U.S. ANTITRUST POLICY, INTERFACE COMPATIBILITY STANDARDS, AND INFORMATION TECHNOLOGY

Thomas Hemphill
Strategic Management and Public Policy
The George Washington University

Nicholas Vonortas
Center for International Science and Technology Policy
&
Department of Economics
The George Washington University

Working Paper

September 2003

1. INTRODUCTION

Since the inception of the nation's seminal pro-competition statute, the Sherman Act of 1890, technology and the pace of innovation has been a major underlying consideration in the evolution of America's antitrust laws and policy (Mowery, 1992). We have also come to realize that technology standards affect further technological change and innovation (Tassey, 2000). While competition and standards-setting practices have traditionally been kept separate in the basket of the policy maker, the past couple of decades have witnessed a rapid increase in interest in their interaction, especially with regards to industries featuring strong network effects. In such industries, present and future competition can be shaped early in the life cycle of a technological trajectory through the definition of a dominant product design. When these industries are high tech with significant technological opportunities and a broad supporting role to other parts of the economy, the stakes are high: policy decision makers are bound to pay notice.

Antitrust policy is one factor among many that contributes to the capacity of a nation's innovation system. Other factors, for example, include research & development (R&D) manpower and spending, extent of patent protection, openness to international trade, and funding of academic research by the private sector (Stern, S., Porter, M., & Furman, J., 2000). However, the effects of antitrust law on R&D and industrial innovation are less direct than the other policy factors. According to David Hart,

> "[T]he (U.S. antitrust) law shapes industrial competition and the terms of cooperation among firms; these in turn influence firms' incentives to undertake R&D, to strive for productivity growth, and to bring new products to market. "Indirect," though, does not mean "unimportant." In some sectors, antitrust policy has been far more consequential for research and innovation than the federal R&D spending policies that have attracted far more attention from analysts and policymakers. As the funding and performance of scientific and technological activity increasingly shift into the private sector in the coming decades, the relative importance of antitrust policy will continue to grow." (Hart, 1998, p.XX)

To reinforce Hart's last assertion, the share of national R&D funding provided by industrial sources in the U.S. has doubled from one third to two thirds of the total between 1966 and 2000 (National Science Board, 2002). Not surprisingly, the importance of an effective antitrust policy to directly enhance the processes and mechanisms that make up the U.S. innovation system emerged in the decade of the 1980s, also reflecting the rapid evolution of the nation's high-technology business sectors competing in a global economy (Federal Trade Commission, 1996). The high-technology sector is estimated to contribute approximately 7 percent of U.S. gross domestic product (GDP), but these innovative technologies account for one-third to one-half of U.S. GDP growth and at least two-thirds of productivity growth.

Three broad technological areas have emerged the past couple of decades as "critical infrastructure" underpinning U.S. national competitiveness into the 21st century: information technology, biotechnology, and advanced materials. Yet, unlike the other

two, information technology (IT)[1] is a network-based industry, characterized by both demand side and supply side economies of scale: the more people use the industry's product the more desirable it becomes (network externalities); firms supplying components can lower average costs with volume in both hardware and software (Shapiro, 2001a). The anticipation of such economies offers tremendous incentives to establish or somehow control the technology standard, since they can not only keep becoming more and more competitive by achieving larger production runs, but can somehow "control" the destiny of component producers. Standards-setting takes on a pivotal role in such sectors because of consumer expectations and interoperability (Balto, 2000). In a network-based industry such as IT, however, market competition for standards may result in a *tipping* to an eventual "winner-takes-all" game. A firm or coalition of firms then enjoys product design monopoly or near-monopoly (often based on the ownership of intellectual property), until a path-breaking technology emerges to challenge the reigning standard.

There is, in other words, a very strong incentive for single companies and/or networks of companies in network-based industries to be the party that owns the "standard". All significant stakeholders try hard to maintain and strengthen it. In contrast, all other parties have a strong incentive to undermine it. So strong is this incentive that, sometimes, companies will choose to get into some ugly, resource-draining, cut-throat competitive actions trying to keep competitors and their designs into check. Put differently, chances are high in network-based industries that the absence of a formal procedure in standards-setting induces "standards wars" between stand-alone firms or between firm networks for imposing their preferred technology standard.

There are too problems with standards wars. First, absent communication between the "warriors", good companies are going to leave the market not because they do not have competitive technologies and good strategies but because they do not have deep enough pockets and chances for cross-subsidization. Second, standards wars do not necessarily result with the best technology as a winner. Shapiro and Varian (1999), for example have argued that the ability to "win" a standards war in information technology industries is dependent on intellectual property rights, control over an installed base of users, the ability to innovate, first-mover advantages, manufacturing abilities, strength in complements, and brand-name and reputation.

Sensing the dangers and uncertainties of standards wars, competitors may attempt to establish technological standards cooperatively. Establishing standards in IT sectors has, for example, become an important cooperative activity. This raises the risk of anti-competitive behavior. Antitrust authorities, caring for innovation, must remain alert. Timothy Murris, chairman of the Federal Trade Commission (FTC), said in a speech before the American Bar Association, Antitrust Section: "It is important to explore practices in the standards-setting area and the manner in which tensions between competition and intellectual property protection typically get resolved (Murris, 2001). A difficult task indeed, given the need for antitrust policy in the area of standards-setting and intellectual property rights to address two important questions (Shapiro, 2002). First, what are the limits on unilateral conduct that might allow a single firm to control a standard that would otherwise be open to all? Second, what are the limits on the co-operative activity permitted as part of the standards-setting process?

[1] XXXX Proper IT Definition XXXX

An additional layer of complication is introduced by the need to place antitrust policy and technology standardization issues in the broader perspective of national competitiveness: How does a national innovation system enhance national competitiveness in its network-based IT industries while ensuring harmony with antitrust policy and intellectual property rights? The question becomes important as the definition of the relevant market changes from the national to the global, in turn changing the perception of monopoly. One would think that it is not a national monopoly we are discussing anymore but the global monopoly: in theory, a company can monopolize one or more national markets without monopolizing the global market. What is then for the national (or regional) government to do with its national/regional antitrust jurisdiction? Moreover, doesn't any government become just another interest bearer, aligned much more closely with the interests of its domestic producers rather than the interests of the consumers of the world?

Under this predicament, many governments have chosen to intervene in important network-based industries like IT to assist "their" producers avoid bleeding standards wars and become the owners of dominant designs. The international high-definition television battles of the 1980s-1990s with heavy government involvement still resonate today. More recently, the mobile telephony has provided a visible standards playground. Failure to agree on domestic technological standards has been argued to be the reason why foreign firms, and not U.S. competitors, were able to capture both technological and market leads in the second generation of cellular telephony. In a recent RAND Institute policy paper focusing on national innovation policies, the nation's science and technology policy community recommended that the federal government "begin a systematic review of the process for setting technical standards considering both the potential importance and limitations of government involvement" (Popper and Wagner, 2001). The report goes on to suggest that the federal "government has a significant trade policy role to play in seeking to make certain that cross-national efforts at harmonization of standards does not come at the expense of U.S. interests." Furthermore, the experts surveyed for the policy paper concluded that the public sector "has a potentially crucial indirect role to play as a convenor and provider of auspices for fostering earlier discussions of standards among and within industry groups."

