cisco Systems and 3COM (1997, 150).

This shift in market power is suggested in the advertisements of PC producers like IBM, Toshiba, Compaq or Siemens-Nixdorf. Their systems are nearly identical and emphasize components or software that have become de facto market standards—Intel Inside and *Microsoft* Windows Installed—rather than unique features of their own brands.

Another important point is that the horizontal supplier network in the electronics industry reaches to the global arena. To describe the global production networks, Borrus and Zysman (1997) adopt the concept of Cross National Production Networks (CPNs). CPNs refer to the disintegration of the industry's value chain into constituent functions that can be contracted out to independent producers wherever those companies are located in the global economy. CPNs now affect the entire global electronics industry. Moreover, CPNs express the reduced need for companies to control production through ownership or direct management of each piece of the value chain.

Indeed, Wintelist strategies of relying on product standards control and intellectual property protection facilitate the rise of global crossnational production networks. A given firm can more easily subcontract production, even across national boundaries, without worrying about the possibility that contract suppliers will develop competitive technologies because that firm can still dominate the market for critical systems elements through setting de facto market standards. Wintelism creates a whole range of market opportunities for de facto standards holders in sectors that were previously dominated by giant assemblers.

THE MODIFIED REGULATORY STATE

State *governance* is mainly defined by the industrial role of the state. The so-called strength of the state—the capabilities of government agencies and other national political institutions in relation to the business sector, including mechanisms of state penetration into society—or state-societal arrangements—defined in terms of the distribution of power among the state, the private business sector, and organized labor—is often considered to be a critical factor for understanding the nature of state governance (Hart 1992). More specifically, the industrial role of the state is embodied as industrial policy, which refers to the deliberate attempt by the government through a range of specific policies such as financial subsidies, trade protectionism, promotion of R&D, and procurement to determine the structure of the economy (Johnson 1982).

The U.S. state is often considered to be a regulatory state; it is frequently contrasted with the developmental states of East Asia—particularly of Japan and South Korea—that intervene directly in industrial matters and try to direct investment into high priority areas.' Nevertheless, the U.S. government has intervened in certain industries where there is a clear national security or public goods rationale. For example, as an advanced user and R&D sponsor, the U.S. government made important contributions throughout much of the history of computer industry—but particularly in the early period.

The so-called first-mover advantages of the American computer industry were generated not only as a result of commercial activity but also by government R&D policies, often through the Defense Advanced Research Projects Agency (DARPA) (Flamm 1987, 1988). The defense-oriented (or mission-oriented) R&D policy of the postwar U.S. government, which included substantial public funding of basic computer science research in universities, was very important in establishing the technological basis for the computer industry (Ergas 1987). The technologies created in some military programs were spun off into commercial computers; this largely unplanned diffusion and sharing of technology resulted in first mover advantages for the American computer industry. IBM's entry into electronic computers, for example, was largely underwritten by military contracts (Alic 1992; Sandholtz et al. 1992).

However, in order to understand the evolution of U.S. government policies toward the computer industry, we need to look beyond the boundaries of what is considered industrial policy—i.e., industrial targeting, subsidies and R&D programs. Industrial policy is designed to help specific industries to achieve and/or maintain global competitiveness. The regulatory pattern of government policy in the U.S. computer industry, which relied on macroeconomic policies, antitrust enforcement, and vigorous Intellectual Property Rights protection, was more important for the growth of that industry than any industrial policy. In particular, we should note that there are two types of important regulatory government policies for the PC industry.

The U.S. government, by strictly enforcing antitrust and fair competition laws, made important, but often largely unrecognized, contributions to the rise of Wintelism. U.S. enforcement of antitrust and fair trading laws in the 1960s led to IBM's unbundling of hardware and software sales, which was central in encouraging value-chain specialization in the computer industry and fostering the growth of both the semiconductor and packaged software industries (Mowery 1994; Mowery ed. 1996). Indeed, the policy-induced emergence of computer component suppliers began subtly to undermine the logic of competition rooted in economies of scale and vertical control of technology. They helped to create the foundation for the emergence of Wintelism.

