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GOVERNMENT/INDUSTRY INTERACTIONS IN THE GLOBAL STANDARDS SYSTEM*

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Abstract: We review the evolution of the global standards system and its relationship to industry. We then discuss some of the approaches that governments have taken in order to modify the system for the benefit of domestic and worldwide economic development. We use as an example an effort of the U.S. National Institute of Standards and Technology to encourage voluntary consensus standards for interoperable broadband wireless access systems.

NOTE — This manuscript is an update of an earlier paper [1] and an earlier summary update [2].

INTRODUCTION

Globalization of the economy has in turn led to globalization of standardization. Governments play a strong role in shaping the global standards system. They have explored many approaches to optimize the system to meet their economic and social needs. However, governmental activity sometimes conflicts with the interests of other governments or of local industry.

Standards are critical for the marketplace success of many technological solutions, particularly in fields such as telecommunications. Standards that are adopted worldwide are especially powerful due to economies of scale. Telecommunications standards adopted globally offer additional benefits by virtue of the interchangeability they offer to users. This flexibility is most obvious in the case of roaming communications devices, but, even with generally stationary equipment, global standards distinctly enhance the value of technologies and reduce testing and certification costs.

Appropriate globally applicable standards are economically efficient and offer significant benefits to end users. Effective global standards, however, are difficult to achieve. Sometimes, local political needs have moved national administrations to use standards as a means of aiding local industry. Similarly, multinational corporations can use the system to impede competition from smaller companies. Recognizing the burden that fragmented or inappropriate standards

can impose on the global economy, international organizations, backed by sovereign nations, have moved to improve the standardization process and the resulting standards.

In the evolving environment of world trade, the World Trade Organization (WTO) has been the convening body bringing nations together to develop international trade rules. Historically, WTO members have recognized that tariffs have been a primary barrier to global trade and have therefore concentrated on that issue. However, as tariffs have fallen in response to WTO agreements, other non-tariff issues continue to unnecessarily hinder global trade. Inappropriate or unnecessarily differentiated national and regional standards have emerged as one of the major non-tariff trade barriers.

BENEFITS OF STANDARDS

The benefits of standards in a modern economy have been classified into four categories [3]:

- Quality and reliability – Standards may define an acceptable level of performance. The standards dealing with boilers and pressure vessels that have been promulgated by the American Society of Mechanical Engineers are good examples. Governmental regulators have sometimes made these standards legally binding to assure a minimum level of public safety.

- Information – Standards may provide evaluated scientific and technical information. For example, in the construction industry, the latest research, from concrete handling to earthquake protection, is evaluated and incorporated into standards. The construction crews and engineers who use these standards can thereby exploit advanced technical information without independent knowledge of all recent research.

- Compatibility and interoperability – Standards may provide agreed-upon interfaces so that systems can operate with parts from different manufacturers. Examples are commonplace and include nuts and bolts, railroad gauges, electrical plugs and outlets, and interoperability standards for computer and telecommunication systems.

- Variety reduction – Standards may limit the number of possible variants of a product or process. Such reductions lead to economies of scale and can also stimulate economic growth. Standardizing the size of a bread slice led not only to an economy of scale for commercial bakers but also to inexpensive toasters and plastic sandwich bags.

As a result of benefits like these, standards have proliferated. About 200,000 exist [4], with broad implications in industry and society.

KEY FACTORS FORCING CHANGES IN STANDARDS DEVELOPMENT

Two key interrelated factors are stimulating changes in the system by which standards are developed and promulgated. The first is the end of the Cold War. During the Cold War, the world was divided into two adversarial camps plus a group of nonaligned nations. In this environment, global trade was constrained, and standards tended to be largely national or harmonized among allied trading partners when convenient. With the end of the Cold War, a truly global economy began to emerge. With increasing mobility of capital, investment flowed to countries with low inflation, a nearly balanced national budget, a strong private sector, deregulated trade and investment, and economic competition [5]. In this environment, the existing system of differentiated standards emerged as a key barrier to trade.

The second factor is the increasing rate at which new technologies are introduced into the economy. During the 1980s and 1990s, many companies demonstrated the economic benefits of aggressively bringing new technology to market. This fact, paired with exponential improvements in microelectronic technology, dramatically shortened some product life cycles to periods measured in months. Short product life cycles create problems for the standards process [6]. Standards are reached by consensus, and development times of five years have been common for complex standards. Inefficiencies in development and information transfer cause some of this delay. These issues are being addressed by many standards-developing organizations through increased use of automation and streamlined procedures. However, some factors behind the delays are less responsive to a technical fix. The development of a consensus standard requires people to agree. Different participants in the process have different expectations and concerns to be identified and resolved. All participants recognize, however, that a standard whose development period exceeds the life of the product is of little use.