The rest of this paper deals with the relationship between technology standards – interface compatibility standards, in particular – and competitive considerations in information technology industries. Following a background section asking whether there are any factors intrinsic to network industries that strengthen the bond between compatibility standards and competition, the paper appraises the relationship between standards-setting procedures in IT industries in the United States and antitrust legislation and policy. To the extent of the previous answer, the paper then sets forth suggestions for policy rectification.

2. BACKGROUND: ANTITRUST AND STANDARDS

2.1. Technical Definitions and Explications

According to Tassey (2000), the process of standardization is the pursuit of conformity of all elements of products, processes, formats, or procedures that make up an *industry standard*, with the objective of increasing the efficiency of economic activity. A "standard" is a set of characteristics or quantities that describes features of a product, process, service, interface or material (Breitenberg, 1987). A standard denotes a uniform set of measures, agreements, conditions, or specifications between parties; the latter may be buyer-seller, manufacturer-user, government-industry or government-governed, retailer-manufacturer-consumer, or any other parties (Spivak and Brenner, 2001). Industry standards ("standards" hereafter) are classified under two categories: interface compatibility standards (David, 1987) and product standards (Afuah, 1998). Interface compatibility standards are dimensional, timing or other specifications that allow two or more components to work together. A product design standard emerges when one of a variety of products beats out competing designs to become the most common in the industry; this is also referred to as a *dominant design*. According to Utterback (1994), a dominant design "in a product class is the one that wins the allegiance of the marketplace, the one that competitors and innovators must adhere to if they hope to command significant market following." Standards are of three types: *open standards* are published and freely available (often times on a fee-basis); *closed standards* are not readily available; and *proprietary standards* are owned by an entity, and are neither "open" nor "closed" (Robinson, 1999).

The business and economics literature has made frequent references to the positive effects of standards: they promote market efficiency and expansion; foster international trade; encourage competition and lower barriers to market entry; speed diffusion of new technologies; protect consumers against unsafe or unsubstantiated products; and enable interoperability among products (Hebner, 1998). The negative economic consequences of a lack of standards include raising transaction costs and barriers to trade, constraining innovation and entrenching inferior technologies, and hindering the development of interoperable systems (Hebner, 1998). From the perspective of the firm, indeterminate standards can raise operating costs, compromise product quality, and negatively impact its market position (Hebner, 1998). Contrarily, Robinson (1999) sees drawbacks to firm participation in standards-setting processes, including cost to the company, loss of market control, and potential imposed conditions. He also believes that formal standards are of reduced consequence where there is a radical innovation well protected by patents.

More generally, the important policy debate is between establishing interface compatibility standards early in the lifecycle of a product family or late. The benefits of early standards listed above are the outcome of the decreased technological uncertainty that standards introduce. The greatest drawback of early standards is the possibility of locking-in to a sub-optimal technological trajectory. The reverse argument applies to late

standards-setting processes. They allow more time to reach optimal designs but protract technological uncertainty and splinter markets.

2.2. U.S. Antitrust Law and Technology Standards

The U.S. antitrust laws have traditionally been unconcerned with competitors meeting to discuss such so-called "neutral" topics as establishing industry safety standards (Shenefield and Stelzer, 1999). The overwhelming majority of U.S. case law is concerned with issues related to quality and performance standards and focuses on the legality of the organizational standard-setting process (Anton and Yao, 1995). There is precious little case law focusing on interface compatibility standards and the outcomes of cooperative standard-setting (Shapiro, 2001a).

One recent private antitrust case challenging a cooperative effort to establish compatibility standards is *Addamus Corporation v. Open Software Foundation, Inc.* 888 F. Supp. 274 (1995). This unsuccessful case, involving an industry consortium formed to develop a platform-independent version of the UNIX computer operating system, was cited by some antitrust and national competitiveness scholars as having a potentially "chilling" effect on encouraging the creation of standards-setting consortia (Federal Trade Commission, 1996). Reacting to antitrust concerns raised by many academic scholars and representatives of the business community about competitor collaborations, the U.S. Department of Justice (DOJ) and the Federal Trade Commission (FTC) issued antitrust guidelines to assist the American business community in establishing and operating legal alliances and joint ventures, including standards-setting consortia focused on alleviating technology compatibility issues (U.S. Department of Justice and Federal Trade Commission, 2000). Such consortia are analyzed under the *rule-of-reason* process to determine their overall competitive effect. The antitrust agencies recognize that consumers may benefit from competitor collaborations in a variety of ways. For example, in the case of a standards development consortium in a network industry, it may enable participants to offer products or services that are less expensive, more valuable to consumers, or brought to market sooner than would be possible absent the collaboration.

Antitrust issues have emerged recently in relation to attempts to influence the development of standards for which a firm or group of firms hold relevant intellectual property rights (Murris, 2001). For example, in *Dell Computer Corp.*, Dkt. C-3658, 121 F.T.C. 616 (1996), Dell was alleged to have threatened to exercise undisclosed patent rights against other computer firms adopting the VL-bus standard, a mechanism designed to transfer data instructions within a computer's operating system and peripherals. During the standards-setting process, the Video Electronics Standard Association asked its members to certify whether they had any patents, trademarks, or copyrights that conflicted with the V-L bus standard. Dell certified that it had no such intellectual property rights. The agreement on the standard was predicated on representations by the participants that none of the participating firms held intellectual property rights that might block others from developing towards the standard, or that any rights that might impinge on the standard would be licensed at a reasonable cost (Balto, 2000). To settle the FTC charges, Dell entered into a consent agreement not to enforce its patent rights against computer manufacturers complying with the established standard, nor to enforce in the

future any patent rights that it intentionally failed to disclose upon request of any standards-setting organization during the standards-setting process.

The problems associated with *hidden patents*, such as in the Dell example, result in what is referred to as *holdup*, whereby new products will inadvertently infringe on patents issued after these products were designed (Shapiro, 2001b). This patent enforcement, if the court finds the patent valid and infringed, could result in injunctive relief. The manufacturer is thus faced with the prospect of redesigning the product (possibly requiring a major disruption in production), being potentially liable for products sold that infringe on the patent, and being responsible for compatibility problems with other products or between different versions of this product (Shapiro, 2001b). Since the *Dell* settlement, many standards-setting organizations have considered strengthening their disclosure requirements, including requiring firms to determine whether the proposed standard conflicts with any existing intellectual property rights (Balto, 2000).

A new twist on the doctrine of "essential facilities" has also emerged in modern antitrust court cases (*Berkey Photo Inc. v. Eastman Kodak Co.*, 603 F.2nd 263 (2nd Cir. 1979), *cert. denied*, 444 U.S. 1093 (1980); *Image Technical Serv., Inc. v. Eastman Kodak Co.*, 903 F.2d 612, 616 n.3 (9th Cir. 1990), *aff'd*, 112 S.Ct. 2072 (1992)). According to Epstein (1998), an "essential facilities doctrine requires a firm with monopoly power in one market to deal equitably with competing firms operating in adjacent markets that depend on it for essential inputs." Traditionally applied to a physical facility (such as a railroad station) that a firm cannot obtain elsewhere (and may cause a "bottleneck" for the business operations of other firms in an industry), the essential facilities doctrine has been recently cited in the nature of technological knowledge. In this most recent application of the doctrine, the access required is in the nature of a connection to a "virtual" network, i.e., a network in which participants are linked together by their economic complementarity and adherence to common technological standards rather than by physical interconnection. "Essentialness," says Langlois (2001), is always an issue that speaks to *intrasystem* competition; consequently, the analysis of an essential facility will depend crucially on the degree of *intersystem* competition in the industry. An input crucial to a system that is one of many alternatives has a status different from that of an equally crucial input to a system that is the only alternative. Complementarity among subsystems and components is especially important in *modular systems* found in the IT industries. It is reasonable to assume that the technical standards embodied in a computer operating system may constitute an essential facility, and the IT industry will see future antitrust proceedings brought by competitors requesting reasonable access to these technological standards.