During the 1980s and early 1990s, the United States government seemed to be relaxing its antitrust policies, especially in sectors with strong R&D and strong foreign competition, and owners of intellectual property rights benefited from a more benign judicial attitude (Merges 1996). Recent actions against Intel and Microsoft taken by the U.S. Department of Justice and the Federal Trade Commission suggest a revival of interest in stricter enforcement of antitrust and fair trading laws.

The U.S. government has also played a major role in promoting Wintelism by defining and protecting the intellectual property rights of major firms. The U.S.

government has long recognized the importance of protecting intellectual property in industry as a way of encouraging technological innovation. Intellectual property is seen as a key asset for modem corporations with very important ramifications for industrial strategy and structure. Merges holds,

> Intellectual property determines the degree of legal shelter an incumbent can count on. Strong protection, like a brick wall, protects such an incumbent from the winds whipped up by potential entrants, while weak protection is more like a tent it helps but cannot be relied on when the winds get too strong (1996: 285).

The legal development of computer program-related intellectual property laws suggests that the United States has adopted a strong protection regime for computer hardware as well as software.

GOVERNANCE STRUCTURES IN SOFTWARE ELECTRONICS

Success or failure in software electronics basically depends on the match between the architectural technological competition of the industry and national institutional arrangements, as argued at the beginning of this essay. The technological properties of software electronics—a loosely coupled system with high causal complexity—are consistent with the rise of horizontal industrial governance, as seen in the U.S. PC industry and in the Silicon Valley model. The properties of software electronics are also consistent with a modified regulatory relationship between the government and other economic actors.

Industrial governance structures in the U.S. computer and software industry approximate a flexible form that blends competition and cooperation in order to cope with the unique innovative patterns of software electronics: large R&D costs, trial and error research yielding fast paced breakthrough-type innovations, and inexpensive copying and distribution of digital media. Small venture capitalists invest in those nodes of the innovation network in which causal relations are sufficiently well understood. Also, rapid innovative patterns in software electronics is likely to give large corporations with decentralized structures an advantage over more centralized research arrangements—like cooperative R&D consortia—in developing new products and in bringing them to the marketplace.

In cases where R&D uncertainties are substantial, a comprehensive *public and semipublic* infrastructure of technological development through universities and public research centers plays a critical role. For example, the defense-oriented industrial policy of the postwar U.S. government, which included substantial public funding of basic computer science research in universities—without any dear industrial applications—has been more successful in establishing a strong domestic industry than interventionist forms of industrial policy in other countries. Moreover, the regulatory role of the U.S. government to provide a competitive market situation has been working as a political foundation for the success of the industry.

This characterization of governance structures in the U.S. computer industry parallels in important ways the general features of the American system of political economy. Robert Gilpin argues,

> Corporate governance in the United States is characterized by extensive fragmentation and an overall lack of policy coordination at both the national and, to a lesser extent, the firm level. As in the case of the government, a primary motive behind this fragmentation of corporate organization is to prevent the concentration of power. . . . the American system fits the neoclassical model of a pure competitive model based on price competition and in which firms seek to maximize profits (1996, 419-20).

In cases where countries already have elements of appropriate governance structures fitted into technological properties of software electronics within their existing national institutions, there are more possibilities that technological success will be achieved within a framework of ***path-dependent learning*** **(Hart and Kim** 1998). In this sense, the U.S. computer industry benefited enormously from existing governance structures conducive to software electronics innovations. The U.S. case shows that, when following the process of path-dependent learning, the initial costs of entering new electronics technology markets are quite modest and therefore even relatively small firms will be able to respond to new opportunities quickly.

The American science and technology (S&T) infrastructure may be uniquely well suited for architectural competitions in new technologies. According to Margaret Sharp, S&T infrastructure involves high quality secondary education, a good vocational training system, a strong university sector, a well-funded academic research base with a major postgraduate component, university-industry linkage, research associations that support technology dissemination to small and medium-sized businesses, and the encouragement of regional initiatives bringing together firms, universities and research institutions (1997, 101). Indeed, the role of a social, cultural or institutional infrastructure in producing human resources and technological knowledge gains attention especially in software electronics.