INDUSTRIAL RESPONSE TO GLOBAL CHANGES

As the geopolitical barriers to global trade were removed, industry moved to compete in and profit from a global market. This trend had implications in the standards arena. For example, in 1995, the Transatlantic Business Dialogue was established “to reduce barriers to transatlantic trade and investment” [7]. This organization brought together leaders of companies with headquarters in Europe and the United States to work closely with government officials in finding creative means to remove trade barriers. In the area of standards, a guiding principle became, “approved once, accepted everywhere.”

Industry also modified its own standards-developing organizations. For example, the American National Standards Institute (ANSI) developed and disseminated the “National Standards Strategy for the United States” [8]. This document, discussed in more detail below, culminated an industry-led process to clearly define which elements of the existing standards system needed to change and which needed to be preserved.

Industry was also taking direct action to bypass the traditional standards process that leads to *de jure* [9] standards. Such changes were driven partially by a perception that the accredited standards process was too slow and partially by a perception that an aggressive approach could lead to huge returns. This attitude was captured in *Wired* magazine’s “encyclopedia of the new economy” [10] which asserted:

> "Companies used to compete by making things and selling them. In the new economy, the game is often over by the time the first product emerges from the factory. Sometimes it's because a… first entrant effectively sets… the standard. In other cases, winners (and losers) emerge from backroom bargaining over the technical details that enable complex technologies to work together…"

Geoffrey Moore [11] identifies Microsoft, Intel, and Cisco Systems as companies that have benefited by *de facto* standards.

Economists have recently focussed on network externalities and "lock-in" effects that result from *de jure* or *de facto* standards. Such economic network effects are exemplified in hardware that, once widely deployed, offers a ready market to software developers and stimulates further hardware sales. Telecommunications networks also provide excellent illustrations of such effects. Examples of exceptional success based on lock-in have become widely known. As these economic models have become better understood, strategies for their exploitation have become increasingly popular. Varian and Shapiro have published a book on the topic, advising [12]:

> "A go-it-alone strategy typically involves competition to become the standard. By contrast, participation in a formal standards-setting process, or assembling allies to promote a particular vision of technology, typically involves competition within a standard. Don't plan to play the higher-stakes, winner-take-all battle to become the standard unless you can be aggressive in timing, in pricing, and in exploiting relationships with complementary products. Rivalry to achieve cost leadership by scale economics and experience, a tried and true strategy in various manufacturing contexts, is tame in comparison."

An important strategy in the lock-in game is to price aggressively to win early market share in the hope that profit will follow later, once customers find change to be expensive. As we wrote in 2001 [1], "This approach may require large capital investment and years of losses. Whether the capital markets will remain as kind to this strategy as they were in the 1990s remains to be seen."

Industry's approach to standards has been driven not only by the economy but also by the regulatory environment. For example, consortia specifications flourished in the 1990s. A 1999 estimate indicated that, in the U.S., approximately 3500 consortia organizations were developing specifications, compared to approximately 250 accredited standards-developing organizations [4]. Cooperative research and development consortia were given great antitrust leeway in the U.S. under the National Cooperative Research Act of 1984 (amended as the National Cooperative Research and Production Act of 1993 [13]). Under the Act, certain types of activities ("such as, arguably, the development of standards" [7]) are protected from the risk of treble damages and liability for a plaintiff's legal fees.

TECHNICAL BARRIERS TO TRADE AGREEMENT (TBTA)