Another issue with a potential impact on standards-setting is the *patent thicket*, described by Shapiro (2001b) as "a dense web of overlapping intellectual property (i.e., patent) rights that a company must hack its way through in order to actually commercialize new technology." Such *blocking patents* create a situation in which IT standards-setting organizations may be required to obtain a multitude of technology licenses from a potentially large number of patent-owning firms, non-profits, and federal agencies to establish an interoperability standard. This is a modern variant of Cournot's classic theory of complements where a manufacturer of brass had to purchase two key inputs, copper and zinc, each controlled by complementary monopolists (Shapiro, 1989). The result was higher prices for the consumers of brass and lower profits for the

manufacturers. A similar situation exists today when multiple IT companies control blocking patents for a particular product or component needed to establish an interoperability standard.

A contractual response to the complements problem is found in *cross-licenses* and *patent pools* or *package licenses* (Shapiro, 2001b). Cross-licenses are negotiated when two companies have patents that affect each other's products or processes. Thus, instead of going to court to enforce a patent infringement or ceasing production, the two firms enter into a cross-license that eliminates the blocking patents. Under a cross-licensing system, firms operating in industries characterized by patent thickets are able to negotiate extensive cross-licensing agreements with other patent holders, sometimes on a royalty-free basis. Beard and Kaserman (2002) argue, however, that cross-licensing agreements between firms possessing substitute patents or engaging in downstream product market competition is at a most basic level, a horizontal agreement between competitors that ordinarily "fixes prices" for some products. In the case of a patent pool, two or more firms that control patents enter into an agreement where licenses are packaged, by one of the patent holders or a new entity, and made available to any firm willing to pay the associated licensing royalties. This creates an open standard. Patent pools are offered as one solution that standards-setting organizations can embrace to alleviate the effects of blocking patents on developing interoperability standards (Shapiro, 2001b). The *Antitrust Guidelines for the Licensing of Intellectual Property* (1995), issued jointly by the DOJ and FTC, describes cross-licensing and patent pools as "providing pro-competitive benefits by integrating complementary technologies, reducing transaction costs, clearing blocking positions, and avoiding costly infringement litigation." (U.S. Department of Justice and Federal Trade Commission, 1995).

All in all, the U.S. antitrust authorities (DOJ and FTC) view standards-setting organizations as integral to establishing interoperability and have strongly supported open and transparent standards-setting processes (Hart, 1998).

2.3. Network Industry Economics and Interface Compatibility Standards: Information Technology[2]

The IT sectors are subject to economic forces such as economies of scale, network effects, switching costs, lock-in, and system effects which affect the role of compatibility (interconnection) standards in determining who wins and who loses, on the one hand, and how the spoils of economic activity are distributed between stakeholders, on the other.[3]

Economies of scale: Economic theory expects most industries to run into diminishing returns because unit costs will eventually start to rise. Under such circumstances, no firm can dominate fully. Information, however, is expensive to produce but inexpensive to reproduce. High fixed costs and small, or negligible, variable costs lead to increasing returns to scale, breeding natural monopolies.

Network effects: There are direct and indirect network effects. Direct network effects are present when the demand for a good depends on how many other people purchase it.

[2] This section draws significantly on Varian (2001) and The Economist (2000).

[3] Space limitations do not allow discussion of other characteristics of IT markets such as the ability to price discriminate, bundle products, and version products.

Indirect network effects work through complementary products: the level of overall consumption of the product in question affects the availability of complementary products. Network effects result in positive feedback.

Switching costs and lock-in: High switching costs are endemic in high technology industries (e.g., a result of specialized supplies or network effects). When such costs are substantial, switching suppliers becomes virtually impossible. The ensuing situation of lock-in can be very profitable for firms.

The combination of supply-side economies of scale, network effects, and lock-in can be powerful and can strengthen a firm's grip on the market immensely: a newcomer must show a huge benefit to unseat the incumbent leader.

Several factors may moderate the negative effect on consumers:

- The mere race to grow and win customers will be probably based on offering lower prices to consumers to win them over. That is to say that, while traditional monopolies maximize profits by limiting quantity and raising prices, a company facing both supply and demand side scale economies will tend to do the opposite.
- If markets grow rapidly, the cost advantages of the largest firm may be overcome more easily.
- Prospective market entrants will try to invent around a patent or bypass other entry barriers.
- The complementarities underlying a lot of the network and lock-in effects may work against the tendency of charging the highest possible prices through a systems effect: producers of complementary products with an interest in lower prices can frequently exert significant pressure on the firm with the cost advantage to follow suit. Importantly, compatibility standards involve a form of complementarity in that they are designed to allow a seamless interconnection of components.

Relative firm size (or market share), then, may not be the most important issue as far as antitrust policy is concerned in information technology markets. Rather, the abuse of market power by a dominant firm to discourage innovation by others is. More than ever before, competitors (or prospective competitors) will try to take advantage of rapidly changing technology to unseat the leader. Sensing that, the leading company will have every incentive to fight back, partly by innovating faster itself (a good thing) but also partly by trying to stifle innovation by others to protect its monopoly position (a bad thing). *Antitrust authorities will need to watch out for cases where the scales tip toward the latter type of reaction. They must be extra careful when the abuse of monopolistic power relates to a technology platform, i.e., the basis on which many other complementary technologies are building (e.g., software operating system).*

Agreed compatibility standards have always allowed companies to attempt to create dominant technology platforms – and virtual dominant players sharing market power (a virtual, high-tech, contemporary type of cartel) – while bypassing the expensive (for producers) competitive race to win customers, mentioned above. If there is anything different with IT in this respect is speed of change: faster rates of technological advance raise the stakes by making it very desirable to producers to avoid costly competition on the platform, on the one hand, while depriving society (consumers) from the benefits that such intense competition entails, on the other. The benefits may include lower prices as well as potentially better technology platforms than the ones agreed early on. The counter

balance is, of course, the loss in consumer welfare due to the absence of a technology platform and the consequent network externalities.

It must be emphasized that the loss to consumer welfare from the lack of a standard technology platform can be pretty substantial if one: (a) considers that technological advance is endogenous to the system (i.e., very much influenced by economic incentives); and (b) keeps in sight the difference between innovation on technology platforms and product/process innovation in general. It can be argued, for example, that technological advance has elements of both risk and uncertainty. Risk means that prospective innovators have in their heads a distribution of likely events, and the question becomes which of those events will play out. Uncertainty means the lack of any such distribution. Companies thrive on risk; they loath uncertainty. If one is ready to argue, as many do, that technology platform standards take out a lot of uncertainty from the system, then, it would not be unreasonable at all to also argue that such standards could well speed up innovation rather than slow it down (within the specific technology platform standard, that is).

The antitrust policy question regarding standards in IT has, thus, yet to be settled. Nevertheless, we can be certain that, if the value of the network depends on its size, interconnection and standardization becomes a very important strategic decision: it allows a group of individually small (relative to the market) producers to quickly grow in (virtual) size and thus vie to dominate the market. Typically, dominant firms with established networks or proprietary standards prefer not to participate in such an exercise. Even larger market participants may come around to participate in a standard, however, when the standard becomes so compelling that the expected increase in total market value overcomes the possible loss of market share.