The domestic system of higher education in the United States, for example, appears to provide a much thicker basis of appropriate human resources for software electronics than those in Japan or Europe. The structure of American higher education systems also has closer links with government-funded research in the computer sector. American Universities have maintained closer relationships with corporations in producing and sharing technological knowledge. In fact, the organizational and disciplinary flexibility of U.S. universities in computer science has not been matched in many of the other economies. This S&T infrastructure has been supported by the unique American technological culture encouraging breakthrough-type and creative but risky innovative attempts in software electronics (Mowery 1996, 306-307; Nelson 1998, 321).

To conclude, the U.S. success in creating Wintelism provides a better explanation of the recent resurgence of U.S. international competitiveness. In effect, the rise of Wintelism enabled U.S. firms to pioneer the new rules of the game in the global computer industry: ones that grew out of the distinctively American market environment and were adapted to overseas opportunities. In the PC industry, for example, U.S. firms lead the industry overall and also dominate many segments including complete systems, microprocessors, operating systems, and packaged applications (Dedrick and Kraemer 1998, 58). United States firms were able to set global standards because they not only had the ability to maintain and expand their spheres of control, but also were supported by (and adjusted to) the American system of political economy.

CONCLUSIONS

The development of software electronics gave rise to a new mode of technological competition where control over architectural standards became more important than advanced manufacturing capabilities. We have tried in this essay to argue that the success of the Wintel coalition—Microsoft and Intel—in the global PC market is an indication of the rise of a new mode of technological competition called Wintelism that is much broader in scope (Wintelism writ large). We claimed that an assessment of the political implications of Wintelism requires a definition of power that goes beyond the conventional understanding of power in terms of control over material resources. Wintelist firms have concentrated on a set of strategies—creative use of technical standards and intellectual property rights, backed by accelerated innovations—that enabled them to define the rules of the game in horizontal markets. They became hegemonic in their horizontal niches. The dominance of technological architectures characteristic of Wintelism is therefore a form of structural power.

This horizontal hegemony poses very interesting problems for governance at the level of the national government. Should national governments promote horizontal hegemony in the name of international competitiveness (as Bill Gates so urgently argues is necessary) or should they enforce their antitrust and competition laws and break up horizontal monopolies to prevent predatory pricing and unfair trade practices? Should they fund new R&D projects proposed by horizontal hegemons or should they preferentially fund small challengers to those hegemons?

Relying on the previous work of Herbert Kitschelt, we argued that innovations in software electronics, a loosely coupled technological system with high causal complexity, are consistent with horizontal industrial governance structures and a modified regulatory state. The regulatory state in the United States has been modified slightly to make it possible to produce a large number of high quality computer professionals and to permit dose university-industry linkages for creative research. From time to time, the U.S. government condones industrial targeting. For example, the creation of R&D consortia like Sematech for the semiconductor industry was permitted as an exception to the general rule of avoiding direct interventions in industrial development.

As described above, Wintelism was born in the transition from the mainframes to PCs in the computer industry and as a response to increased competition from Japan in the 1980s; but we are now observing another transition in the computer industry. Since the early 1990s, there have been signs of the growing importance of a combined computer and telecommunications industry that increasingly revolves around global network infrastructures (Moschella 1997). As this network-centric era begins, the prospects for new market leaders and new types of power are once again topics of speculation.[6] The critical question that arises here is whether the current shift toward networked computers will result in the same kinds of fundamental changes across a wide range of customer, technology, distribution, sales, marketing, and supplier businesses that characterized the rise of Wintelism or whether Wintelism will simply adapt itself to the increased importance of network computing.

NOTES

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1. Please note the parallels between our argument on this subject and those of Braman, Comor and Deibert in this volume.

2. Based on this new conceptualization of technology, we can attempt to go beyond the inherited and limited view of technology as easily transferrable, proprietary knowledge. We propose a more complex concept of technology that includes technical standards, intellectual property rights, norms, craft knowledge, and embedded institutions and culture. Hart and Kim (2000) coined a new term, technoledge, compounded from technology and knowledge, in order to emphasize this new and more complex conceptualization of technology.