Given the economic benefit of standards, most countries want to assure that the standards process does not harm their industry and, if possible, boosts it. An important early step to adapt the world's standards system to global trade was the Technical Barriers to Trade Agreement (TBTA) [14], concluded during the 1994 Uruguay round of multilateral trade negotiations under the auspices of the World Trade Organization (WTO). A specific motivation for that agreement was to "encourage the development of… international standards… systems." Sections 2.4 and 2.6 impact gov-

ernment relationships with standards organizations. In Section 2.4, signatories—national governments—agreed to use international standards as the basis for regulations whenever possible. As detailed in Section 2.6, the WTO signatories have also agreed to become participants in the preparation of international standards by "appropriate international standardizing bodies." This last term was undefined. Many organizations have defensible claims to be appropriate international standardizing bodies for various industries, technologies, or classes of products or processes. Annex 3 of the TBTA [15] establishes process attributes for use by national and regional standards developing organizations in the development of sound and fair standards. These attributes, including consensus, openness, and transparency, are further detailed in Annex 4 of the TBTA Second Triennial Review [16], which references transparency, openness, impartiality, consensus, effectiveness, relevance, and coherence as the hallmarks of effective international standards development. These attributes are process-oriented rather than outcome-oriented. As global standardization matures, outcome rather than process may be recognized as the more effective gauge of standardization.

The TBTA explicitly recognizes the legitimate need for technical regulations, standards, and procedures for assessing product conformity with standards. Thus, it recognizes the rights of governments to adopt the regulations and standards that they consider appropriate to protect health, safety, or the environment, to meet essential security needs, or meet consumer interests in their countries. The Agreement's provisions are designed to preserve the ability of governments to act in this area but guard against use of arbitrary or scientifically unjustified measures to protect domestic industries.

As a result of Sections 2.4 and 2.6 of the TBTA, national regulations may now be determined partially by industry and, because of Section 2.6, partially by outside governments. This is consistent with the trend [3] of decreasing local autonomy in the global economy.

U.S. Response to TBTA

The U.S. standards system has its roots in private industry. Over the last century, it has successfully met marketplace needs on a sector-by-sector basis. It has developed the rules for consensus, transparency, openness, and due process that were adopted by the World Trade Organization as bedrock principles [2].

The United States' WTO commitments, including conformance with the commitments embodied in the TBTA, were incorporated into U.S. law through a 1994 amendment to the Trade Agreements Act of 1979. Furthermore, many of the principles of the TBTA were echoed in the 1995 National Technology Transfer Advancement Act (NTTAA) [17]. The NTTAA has three major implications for the relationship between the government and standardization: (1) government procurement, (2) government regulations, and (3) government participation in standards development.

Under the NTTAA, federal agencies are directed to rely on voluntary consensus standards wherever feasible and appropriate in their regulatory, procurement and policy activities. In particular, "Federal agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies, using such technical standards as a means to carry out policy objectives or activities determined by the agencies or departments." Unless the use of a private-sector standard is "inconsistent with applicable law or otherwise impractical," its use in specifying procurement criteria for a given purchase is mandatory [18]. In parallel with Section 2.4 of the TBTA, the NTTAA also applies to government agencies in their regulatory activities; wherever possible, Federal regulations are to be consistent with voluntary consensus standards.

In parallel with Section 2.6 of the TBTA, the NTTAA also requires that Federal agencies "shall, when such participation is in the public interest and is compatible with agency and departmental missions, authorities, priorities, and budget resources, participate with such bodies in the development of technical standards." This clause provides a route for direct government involvement in private standardization through voluntary consensus-standards bodies. We discuss this issue in greater detail below.

The United States interprets the term "appropriate international standardizing bodies" broadly, to include any voluntary consensus standards organization implementing the principles of TBTA Annex 4 and whose documents are used globally. At the same time, U.S. industry continues to experiment with different structures. The current government position was developed during the Clinton Administration and reflected in the 1998 Office of Management and Budget (OMB) Circular A-119 [19], which implements the NTTAA with specific policy and language. Circular A-119 specifies that each federal agency "must use voluntary consensus standards, both domestic and international, in its regulatory and procurement activities in lieu of government-unique standards, unless use of such standards would be inconsistent with applicable law or otherwise impractical." A-119 defines "voluntary consensus standards" using language far more specific that that of the NTTAA, in accord with the TBTA Annex 4 principles and, generally, with ANSI accreditation rules [20]. This definition excludes many consortia-developed standards, a fact that has been criticized by some in U. S. industry, including in testimony before the U.S. House of Representatives [21]. Circular A-119 has had specific regulatory implications. For example, a number of comments filed before the U.S. Federal Communications Commission (FCC) have referred to Circular A-119, and the agency has, in at least one case, taken note of the accordance of its decision with A-119 [22].