Following Besen and Farrel (1991) and Shapiro and Varian (1999), we can distinguish between three basic strategies in setting technology standards, also applying to IT (network) industries: standards negotiation, standards war, and standards leader.

- *Standards negotiation* is a “Battle of the Sexes” type of game: all agents are for adopting a standard, if it is their own. The agent with the highest bargaining power will typically manage to influence the outcome of the negotiation. Serious problems of mistrust are frequently handled by third party oversight of the negotiations. These may include government agencies such as the National Institute of Standards and Technology (NIST) or other national and international bodies such as the American National Standards Institute (ANSI) and the International Telecommunications Union (ITU).
- *Standards wars* refer to competitive strategies such as penetration prices, commitments to low future prices, expectations management regarding future market share or product announcements, and coalition building with complementors against rivals.
- *Standards leader* where a large, established firm maintains the standard with which smaller firms interconnect.

Given the high stakes in the case of IT (network) industries, which of the three basic strategies will be selected and how that will affect the competitive market outcome should be of utmost importance to all stakeholders.

3. STANDARDS-SETTING REGIMES IN U.S. IT INDUSTRIES

There are three principal types of standards development processes: 1) *de facto* standards; 2) *de jure* or voluntary consensus standards; and 3) *mandatory* standards (National Research Council, 1995). A *de facto* standard arises from uncoordinated processes in the competitive marketplace, such as when product or process specifications acquire authority or influence. A *de jure* standard arises from a formal, coordinated process in which key participants, e.g., designers, producers, consumers, corporate and government purchasing officials, and regulatory authorities, in a market seek formal consensus. A *mandatory* standard is established by government, either as procurement or regulatory standards. In the U.S., many government standards make reference to *de jure* standards in whole or part; thus, making such private, voluntary standards, in effect, mandatory.

Standards-setting institutional arrangements can be categorized on a spectrum ranging from market (private-sector) on the one extreme to non-market (government-sector) typologies on the other. In-between these polar opposites lie institutional arrangements emphasizing greater or lesser reliance on private- and public-sector coordination (figure I). Five institutional standards-setting typologies can be defined:[4]

- *Market.* This typology describes *de facto* standards developed through, for example, competitive market forces, *ad hoc* industrial consortia pooling resources to establish a technology standard, and unofficial standards-setting organizations.
- *Market/Non-Market.* This typology describes *de jure* standards established through formal standards-setting organizations. These standards-setting organizations involve limited government involvement, usually in an advisory capacity, e.g., technical or legal advice.
- *Market & Non-Market*. In this typology, the private-sector and public-sector are equally responsible for developing *de jure* technology standards.
- *Non-Market/Market.* This typology places primary responsibility for *de jure* technology standards-setting in the public-sector, with industry involved in a technical advisory capacity.
- *Non-Market.* This typology requires the public-sector to develop *de jure* standards mandated by law. The technical aspects of these standards can be

[4] In a related categorization, the Organization for Economic Cooperation and Development (1991) has defined four institutional models to describe national standardization systems:

Vertical Model. Monolithic government authority and a centralized government standards system characterize this model, popular in Eastern Europe, Russia, China, and many developing countries.

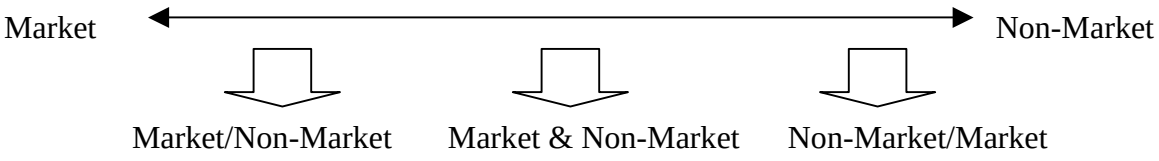
Centralized Model. In this model, there are strongly centralized national standards bodies and structure, which may be government agencies, or a number of private or quasi-governmental bodies closely linked by structural, contractual, or financial arrangements to the central government. Both Japan and Germany have institutional arrangements closely resembling this model.

Decentralized Model. This model represents a clear separation between the voluntary sector and the government sector in standards development, popular in Canada and, to a lesser extent, the U.S.

Horizontal Model. In this model, the coordination either is not as comprehensive as with the other standards models or has strong co-equal partners and has an extremely large base of standards developers. The U.S. has a standards-setting system that can also be characterized by this model.

influenced by the private sector in the public comment period required when regulations are being developed.

Figure I
Market/Non-Market Standards-Setting Framework



In terms of the typologies on Figure I, the U.S. standards-setting approach is best represented by the *market/non-market* typology, emphasizing private sector, formal institutional leadership combined with government technical advice.[5] Standards-setting in this country has typically taken place through formal standards-setting processes promulgated by voluntary standing organizations, including some 130 scientific and professional societies, 300 trade associations, and 40 standards developing organizations (*de jure* standards). The basic characteristic of such processes is a voluntary, industry consensus that involves diversified participants with varied objectives. Furthermore, procedures tend to be open with due process, public review, and authorization, communication easy, and standards readily available. More recently, American companies have also turned to alternative institutional mechanisms of co-ordination – 150 informal standards-setting bodies and groups that negotiate over product specifications (*de facto* standards) (David and Greenstein, 1990; Egan, 2002; Toth, 2001). The basic characteristic of informal standards-setting processes is that they are promulgated by relatively homogeneous industry consortia and user groups who are interested in expediency and near-term results, consequently ignoring or short-cutting traditional procedures.

Informal standards are further categorized as *proprietary* standards and *consortia* standards (Toth, 2001). When products or services of one company become widely accepted as "the standard" within a market, the result is a proprietary informal standard. There are two ways that these standards can emerge: first, proactively when a company or alliance strategically positions its products to expand market share and license to others (e.g., Microsoft Windows); and second, retroactively as end-result *de facto* standards when market forces designate one company's product as the standard from among equally effective competitors (e.g., VHS video format over Beta). Consortia standards are developed by *ad hoc* groups of suppliers or users, R&D consortia, and patent licensees. There are two ways that these standards can emerge: first, as strategic *de facto* standards when suppliers, and occasionally users, attempt to establish sufficient critical mass to define the standard or standards in a particular field (e.g., DVD Multimedia Disk); and second, as *ad hoc* variety-reduction standards when the application of industrial standardization principles has focused on reducing the number of

[5] The U.S. leads the world in established industrial standards with 85,000, with Germany trailing behind with 37,000 (Toth, 2001).

types, sizes, and kinds of parts, materials, and processes to realize cost-savings and improve productivity (e.g., U.S. Council for Automotive Research).

An example of an IT strategic *de facto* standards-setting arrangement is found in the development of the standardization protocol of the DVD Multimedia Disk. Throughout the 1990s, video hardware and software manufacturers sought a digital format to replace videocassettes. In order to avoid the debacle that was the Beta/VHS format standards war, hardware manufacturers led by Sony, Toshiba, and Panasonic, and film studios, led by Warner and Columbia, a division of Sony, worked together to establish a single standard for the DVD-Video and DVD-ROM (Gandal, 2002). Sony, Philips, Pioneer and seven other firms established the final standard specifications for the DVD-Video and DVD-ROM. These specifications also included rules, conditions and mechanisms for players to read the discs and convert them into images for screen display. The standard specifications implicate the intellectual property rights of a number of firms, including Philips, Sony and Pioneer. However, through a license from Philips, makers of discs and players that comply with the standard specifications are able to license these essential patents of Philips, Sony and Pioneer through a patent pool. (U.S. Department of Justice, 1998).