3. Concerning the architectural dominance and business strategies of Intel and Microsoft, there are many well-documented works. For example, for the rise of Intel and Microsoft in the context of IBM's collapse, see Chposky and Leonsis (1988), Carroll (1993), and Ferguson and Morris (1994). Concerning Intel and its microprocessor business, see Moore (1996) and Jackson (1997)- Concerning Microsoft and Bill Gates, see Wallace and Erickson (1992), Ichbiah and Knepper (1992), Manes and Andrews (1993), Cusumano and Selby (1995), Stross (1996), and Wallace (1997).

4. International theorists are recently thinking more about the larger set of norms, rules, and structures, which have governed international systems. For example, works by IR theorists, such as Alexander E. Wendt (1987 1992), in the tradition of social constructivism, have taken their cues from Anthony Giddens's structuration theory in sociology (1984). In the most recent work in this tradition, the constructivists have made the formation of identities and social norms a key question for research (Katzenstein, ed. 1996).

5. See the essays by Aronson, McDowell, and Zacher in this volume for further discussion of the differences among the advanced industrial nations in their approaches to regulating the computer and telecommunications industries.

6. See the essays by Aronson, Singh and Zacher in this volume for further discussion of the impact of network technologies.

REFERENCES

Alic, John A. et al. 1992. Beyond *Spinoff:* Military and Commercial Technologies in a Changing World. Boston: Harvard Business School Press.

Bergsten, C. Fred, and Marcus Noland. 1993. Reconcilable Differences?: United States-Japan Economic Conflict. Washington D.C-: Institute for International Economics.

Borrus, Michael and John Zysman. 1997. Globalization with Borders: The Rise of Wintelism as the Future of Global Competition. Industry and Innovation. 4(2).

Carroll, Paul. 1993. Big *Blues:* The Unmasking of IBM. New York: Crown Trade Paperbacks.

Chang Jr., Ike Y. 1994. The Economics of Dominant Technical Architectures: The Case *of the* Personal Computer Industry. Santa Monica, CA: RAND.

Chposky, James, and Ted Leonsis. 1988. Blue Magic: The People, *Power* and Politics *Behind* the IBM Personal Computer. New York: Facts on File.

Clapes, Anthony L. 1993. Softwars: The Legal Battles for Control *of* the Global Software *Industry*. Westport, Conn.: Quorum Books.

Cringely, Robert. 1993. Accidental Empires: How the Boys of Silicon Valley Make Their Million, Battle Foreign Competition, and Still Can't Get a Date. Reading, MA: Addison-Wesley.

Cusumano, Michael A. 1991. Japan's Software Factories: A Challenge to U.S. Management. New York: Oxford University Press.

Cusumano, Michael A., and Richard W. Selby. 1995. Microsoft Secrets: How the World's Most Powerful *Software* Company Creates Technology, Shapes Markets, and Manages People. New York: Free Press.

Cusumano, Michael A., and Stanley A. Smith. 1997. Beyond the Waterfall: Software Development at Microsoft. In David B. Yoffie, ed. Competing in the Age *of* Digital Convergence. Boston: Harvard Business School Press.

Dedrick, Jason, and Kenneth L. Kraemer. 1998. Asia's Computer Challenge: Threat or Opportunity for the United States & the World? New York: Oxford University Press.

Drucker, Peter F. 1993. Post-capitalist Society. New York: HarperBusiness.

Ergas, Henry. 1987. Does Technology Policy Matter? In Bruce R. Gile and Harvey Brooks, eds. *Technology* and Global Industry: Companies and Nations in the World Economy. Washington, D.C.: National Academy Press.

Ferguson, Charles H., and Charles R. Morris. 1994. Computer Wars: The Fall *of* IBM and the Future *of* Global Technology. New York: Times Books, Random House.

Flamm, Kenneth. 1987. Targeting the Computer: Government Support and International Competition. Washington, D.C.: The Brookings Institution.

Flamm, Kenneth. 1988. Creating the Computer: Government, Industry, and High Technology. Washington, D.C.: The Brookings Institution.