So, following the TBTA, U.S. law has moved toward a domestic position parallel to that defined by the TBTA. One significant difference is that, while the TBTA puts "appropriate international standardizing bodies" in a key position, the U.S. has "voluntary consensus standards," sometimes defined according to ANSI accreditation policies, in a parallel position. Since "international standardizing bodies" are generally driven to a large degree by national interests while "voluntary consensus standards" are more representative of private interests, this distinct approach is in accord with the U.S. tradition of private-sector standardization. U. S. industry supports both an ANSI-accredited system and a significant consortium activity.

EUROPEAN RESPONSE TO TBTA

Compared to the U.S., Europe's standardization tradition involves a greater degree of government involvement. Furthermore, Europe has been integrating its economic activities since the 1990s. Perhaps as a result of these factors, the European response to the Technical Barriers to Trade Agreement has revolved around coordination of efforts regarding the more formal "international standardizing bodies." One noteworthy effort was the effective development of the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) within Europe. Both of these organizations, which trace their roots to the 1960s or earlier, attempt to harmonize standards throughout Europe. With the development of open trade within the European Union, the European Union decided it was important to eliminate arbitrary standards-related trade barriers. The importance they attributed to this issue is underscored by the fact that about 40 % of CEN's budget is covered by the European Union [23]. CEN and CENELEC are multinational, though not international, standards organizations. As such, they have

made agreements that, if managed properly, can be used to assist industry within the European Union. The Vienna Agreement [24] and the Dresden Agreement [25] provide a mechanism for European harmonization to proceed nearly concurrently with international harmonization through the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). The ISO and the IEC are Geneva-based nongovernmental standards-developing organizations that aspire to be truly global in their influence.

In the case of telecommunications, Europe has also engaged with the International Telecommunications Union, an international treaty organization linked to the United Nations. The Geneva-based ISO, IEC, and ITU each assign one vote to each country's representative, typically cast in the ISO and the IEC by a private-sector national committee. This approach gives particular strength to well coordinated alliances such as the European Union and its coordinating organizations. Funding, such as that provided by the European Union to CEN, CENELEC, and the European Telecommunications Standards Institute (ETSI), can support such alliances. If the funding and the shared vision is sufficient, such an organization has the potential of influencing the agenda of the ISO, IEC, or ITU and of accelerating or slowing the process for the benefit of the alliance. If, for example, companies operating within the alliance are not generally at the leading edge of technology, the alliance may seek to slow the standards process and adopt standards that impede the introduction of the latest technology. Conversely, an alliance of high-technology countries could assist domestic companies to increase their market share by accelerating the standards process and thereby speed the introduction of new technology. So, the current ISO, IEC, and ITU rules offer potential benefit in alliances.

THE U.S. NATIONAL STANDARDS STRATEGY

Partially in reaction to European initiatives, many in the U.S. have called for a more coherent approach to standardization. ANSI's U.S. National Standards Strategy [6] articulates these concerns:

> "The European Union is aggressively and successfully promoting its technology and practices to other nations around the world through its own standards processes and through its national representation in the international standards activities… Emerging economies with the potential for explosive growth are looking to ISO and IEC for standards. In some sectors these standards do not reflect U.S. needs or practices… The exclusion of technology supporting U.S. needs from international standards can be a significant detriment to U.S. competitiveness. The U.S. will lose market share as competitors work hard to shape standards to support their own technologies and methods. Equally important, standards are the basis for protection of health, safety and the environment. When our standards in these areas are not accepted elsewhere, we all lose."

U.S. governmental policy has evolved along the lines of these industry concerns. For example, in the "Memorandum of Understanding between the ANSI and the [U.S.] National Institute of Standards and Technology (NIST)" [16], the two organizations "agree on the need for a unified national approach to develop the best possible national and international standards, as reflected by the U.S. National Standards Strategy adopted by ANSI." NIST has not reached a similar agreement with the less centralized group of consortium standards setters.

One important implication of the cooperation between ANSI and the U.S. government regards the definition of "voluntary consensus standards" and therefore the legal position of traditionally developed standards as compared to consortia-promoted specifications. The ANSI National Standards Strategy states that "U.S. interests strongly agree on the

principles necessary for the development of national or international standards to meet societal and market needs." Among these principles of "successful standards processes" are consensus, open participation, balance, transparency, and due process. While the strategy applauds the benefits of consortia-based specification development, it encourages coordination among consortia and traditional standards developers. It also requests the U.S. government to "encourage more use of the principles embodied in accreditation by recognizing the ANSI process as providing sufficient evidence that American National Standards (ANSI) meet federal criteria for voluntary consensus standards." These federal criteria may trace back to the definitions of voluntary consensus standards in the NTTAA and in OMB Circular A-119. Because of the relationships among NIST, ANSI, consensus standards-developing organizations, and market-driven consortia, the details of the NTTAA and A-119 directly affect regulatory matters [26].