Common criticisms of formal standards-setting processes by industry representatives include that they are too political, too slow, and they do not choose the "best" technology (Shapiro, 2001a). Proponents of informal standards-setting processes laud the emphasis on near-term results and the lack of burdensome due-process procedures (Toth, 2001). Yet the long history of such organizations substantiates the claim that formal standards-setting is critical in launching new technologies (Shapiro, 2001a). An example is the International Telecommunications Union (ITU) which has been instrumental in establishing international standards for the IT sector since the late 19th century. In the U.S., the Telecommunications Industry Association communicates standards concerns to the U.S. Department of State, which formally represents U.S. business interests to the ITU, an agency of the United Nations since 1947. In response to industry criticism, the ITU has overhauled its standards process over the last decade; an average standard which took 4 years to develop ten years ago can now be produced in as little as nine months (International Telecommunications Union, 2002). The ITU produces around 210 recommendations for a new or updated standard per year.

In the U.S., the American National Standards Institute (ANSI) is the "peak" formal organization responsible for promoting voluntary, private-sector standards-setting, with an organizational goal to "enhance both global competitiveness of U.S. business and the U.S. quality of life" (American National Standards Institute, 2002a). The decentralized U.S. standards system, unlike many other nations where national governments play a major role, has the U.S. government participating as one among many stakeholders (some 600 standards-making organizations, including about 150 industrial consortia) in the standards-making process.[6]

[6] The National Institute of Standards and Technology (NIST), located in the U.S. Department of Commerce, is called upon (in an advisory capacity) to provide technical support that contributes to the development of high quality domestic and international standards. Through its efforts to build consensus, due process, and openness, ANSI has accredited some 175 distinct entities responsible for the approval of over 14,650 American National Standards. ANSI has also established an Information Infrastructure Standards Panel to facilitate development of standards critical to the Global Information Infrastructure. ANSI is the representative to the two major non-treaty international technology standards organizations, the

5. A STANDARDS-SETTING FRAMEWORK FOR GLOBAL COMPETITIVENESS

In a global economic setting, one wonders how does a nationally-based standards-setting process like that of the United States enhance competitiveness in its network-based IT industries. A perceived weakness of the *market/non-market* typology is exactly the fact that there is little, if any, overall coordination of the process, occasionally leaving domestic industry at a disadvantage compared to their foreign counterparts. A recent example has involved the second generation of equipment in mobile telephony:

> For example, in the late 1980s, Europe advanced a single standard for the current generation of digital cellular phones. Meanwhile, U.S. companies were slugging it out in the market, each aiming to position its particular technology as the *de facto* standard by building an enormous base of subscribers that could not be ignored. European companies bypassed the fray, concentrated on enlisting subscribers worldwide, and emerged victorious (Mallet, 1998b).

It has been estimated that in the late 1990s standards affected sale transactions of at least $150 billion in U.S. exports – with standards requirements, according to the American Electronics Association, adding almost 10 percent ($1.4 billion annually) to the cost of certifying telecommunications equipment and information technology product export sales in Europe (Mallett, 1998a). Moreover, international standards accounted for approximately 45 percent of the standards used by U.S. industry in 1995, up from about 10 percent in 1970 (National Research Council, 1995). This trend will only continue: under the Technical Barriers to Trade Agreement, which was part of World Trade Organization Treaty signed in 1994, the U.S. and 130 other government signatories are obliged to give preference to international standards as a basis for their technical regulations. Because of their growing importance in international trade, other countries and regions have made standards an integral element of their national competitiveness policies. The European Union (EU) has moved rapidly to position itself in the increasingly important international standards arena, and has allegedly benefited from its strategy as mentioned above. The EU strategy has been to harmonize the standards of member nations, and has given responsibility to three organizations that give preference to international standards: the European Committee for Standardization (CEN); the European Committee for Electrotechnical Standardization (CENELEC); and the European Telecommunications Standards Institute (ETSI).

In March 1998, NIST challenged the U.S. standards community to develop a national strategic response to the EU and other regional challengers in the adoption and development of international standards. Later that year, NIST and ANSI sponsored a national standards summit where over 300 representatives of U.S. companies, standards

---

International Organization for Standardization (IOS) (responsible for developing global consensus for most technology standards) and the International Electrotechnical Commission (IEC) (responsible for creating international consensus in all areas of electrical and electronic engineering).

development organizations, and federal agencies initiated first steps to develop a national standards strategy (American National Standards Institute, 2000). With a goal of enhancing U.S. national competitiveness, the participants at the summit agreed on the need to improve public-private sector cooperation on standards policy. Two years later, ANSI announced that its membership had approved a *National Standards Strategy* that establishes a framework of a dozen strategic (and additional supporting tactical) initiatives available to all participants to improve U.S. competitiveness in foreign markets while continuing to provide strong support for domestic markets. The initiatives are designed to build on the U.S. traditions of sectorally-based standards, consensus, openness, and transparency while simultaneously providing greater emphasis to speed, relevance, and meeting the needs of public-interest stakeholders (American National Standards Institute, 2000). According to Stephen P. Oksala, director of standards management at Unisys and chairman of the *National Standards Strategy* development group,

> "The purpose of a national strategy is to succeed in a changing world while maintaining the strengths that have served us in the past. We face new challenges in health, safety, consumer issues, and protection of the environment as well as in the explosion of world trade and rapid changes in technology and communications. Voluntary private sector standards are increasingly being used for both market and regulatory purposes. *As other regions of the world promote their own technologies and practices, the U.S. must "step it up" to be competitive."* (emphasis added) (American National Standards Institute, 2000).

While the *National Standards* Strategy is a major document that coherently focuses the voluntary, private-sector driven U.S. standards-making community on shaping the international standards framework and levels the global competitive environment for all participants, it is remiss in not addressing the aforementioned concerns with antitrust policy and intellectual property rights (American National Standards Institute, 2002b). We believe that to reinforce the nation's competitive industrial infrastructure, it requires a national policy framework be created that becomes "part-and-parcel" of the U.S. innovation system, with application to technological systems in the critical network-based industries supplying information technology products and services. To that end, we next present a standards-setting approach which encourages an early domestic industry consensus on a standard for critical interoperable technology specification and recommends appropriate legal and policy involvement by U.S. antitrust agencies in the network industries standards-setting process.

5.1. A Standards Competition

We propose a policy framework that recognizes the symbiotic relationship between antitrust and technology standards and, contrarily. This framework adds a new variant to the three basic strategies in setting technology standards mentioned earlier (standards negotiation, standards wars, standards leader). A *standards competition* will be designed to facilitate rapid standardization of critical technologies for emerging IT products. The policy framework also includes an antitrust policy review process ensuring

a competitive environment encouraging national competitiveness and the protection of intellectual property rights.