Fransman, Martin. 1995. *Japan's* Computer and Communications Industry: The Evolution *of* Industrial Giants and Global Competitiveness. Oxford: Oxford University Press.

Gabel, H. Landis, ed. 1987. Product Standardization and Competitive Strategy. Amsterdam: North-Holland.

Gabel, H. Landis. 1991. Competitive Strategies *for* Product *Standards*: *The Strategic* Use **of** *Compatibility Standards for Competitive* Advantage. London: McGraw-Hill.

Giddens, Anthony. 1984. The *Constitution of Society: Outline* **of** *the Theory of Structuration.* Cambridge, England: Polity.

Gilder, George. 1989. Microcosm: The Quantum Revolution in Economics and Technology. New York: Touchstone.

Gilpin, Robert. 1996. Economic Evolution of National Systems. International Studies Quarterly. (September) 40(3).

Grindley, Peter. 1995. Standards Strategy and Policy: Cases and Stories. Oxford: Oxford University Press.

Guzzini, Stefano. 1993. Structural Power: the Limits of Neorealist Power Analysis. International Organization. 47(3).

Hamilton, Marci A. 1997. The TRIPs Agreement: Imperialistic, Outdated, and Overprotective. In Adam D. Moore, ed. Intellectual Property: Moral, Legal, and International Dilemmas. Lanham, MD: Rowman & Littlefield.

Hansen, Hugh C. 1997. International Copyright: An Unorthodox Analysis. In Adam D. Moore, ed. Intellectual Property: Moral, Legal, and International Dilemmas. Lanham, MD: Rowman & Littlefield.

Hart, Jeffrey A. 1976. Three Approaches to the Measurement of Power in International Relations. International Organization. 30(2).

—. 1989. ISDN and Power. Discussion Paper 7, Center for Global Business, the Business School of Indiana University.

—. 1992. Rival Capitalists: International Competitiveness in the United States, Japan, and Western Europe. Ithaca: Cornell University Press.

Hart, Jeffrey A. Hart, and Sangbae Kim. 1998. Technological Capacity as Fitness: an Evolutionary Model of Change in the International Political Economy. Paper prepared for delivery at the conference on Evolutionary Perspectives on International Relations, Bloomington, IN. (December 4-6)

—. 2000. Power in the Information Age. In Jose V. Ciprut, ed. Of Fears and Foes: Security and Insecurity in an Evolving Global Political Economy. Westport, Conn.: Praeger.

Ichbiah, Daniel, and Susan L. Knepper. 1992. The Making of Microsoft: How Bill Gates and his Team Created the World's Most Successful Software Company. Rocklin, CA: Prime Pub.

Jackson, Tim. 1997. Inside Intel: Andy Grove and the Rise of the World's Most Powerful Chip Company. New York: Dutton.

Johnson, Chalmers. 1982. MITI and the Japanese Miracle: The Growth of Industrial Policy 1925-1975. Stanford: Stanford University Press.

Katzenstein, Peter J., ed. 1996. The Culture of National Security: Norms and Identity in World Politics. New York: Columbia University Press.

Kenney, Martin. 1996. The Role of Information, Knowledge and Value in the Late 20th Century. Working Paper.

Kitschelt, Herbert. 1991. Industrial Governance Structures, Innovation Strategies and the Case of Japan: Sectoral or Cross-National Comparative Analysis. International Organization. 45(4).

Krasner, Stephen D. 1985. Structural Conflict. Berkeley: University of California Press.

Leaffer, Marshall A. 1991. Protecting United States Intellectual Property Abroad: Toward a New Multilateralism. Iowa Law Review. 76.

Manes, Stephen, and Paul Andrews. 1993. Gates: How Microsoft's Mogul Reinvented an Industry and Made Himself the Richest Man in America. New York: Doubleday.

Merges, Robert P. 1996. A Comparative Look at Intellectual Property Rights and the Software Industry. In David C. Mowery, ed. The International Computer Software Industry: A Comparative Study of Industry Evolution and Structure. New York: Oxford University Press.