U.S. Governmental Role in Standards Development

According to Circular A-119, federal agencies "must consult with voluntary consensus standards bodies, both domestic and international, and must participate with such bodies in the development of voluntary consensus standards when consultation and participation is in the public interest and is compatible with their missions, authorities, priorities, and budget resources". Agencies are authorized to contribute funds as well as personnel. Furthermore, "Agency representatives serving as members of voluntary consensus standards bodies should participate actively and on an equal basis with other members, consistent with the procedures of those bodies, particularly in matters such as establishing priorities, developing procedures for preparing, reviewing, and approving standards, and developing or adopting new standards. Active participation includes full involvement in discussions and technical debates, registering of opinions and, if selected, serving as chairpersons or in other official capacities. Agency representatives may vote, in accordance with the procedures of the voluntary consensus standards body, at each stage of the standards development process unless prohibited from doing so by law or their agencies."

Many voluntary consensus standards have relevance to one or more federal agencies, typically due to an agency's procurement requirements or regulatory authority. Circular A-119 outlines conditions under which those agencies participate in standards development. However, one agency has a unique mission related to standards. The mission of the National Institute of Standards and Technology, an agency of the United States Department of Commerce, is "to strengthen the U.S. economy and improve the quality of life by working with industry to develop and apply technology, measurements, and standards." NIST lacks regulatory authority, and its procurement needs are rather small. However, NIST's standards mission has always been carried out through involvement in voluntary standards activities, particularly where measurements important to commerce are incorporated in standards. Circular A-119 provides encouragement for NIST staff members to participate directly in the development of voluntary consensus standards if such standardization will improve the economy and quality of life.

An Example of Proactive NIST Action in Standards Development

Standardization is a key driver in telecommunications. Regarding wireless communications, the U.S. in 1994 began taking the position that spectrum would be auctioned to private users, who would then be largely free to decide on its use. Following years of regulated specifications, the wireless communications industry was slow to develop the traditions of consensus standardization. In the 1990s, Europe's broadly supported GSM standard developed a strong posi-

tion in the world market for “second-generation” cellular telephones, while the U.S. market remained fractured. The standards wars of “third-generation” cellular were fought by many companies and consortia and ultimately in the International Telecommunications Union (ITU). As a treaty organization, the ITU voting policy is one vote per country.

In 1998, NIST began looking at a different wireless application: fixed broadband wireless access providing high-speed network access to businesses, homes, and other stationary sites, generally through rooftop antennas [27]. NIST found little evidence of U.S. or worldwide efforts to standardize such services, although an early program in the European Telecommunications Standards Institute (ETSI) had begun. This application seemed ripe for standards [28,29], but industry needed a catalyst. NIST assumed the role and called a meeting to discuss the topic in August 1998. With the participation of 45 attendees, a plan was crafted to initiate the standardization process.

The plan developed by this group did not follow the traditional telecommunications model of creating one or more national standards and then moving toward an international standards competition. Instead, the plan was to follow the traditions established in data communications that had led to the global standards underlying the Internet. These standards had yielded a vibrant business in which customers were delighted with dramatically declining prices while manufacturers enjoyed accelerating unit sales growth.

Following that model, the NIST-initiated group, after considering possible consortium development, elected to proceed with standardization through the ANSI-accredited IEEE Standards Association (IEEE-SA), which is the standards developing arm of the Institute of Electrical and Electronics Engineers (IEEE), a transnational nonprofit technical society of over 350,000 members [30]. In particular, that group approached the IEEE 802 LAN/MAN (Local/Metropolitan Area Networks) Standards Committee. IEEE 802 is the source of the ubiquitous Ethernet standards that define local area networks and that have rapidly turned new technology into readily available commodity equipment. IEEE 802 has also taken the lead in wireless data networking, with an active and successful project in the IEEE 802.11 Wireless LAN standards as well as a more recent effort developing the IEEE 802.15 Wireless Personal Area Network standards [31, 32].