When does an *ad hoc* standards-setting competition take place in terms of the market conditions of an IT technology? Besen (1995) has developed a typology that is useful in determining the institutional setting of a particular standardization activity based on the characteristics of market participants. There are four basic situations in this typology, reflecting different types of participant objectives in a standardization effort:

- All participants have a common interest in the standard, and quickly and efficiently want to determine which standard best serves those interests. Everybody is welcome to join the process, and decision-making is reached through consensus.
- The participants have directly opposed interests and want their own solution to be adopted as standard, but each would prefer no standards as an alternative. This often leads to "standard wars" and the emergence of *de facto* standards through market mechanisms.
- The participants prefer their own solution, but are actually interested in establishing some common standard to none at all that often includes extensive sharing of intellectual property. The process allows some competition, but ultimately leads to a compromise, often through some form of voting procedure.
- At least one participant may prefer that others be unable to produce compatible products, reflecting a desire to slow down the process of establishing compatible products through open standards, in order to strengthen market position.

The market conditions under which a proposed standards-setting competition would take place would initially fall under the second situation, where a "standards war" was threatened or already in progress within the U.S. marketplace. However, simultaneously other regions of the global economy are operating under the first or third conditions, with pressure building to establish a global *de jure* IT standard. This global, competitive scenario requires the U.S. IT industry to recognize the need to move to a variation of situation three and shift competitive strategy to the more conventional competition within a standard (Besen and Farrell, 1994).

The mechanics of the proposed *ad hoc* standards competition would not be simple. As a first step, it will require the voluntary designation of a representative body for the IT sectors.[7] The second step would requite the formal recognition of this body's status by the FTC and DOJ, thus allowing the standards competition to accelerate the typical market-based process to establish a U.S. IT technology standard.

[7] One such candidate could be the Information Technology Industry Council (ITI), with a membership of some of the leading U.S. providers of IT products and services (including AOL Time Warner, Dell Computer Corporation, Intel Corporation, and Microsoft), which serves as secretariat for the National Committee for Information Technology Standards and for the U.S. technical advisory group for the International Organization for Standardization and the International Electrotechnical Committee's Joint Committee on Information Technology Standardization (Information Technology Industry Council, 1998). Furthermore, ITI is the sponsor of the InterNational Committee for Information Technology Standards (INCITIS), whose mission is to produce market-driven, voluntary consensus standards in the areas of multimedia (MPAG/JPEG); intercommunication among computing devices and information systems (including the information infrastructure); SCSI interfaces; Geographic Information Systems; storage media (hard drives, removable cartridges); databases (including SQL3); security; and programming languages (such as C++) (InterNational Committee for Information Technology Standards, 2002).

While NIST has a long track record of coordinating industrial standards-setting networks, such as consortia pursuing test methods for integrated circuits (Tassey, 1995), and while standards-setting activities are presently promulgated under a variety of standards-setting processes, ranging from government-sanctioned organizations to *ad hoc* cooperative arrangements, there is no formal, government sanctioned, standards-setting competition process that presently exists in the United States. Past examples, however, exist. An example of a less formal (*market*) type of an international standards-competition took place in 1980, involving the digital audio disk (DAD) technology. Another example of a more formal competition took place in 199X, involving the technology underlying High Definition Television.

During the critical, transformational 1979-81 period when the technology format was being developed, the CD network had its core capabilities held by two companies: Sony and Philips (Rycroft and Kash, 1999). Sony's capabilities were in audio technology and computer simulation and Philip's capabilities were in optics and lasers. The CD network was linked into an international *ad hoc* DAD committee formed by over 50 companies to exchange information about the technology (Hill, 1997; Lundvall, 1995). In 1980, the DAD committee served as the judge in a competition among three candidate formats (including Sony/Philips, JVC, and Telefunken) that would result in one being crowned the world standard. The Sony/Philips design won the competition as the "best" technology (although the USDOJ did initiate a *post hoc* investigation into this standard-setting process). The DAD committee's function evolved from exchanging information to making a key technology decision because none of DAD's members wanted to take the risks associated with leaving the design selection to the market.

[INSERT HDTV EXAMPLE HERE]

Broadly speaking, the purpose of a U.S.-based, standards-setting ad hoc competition would be to accelerate the establishment of a national technical standard in network industries, such as those found in IT. This would be especially important in critical transformative technologies if the result of the competition could be proposed as a strong candidate for the world standard before the ISO or IEC. The general form of such a voluntary, national competition would involve:

- An *open competition* that would include all available IT technologies with significant U.S. content, representing products or processes marketed by domestic and foreign companies that have, for example, attained or exceed a (pre-determined) minimum "threshold" percentage share of the present U.S. market, thus recognizing those technologies having commercial viability;[8]
- An *adjudicative committee* membership that is mutually agreed to by those participating in the standard competition, i.e., those entities (firms or alliances) meeting or exceeding the minimum threshold percentage of market share;
- A set of *criteria* of "best design" developed by consensus among members of the adjudicative committee that is transparent to all. These criteria must reflect a combination of important factors in high-tech network-based industries, including

[8] Lemley (2001) points out a potential weakness of the approach to unlimited participation: if the decision rules require unanimity, then expanding participation might slow down decision-making. Our approach leaves the decision-making in the hands of independent evaluators, eliminating the problem of unanimity.

most innovative technology, ease of interoperability (compatibility), speed to mass commercialization, and consumer utility, among others.

- The evaluation of applicant technologies by an independent and highly respected group of experts agreeing to full public disclosure of the basis of the winner-choosing decision; and
- Following in the tradition of the ITU and ANSI, a requirement that all participants in the standards competition to agree beforehand to *license all essential intellectual property* (e.g., patents, copyrights, know-how) to comply with the winning standard on either a compensation-free basis or "fair, reasonable, and non-discriminatory (financial) terms." It is emphasized that this approach follows the doctrine of essential facilities, mentioned earlier as an important ingredient for standards-setting involving network-based technology. The definition of terms should be undertaken by the standards-setting organization. It may be suggested that a mutually acceptable advisory committee (consisting of industry experts in marketing, engineering, law, and economics) to the standards-competition sponsoring organization decides *ex ante* on a royalty fee. Their decision is final.[9]

It cannot be overemphasized that a formal technology standards competition is to be undertaken only when a critical technology de facto standard, i.e., one having significant impact on the future competitiveness of the nation's IT industries, has not emerged through competitive market forces and there is a critical, time-sensitive requirement that such a standard be offered as a world standard or result in U.S. IT industry preferences being excluded from international consideration.

The antitrust concerns that might accompany this proposed formal standards-setting competition can be addressed through the promulgation of an FTC/DOJ industry guide and the issuance of an FTC advisory opinion letter or DOJ business review letter.[10] Industry guides are administrative interpretations of laws administered by the FTC for the guidance of the public in conducting its affairs in conformity with legal requirements (Code of Federal Regulations, 2002). The DOJ is actively involved in the co-development of industry guides that pertain to business practices involving antitrust concerns. In practice, most FTC advisory letters are staff letters offering opinions on the legality of proposed (intended) conduct, not conduct that is ongoing. The letters are considered a reliable indicator of the FTC staff's enforcement intentions and views absent a significant change of fact (Moreland, 1997). The USDOJ business review letter contains an appraisal of proposed (intended) business conduct and a statement of the agency's enforcement intentions (Moreland, 1997). While the opinion of one antitrust agency is not binding on the other, the agencies work closely together in issuing opinion letters (Moreland, 1997).

Federal government involvement in the formal standards competition process, although limited, is nevertheless important. Both the FTC and DOJ will be petitioned by the designated IT industry associations and consortia to promulgate an industry guide

[9] The issue of the licensing terms is complicated and needs additional development. Royalty fees are an exception rather than the rule. Moreover, the American National Standards Institute's policy position is that standards-setting organizations usually do not have the legal and business responsibilities nor necessary resources to adjudicate what are essentially commercial and highly-technical issues (Marasco, 2003).