Moore, Adam D., ed. 1997. Intellectual Property: Moral, Legal, and International Dilemmas. Lanham, MD: Rowman & Littlefield.

Moore, Gordon E. 1996. Intel: Memories and the Microprocessor. Daedalus. (Spring) 125(2).

Morris, Charles R., and Charles H. Ferguson. 1993. How Architecture Wins Technology Wars. *Harvard Business Review.* (March-April)

Moschella, David C. 1997. *Waves of Power: Dynamics of Global Technology Leadership, 1964-2010.* New York: AMACOM.

Mowery, David C. 1994. *Science and Technology Policy in Interdependent Economics*. Boston: Kluwer Academic Publishers.

Mowery, David C., ed. 1996. *The International Computer Software Industry: A Comparative Study of Industry Evolution and Structure.* New York: Oxford University Press.

Nelson, Richard R. 1998. The Co-evolution of Technology, Industrial Structure, and Supporting Institutions. In Giovanni Dosi, David J. Teece, and Josef Chytry, eds. *Technology, Organization, and Competitiveness: Perspectives on Industrial and Cmporate Change.* Oxford: Oxford University Press.

Nye, Jr. Joseph S. 1990. Bound to Lead: The Changing Nature of American Power. New York: Basic Books.

Ostry, Sylvia. 1996. Policy Approaches to System Friction: Convergence Plus. In Suzanne Berger and Ronald Dore, eds. National Diversity and Global Capitalism. Ithaca and London: Cornell University Press.

Rosenberg, Nathan. 1982. *Inside the Black Box: Technology and Economics*. Cambridge University Press.

Ryan, Michael P. 1998. Knowledge Diplomacy: Global Competition and the Politics of Intellectual Property. Washington, D.C.: Brookings Institute.

Sandholtz, Wayne, Michael Borrus, John Zysman, Ken Conca, Jay Stowsky, Steven Vogel, and Steve Weber. 1992. *The Highest Stakes: The Economic Foundations of the Next Security System.* New York: Oxford University Press.

Saxenian, Annalee. 1994. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128.* Cambridge: Harvard University Press.

Schaller, Robert R. 1997. *Moore's Law: Past, Present, and Future*. http://www.cs.uoregon.edu/classes/ cis629/Readings/moore.htm.

Schumpeter, Joseph A. 1950. *Capitalism, Socialism and Democracy*. 3rd ed. New York: Harper and Row.

Sell, Susan K. 1998. *Power and Ideas: North-South Politics of Intellectual Property and Antitrust.* Albany: State University of New York Press.

Sharp, Margaret. 1997. Technology, Globalization, and Industrial Policy. In Talalay, Michael, Chris Farrands, and Roger Tooze, eds. *Technology, Culture, and Competitiveness: Change and the World Political Economy*. London and New York: Routledge.

Strange, Susan. 1988. *State and Markets-* London: Pinter.

Stross, Randall E. 1996. *The Microsoft Way: The Real Story of How the Company Outsmarts Its Competition-* Reading, MA: Addison-Wesley.

Toffler, Alvin. 1990. *Power Shift.* New York: Bantam Books.

Tyson, Laura D'Andrea. 1992. *Who's Bashing Whom?: Trade Conflict in High-Technology Industries.* Washington, D.C.: Institute for International Economics.

Wallace, James. 1997. *Overdrive: Bill Gates and the Race to Control Cyberspace.* New York: Wiley.

Wallace, James, and Jim Erickson. 1992. *Hard Drive: Bill Gates and the Making of the Microsoft Empire.* New York: HarperBusiness.

Wendt, Alexander E. 1987. The Agent-Structure Problem in International Relations Theory. *International Organization.* 41(3).

Wendt, Alexander E. 1992. Anarchy is What States Make of It: the Social Construction of Power Politics. *International Organization*. 46.

West, Joel. 1995. Software Rights and Japan's Shift to an Information Society: The 1993-1994 Copyright Revision Process. *Asian Survey*. 35(12).

Yoffie, David B., ed. 1997. *Competing in the Age of Digital Convergence.* Boston: Harvard Business School Press.