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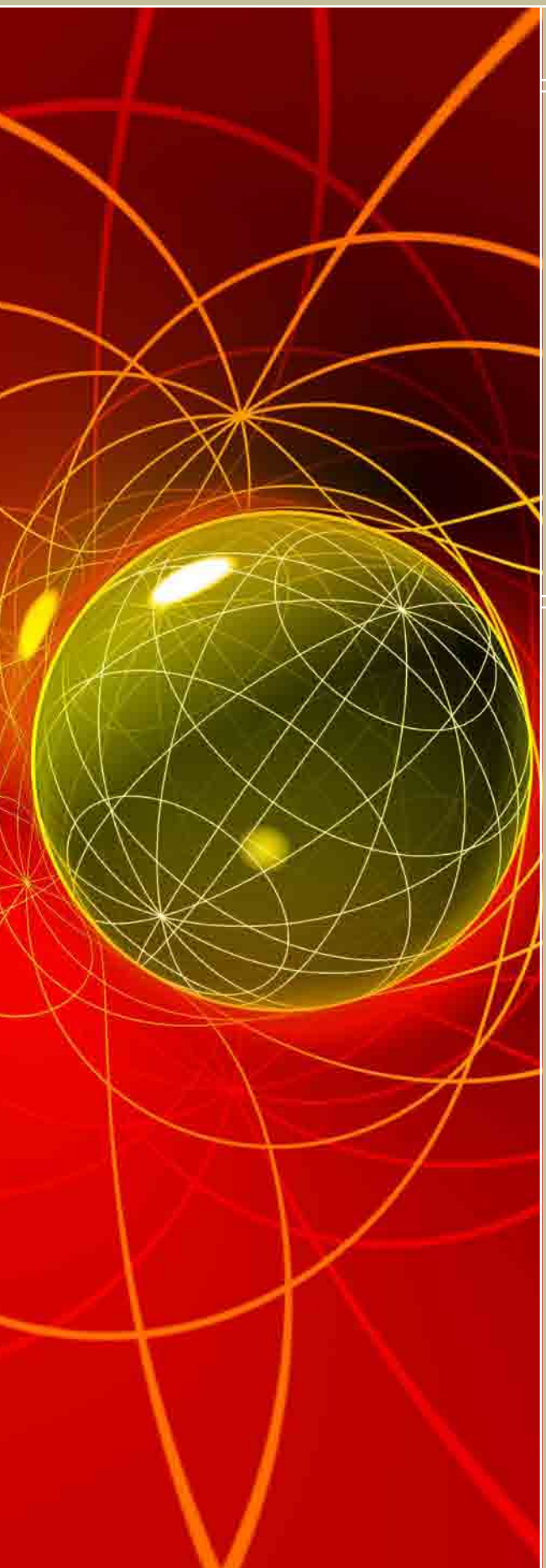

STANDARDS, STAKEHOLDERS, AND INNOVATION

China's Evolving Role in the Global Knowledge Economy

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TABLE OF CONTENTS

THE NATIONAL BUREAU *of* ASIAN RESEARCH

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FOREWORD

Today, China is moving rapidly toward fulfillment of its objective to become an "innovative society" by 2020. The implications of this transition are multifold and will bear significant consequences for the future of global information and communications technology (ICT) and other high technology sectors. A core component of this strategy is the development of indigenous innovative activities, or *zizhu chuangxin*. China has highlighted the development of technology standards as an integral part of this broad goal, and as a result, over the past several years we have witnessed China strengthening domestic institutions for standardization and increasing its activity in international standards bodies. With the country having emerged as a large and fast-growing market and an increasingly important site for a wide range of innovation-intensive activities within regional and global production networks, China's policies in the area of standards are now a subject of intense interest for the international business community as well as for the academic and policymaking communities in many of China's major trading partners.

Over the past five years NBR has directed a research project to examine a range of issues associated with standards-setting policy in China that has resulted in several international conferences, articles, reports, and briefings for policymakers. Marking the culmination of the third phase of this ongoing research initiative, this report both sheds new light on the environment in which China is developing its own standards-setting policies and assesses the implications and prospects for the success of these efforts.