[10] This federal government involvement would invoke FTC and/or DOJ antitrust economists to verify the market basis for initiating the standards competition and advocate a rule-of-reason treatment.

outlining the antitrust agencies views on network-oriented industries and the formal use of an *ad hoc* standards competition to enhance national competitiveness. Based on the premise that this is subject matter of "significant public interest," both agencies should be amenable to developing such a guide (FTC Organization, Procedures and Rules of Practice, 1989). Also, in each *ad hoc* standards competition, the designated IT industry body will petition for an FTC advisory letter (or DOJ business review letter) legally reviewing the circumstances for calling such a competition, the process employed in the contest for "best design", and establishment of the *ex ante* royalty-licensing fee.

6. CONCLUDING REMARKS

The importance of a critical infrastructure industry like IT to U.S. national competitiveness is recognized by economists and policy-makers without question. The network-based characteristics of this industry often lead to an important competitive reliance on *de jure* interoperability standards-setting processes as a deciding factor for which technology becomes the recognized dominant design in not only the national market, but most importantly from an international trade perspective, globally as well. The U.S. technology standards system is largely driven by the private sector, mixed formal-informal in operation, and aligned by industry. Ostensibly, this makes it more open and responsive to marketplace needs. The U.S. model, however, is occasionally prone to multiple standards, resulting in serious national competitive consequences for the nation's industries in the international arena.

For the U.S. to be a player in the international standards-setting arena, reaching an early domestic IT industry consensus for a critical interoperable technology design is often essential. While in most cases such a consensus is reached in the standing U.S. technology standards system, there have been situations where a timely consensus has failed to be attained (e.g., second generation cellular telephony). The consequences of such standards development "market failure" has resulted in negative consequences for the U.S. economy (e.g., in the case of cellular telephony, foreign firms were able to capture both technological and market leadership positions). Changing the U.S. standards development system that is market-driven is not required; instead, an anticipatory policy approach which builds on the competitive strengths of this system and includes active government oversight is proposed as a solution. The proposed national standards competition also incorporates potentially serious issues related to antitrust policy and intellectual property rights protection. When a standards competition is needed to allow a "stalled" U.S. technology standard to emerge as a serious candidate in the international standards-setting arena, the involvement of the U.S. antitrust agencies allows for a legal "safe harbor" in a largely private sector managed standards competition. Access to protected intellectual property found in the "winning" technology standard is also made universally available for a reasonable royalty fee.

Finally, it should be stressed that the ad hoc standards-setting competition proposed in this article does not contradict recent policy conceptualizations beyond the mainstream economic literature. From an antitrust policy perspective, the recent literature in evolutionary economics and complexity science support authorities emphasizing interventions on process and de-emphasize interventions on outcomes (Ellig and Lin, 2001). Moreover, since (a) market structure in the evolutionary approach endogenously emerges out of the process of innovation/adaptation and of the market environment and (b) the ability of a large firm to exhibit market power is not due to its size but due to its success in innovating or adapting, antitrust policy should de-emphasize concentration . The standards competition proposed herein emphasizes antitrust authority involvement in the *process* of establishing a "fair and reasonable" technology standards outcome for interface compatibility in a network-based industry. When exercised, this application of an evolutionary perspective to complex technology standardization may have significant consequences for U.S. competitiveness in the network-based IT industry.

REFERENCES

Afuah, A. (1998). Innovation Management: Strategies, Implementation, and Profits, New York, NY: Oxford University Press.

American National Standards Institute (ANSI) (2000). U.S. National Standards Strategy Approved: New Strategy to Strengthen U.S. Global Trade; U.S. House Hearing on Strategy Set for September 13, Press Release, August 31. New York, NY.

American National Standards Institute (ANSI) (2002a). Background information on ANSI @http//www.ansi.org accessed on September 20.

American National Standards Institute (ANSI) (2002b). National Standards for the United States @http//www.ansi.org/public/nss.html accessed on September 22, 2002.

Anton, J. and Yao, D. (1995). Standard-Setting Consortia, Antitrust, and High-Technology Industries, Antitrust Law Journal, 64, pp. 247-265.

Balto, D. (2000). Standard Setting in a Network Economy (Prepared Remarks of David A. Balto, Assistant Director, Office of Policy and Evaluation, Bureau of Competition, Federal Trade Commission, before Cutting-Edge Antitrust Law Seminars International, February 17). New York, NY.

Beard, T.R. and Kaserman, D.L. (2002). Patent Thickets, Cross-Licensing, and Antitrust. Antitrust Bulletin, 47(2/3), pp. 345-368.

Besen, S. (1995). The Standards Process in Telecommunications and Information Technology. In R.W. Hawkins, R. Mansell, and J. Skea (Eds.), Standards, Innovation and Competitiveness: The Politics and Economics of Standards in Natural and Technical Environments, pp. 136-146, Aldershot, UK: Edward Elgar.

Besen, S. and Farrell, J. (1991). The Role of the ITU in Standardization. Telecommunications Policy, 15 (4), pp. 311-321.

Besen, S. and Farrell, J. (1994). Choosing How to Compete: Strategies and Tactics in Standardization. Journal of Economic Perspectives, 8(2), pp. 117-131.

Breitenberg. M. (1987). The ABCs of Standard-Related Activities in the United States. Prepared for the National Bureau of Standards, U.S. Department of Commerce, Gaithersburg, MD: NBS.

Code of Federal Regulations (2002). 16 CFR: Commercial Practices, Chapter I, Federal Trade Commission, Subchapter B – Guides and Trade Practice Rules, Part 17 – Application of Guides in Preventing Unlawful Practices, September 27.

David, P.A. (1987). Some New Standards for the Economics of Standardization in the Information Age. In P. Dasgupta and P. Stoneman (Eds.), Economic Policy and Technological Performance, pp. 206-239, Cambridge, UK: Cambridge University Press.

David, P.A. and Greenstein, S. (1990). The Economics of Compatibility Standards: An Introduction to Recent Research. Economics of Innovation and New Technology, 1, pp. 3-41.

Egan, M. (2002). Setting Standards: Strategic Advantages in International Trade. Business Strategy Review, 13(1), pp. 51-64.

Ellig, J. and Lin, D. (2001). A Taxonomy of Dynamic Competition Theories. In J. Ellig (Ed.), Dynamic Competition and Public Policy: Technology, Innovation, and Antitrust Issues, pp. 16-44, Cambridge, UK: Cambridge University Press.
Epstein, R. (1998). Principles for a Free Society: Reconciling Individual Liberty with the Common Good, Reading, MA: Perseus Books.

Federal Trade Commission (1996). Anticipating the 21st Century: Competition Policy in the New High-Tech, Global Marketplace (Staff Report), May. Washington, DC.

FTC Organization, Procedures and Rules of Practice (1989). Part I – General Procedures, Subpart A – Industry Guidance, Advisory Opinions, p. I-1, June 16.

Gandal, N. (2002). Compatibility, Standardization, and Network Effects: Some Policy Implications. Oxford Review of Economic Policy, 18(1), pp. 80-91.

Hart, D. (1998). Antitrust and Technological Innovation. Issues in Science and Technology, Winter, pp. 75-81.

Hebner, R.E. (1998). Standards and Trade—Who Really Cares? (Prepared Remarks of Robert E. Hebner, Acting Deputy Commissioner, National Institute of Standards and Technology, U.S. Department of Commerce, Fall 1998 Public Lecture Series: Technology Standards and Standardization Process, Stanford University – U.S.-Japan Technology Management Center, September 28). Palo Alto, CA.