In two months, the NIST-pioneered effort to create standards for fixed broadband wireless access led to an IEEE 802 Study Group chartered to develop a standardization plan. Four months later, this plan was approved, and the IEEE 802.16 Working Group on Broadband Wireless Access [33] was created and chartered to develop its first standards project. The project attracted broad global interest, eventually drawing members from 13 countries. Holding bimonthly weeklong sessions, it moved quickly. The core standard defining the WirelessMAN® air interface was approved as IEEE Standard 802.16 in 2001 [34,35]. Four additional standards to enhance the applicability of the work and aid deployment of the systems have also been published, with several more under development. Active work continues, with attention aimed at expanding the specification for mobile applications and at publishing a set of conformance test documents as standards [36]. Industry activity supports the standardization efforts, and the Worldwide Interoperability for Microwave Access (WiMAX) Forum is preparing to support compliance tests. Companies, small and large, are currently implementing the standard into commercial equipment.

NIST has actively participated in IEEE 802.16 activities. After initiating the project, a NIST staff member (the first author of this paper) was elected 802.16 Working Group Chair, leading the activities, driving the development of standards, and representing the group to its superior bodies. The same staff member has served as Technical Editor of standards, organized a number of sessions, and provided many other services to maintain the group’s progress.

This activity fulfills NIST's mission in several ways:

1. By encouraging standardization through the voluntary consensus standards process, the work supports the goals of the NTTAA, OMB Circular A-119, and the ANSI National Standards Strategy.
2. By encouraging the development of standards in an open, global, technically based, consensus process, the project ensures that all participants, large and small alike and regardless of nationality, can, if they have the resources, have access to the process so that the resultant outputs are likely to be of high quality.
3. By accelerating standardization, the work moves broadband wireless access closer to widespread deployment. This will expand opportunities for equipment vendors and service providers.
4. By leading to wider deployment, standardization will offer more broadband access alternatives to a wider range of U.S. consumers and businesses, including those in locations that may otherwise be poorly served by more conventional broadband access networks.
5. By enhancing the deployment of broadband services, the work will expand the applicability of the Internet and its positive effect on the economy.
6. By developing standards with global participation, the project will increase the chances of a uniform global result with broad export market opportunities for manufacturers in all countries.

NIST has also contributed its unbiased technical expertise to IEEE 802 standardization projects. In support of further such contributions, NIST has also planned to develop the National Wireless Electronic Systems Testbed (N-WEST) for use in measurements that contribute to effective standardization and compliance testing [37, 38]. Such an undertaking will require significant investment.

BALANCING INTERESTS: MANUFACTURERS VERSUS USERS

When seeking to boost their own economies, governments may wish to consider the full range of voices within their constituencies. For instance, standardization is often driven most strongly by manufacturers and other product vendors. These voices may argue that government action on standards should be driven, within WTO obligations, by the goal of enhancing production and profits among manufacturers. However, governments should not overlook the economic interests of the users of the technology. Interesting case studies might come from the fields of computer networking, including the most popular standards for wired and wireless networks developed by the IEEE 802 LAN/MAN Standards Committee. For instance, the success of Ethernet has been so strong over the past 30 years that the technology's primary inventor, Bob Metcalfe, considers it not so much a technology standard but as a business model [39]:

> "There are four business models out there today. The first is the vertical model... The second, which dominates today, is the horizontal model... The third is the Linux/open-source business model. And the fourth is the Ethernet business model. It's based on *de jure* standards with proprietary implementations of those *de*

> *jure* standards, and it is unlike open source in that competitors don't give their intellectual property away. The competition is fierce, but there is a market ethic that products will be interoperable. And the standard evolves rapidly based on market engagement in such a way to value the installed base. There is a heavy value placed on sustaining and maintaining the installed base. That's the Ethernet business model."

Clearly, deployment of these standards-based networks has had enormous impacts on economies. For example, IEEE 802.11 networks are widely used in the United States, with significant economic impact, even if most 802.11 equipment is manufactured elsewhere. Would the United States as a whole have benefited more from a policy of supporting, through standards policy, the U.S. manufacturing industry? Perhaps not.

CONCLUSIONS

The world standards system has undergone rapid change and restructuring. The role of governments in the emerging system is taking shape. Widely different models for government engagement exist in different regions of the world. Europe is oriented primarily toward interaction with formal international standardization bodies. In the United States, government and industry are agreeing that government should play an active role in encouraging and accelerating voluntary consensus standardization. As NIST is demonstrating through its participation in the IEEE 802.16 Working Group on Broadband Wireless Access, this role can constructively contribute to the economy and quality of life.

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