Hill, C.L. (1997). Establishing a Standard: Competitive Strategy and Technological Standards in Winner-Take-All Industries. Academy of Management Executive, 11(2), pp. 7-25.

InterNational Committee for Information Technology Standards (2002). Where IT all begins @http: //www.ncits.org/geninfo.htm accessed on August 10, 2003.

Information Technology Industry Council (1998). ITI Supports Open Discussion of National Standards Policy. News Release, September 23.

International Telecommunications Union (2002). @ http://www.itu.ch accessed on September 20, 2002.

Langlois, R.N. (2001). Technological Standards, Innovation, and Essential Facilities: Toward a Schumpeterian Post-Chicago Approach. In J. Ellig (Ed.), Dynamic Competition and Public Policy: Technology, Innovation, and Antitrust Issues, pp. 193-228, Cambridge, UK: Cambridge University Press.

Lemley, M. (2001). Antitrust, Intellectual Property and Standard-Setting Organizations. Mimeograph @http://arxiv.org/ftp/cs/papers/0109/0109037.pdf accessed on March 9, 2003.

Lemley, M. and McGowan, D. (1998). Legal Implications of Network Economic Effects. California Law Review, 86(3), pp. 479+.

Lundvall, B. (1995). Standards in an Innovative World. In R.W. Hawkins, R. Mansell, and J. Skea (Eds.), Standards, Innovation and Competitiveness: The Politics and Economics of Standards in Natural and Technical Environments, pp. 7-12, Brookfield, VT: Edward Elgar.

Mallett, R.L. (1998a). (Prepared Remarks of Robert L. Mallett, Deputy Secretary, U.S. Department of Commerce, ASME-Industry Standards Summit, April 15). Washington, DC.

Mallett, R.L. (1998b). Why Standards Matter. Issues in Science and Technology, Winter, pp. 63-70.

Marasco, A. (2003). Inclusion of IPR in Standards. (Presentation of Amy A. Marasco, Staff Attorney, American National Standards Institute, GSC-8/GTSC-1/GRSC-1, April 28-May 1, 2003). Ottawa, Canada.

Moreland, J.A. (1997). Overview of the Advisory Opinion Process at the Federal Trade Commission (Presentation of Judith A. Moreland, Attorney, Bureau of Competition, Federal Trade Commission, at the National Health Lawyers Association, Antitrust in the Health Care Field, February 13 and 14). Washington, DC.

Mowery, D.C. (1992). The U.S. National Innovation System: Origins and Prospects for Change, Research Policy, 21, pp. 125-144.

Murris, T. J. (2001). Competition and Intellectual Property Policy: The Way Ahead (Prepared Remarks of Timothy J. Murris, Chairman, Federal Trade Commission, before the American Bar Association, Antitrust Section, Fall Forum, November 15). Washington, DC.

National Institute of Standards and Technology (2000). New National Standards Strategy Can advance U.S. Technology Interests, NIST Director Tells Congress, Press Release (NIST 2000-14), September 13. Washington, D.C.

National Research Council (1995). Standards, Conformity Assessment, and Trade into the 21st Century. Washington, DC: National Academy Press.

National Science Board (2000). Science and Engineering Indicators-2000. Washington, DC.

Organization for Economic Cooperation and Development (1991). Report of the OECD/CCP Committee on Consumer Policy, Consumers, Product Safety Standards and International Trade, Paris, France.

Popper, S.W. and Wagner, C.S. (2001). New Foundations for Growth: The U.S. Innovation System Today and Tomorrow (MR-13380.0/1-OSTP). RAND: Science and Technology Policy Institute, Washington, DC, January.

Robinson, D. (1999). An Industry View of the Standardization Process. In Technology Standards and Standardization Process: Their Impact on Innovation & International Competitiveness: Proceedings of a Lecture Series Presented by: US-Japan Technology Management Center, Stanford University, pp. 43-54.

Rycroft, R.W. and Kash, D.E. (1999). The Complexity Challenge: Technological Innovation for the 21st Century, London, UK: Pinter.

Shapiro, C. (1989). Theories of Oligopoly Behavior. In R. Schmalensee and R. Willig (Eds.) Handbook of Industrial Organization, pp. 330-414, Amsterdam, The Netherlands: Elsevier Science Publishers.

Shapiro, C. (2001a). Setting Compatibility Standards: Co-operation or Collusion? In R. Dreyfuss, D. Zimmerman & H. First (Eds.) Expanding the Boundaries of Intellectual Property, pp. 81-102, New York, NY: Oxford University Press.

Shapiro, C. (2001b). Navigating the Patent Thicket: Cross-Licenses, Patent Pools, and Standard-Setting. In A. Jaffe, J. Lerner, & S. Stern (Eds.) Innovation Policy and the Economy (Vol. I) pp. 119-150, Cambridge, MA: MIT Press.

Shapiro, C. (2002). Competition Policy and Innovation. Organization for Economic Co-operation and Development, Directorate for Science, Technology and Industry (STI Working Papers 2002/11). Paris, France.

Shapiro, C. and Varian, H.R. (1999). Information Rules: A Strategic Guide to the Network Economy, Boston, MA: Harvard Business School Press.

Shenefield, J.H. and Stelzer, I.M. (1999). The Antitrust Laws: A Primer (Third Edition), Washington, D.C.: The AEI Press.

Spivak, S.M. and Brenner, F.C. (2001). Introduction. Standardization Principles: Principles and Practices, pp. 1-6, New York, NY: Marcel Dekker, Inc.

Stern, S., Porter, M., & Furman, J. (2000). The Determinants of National Innovation Capacity, National Bureau of Economic Research (Working Paper #7876), September.

Tassey, G. (1995). The Roles of Standards as Technology Infrastructure. In R.W. Hawkins, R. Mansell, and J. Skea (Eds.) Standards, Innovation and Competitiveness: The Politics and Economics of Standards in Natural and Technical Environments, pp. 161-171, VT: Edward Elgar.

Tassey, G. (1999). R&D Trends in the U.S. Economy: Strategies and Policy Implications, Planning Report 99-2, The National Institute of Standards and Technology. Gaithersburg, MD.

Tassey, G. (2000). Standardization in Technology-Based Markets, Research Policy, 29, pp. 587-602.

The Economist (2000). The New Economy (Survey), 356, September 23.

Toth, R.B. (2001). The U.S. Standardization System: A New Perspective (Chapter 14). In Spivak, S.M. and Brenner, F.C. Standardization Principles: Principles and Practices, pp. 131-147, New York, NY.: Marcel Dekker, Inc.

U.S. Department of Justice (1998). Justice Department Approves Joint Licensing of Patents Essential for Making DVD-Video and DVD-ROM Discs and Players. Press Release, December 17.

U.S. Department of Justice and Federal Trade Commission (1995). Antitrust Guidelines for the Licensing of Intellectual Property, April. Washington, DC.

U.S. Department of Justice and Federal Trade Commission (2000). Antitrust Guidelines for Collaborations Among Competitors, April. Washington, DC.

Utterback, J.M. (1994). Mastering the Dynamics of Innovation, Cambridge, MA: Harvard Business School Press.

Varian, H. (2001). Economics of Information Technology. Raffaele Mattioli Lecture, Luigi Bocconi University, Milan, Italy, November 15-16.