Given the importance of China's development in this area, standards and innovation policy in China will continue to be a priority research area for the Economics and Trade Affairs Group at NBR. As such, we are already in the process of undertaking a new round of research on this important topic.

We would like to express our appreciation to Scott Kennedy and Richard (Pete) Suttmeier for their service as project research directors who played key roles in developing the agenda for the round of research that lead to this report. Their leadership was instrumental in ensuring a successful research project. We are also indebted to the third author of this report, Jun Su, who has partnered with NBR over the past three years by hosting workshops and conferences in Beijing, writing papers, and giving presentations. We would like to thank Professor Su for his all-around support of the project. Finally, we would like to thank Yao Xiangkui for his support of this project, in particular for the tremendous amount of work he put into the Chinese-language translation of this report.

Eric Altbach
Vice President, Economic and Trade Affairs
The National Bureau of Asian Research

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The National Bureau of Asian Research

EXECUTIVE SUMMARY

This report examines the circumstances in which China's efforts to develop its own technology standards are occurring and assesses the implications and prospects for success of the initiatives.

MAIN ARGUMENT

- In information and communications technologies (ICT), China is making a long-term commitment to the development of standards as part of an effort to promote domestic technological innovation and make China an "innovative society."
- China's aspirations to become a standards setter in ICT should be seen against a background of institutional uncertainty in an international economy struggling to devise mechanisms of governance to accommodate rapid technological change and the emergence of large economies, and amidst a pluralism of views on techno-nationalist versus techno-globalist approaches.
- China's efforts to set and commercialize ICT standards domestically have met with only limited success due to inappropriate government intervention, failures to forge winning coalitions in standards-setting forums, and an inability to displace established international standards. Nevertheless, China is learning from experience, will push forward with standards development, and is likely to have greater success in the future.
- China has achieved some success in having its domestic standards adopted internationally and has made some contributions to jointly developed standards but has proven less capable of blocking standards initiatives that it opposes. Those elements of the Chinese government, research community, and industry that are most deeply integrated into the global economy have had the greatest chance for success because they have more quickly adapted to the global standards system.

POLICY IMPLICATIONS

- The techno-nationalist sentiments sometimes associated with China's standards initiatives should be tempered with a techno-globalist vision, both to promote the technological progress of the Chinese economy and to contribute to the provision of international public goods.
- The international community will want to monitor the implementation of China's innovation and standardization strategies and work with China in developing its capabilities for standards development.
- The international community can accommodate the emergence of a technologically dynamic, standards-setting China by facilitating Chinese participation in international standards bodies and consistently engaging Chinese experts, industry, and officials.

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Since 2003, when China announced its mandatory WAPI standard as an alternative to the widely used Wi-Fi wireless communications standard, international interest in standardization in China has expanded rapidly.[1] The growing size and influence of China's economy, and China's steadily improving technological capabilities, make analysis of Chinese standardization an ongoing challenge. This is especially true in light of recent trends.

The first is China's growing involvement with international standards organizations—formal standards development organizations (SDO) and various standards consortia that have become key forums for information and communications technology (ICT) standardization—and the increasingly differentiated and expanding institutional arrangements for standardization in China itself. China's participation in international standards organizations has grown rapidly and indicates a commitment to a Chinese presence in governance mechanisms. China's learning curve regarding the operation of international standards organizations is showing itself to be remarkably steep.

A second important trend is the build-up of China's science and technology, marked by the initiation in 2006 of China's "National Medium- and Long-Term Program for Scientific and Technological Development (2006–2020)" (MLP), with

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[1] "China's WTO Implementation and Other Issues of Importance to American Business in the U.S.-China Commercial Relationship," U.S. Chamber of Commerce, September 2007, http://www.uschamber.com/publications/reports/0709us_china.htm.

its goal of creating an "innovative society" in China by 2020, and the complementary science and technology programs of the Eleventh Five-Year Plan.[2] Both plans focus on "innovation," now a ubiquitous buzzword in government policy statements and popular discourse, and take as measures of success in innovation the development of Chinese standards incorporating Chinese intellectual property (IP). Thus, the filing of patents and the initiation of standards are considered important "outputs" in formal research evaluation, and an organization's IP and standards record affect its eligibility for technology policy privileges. The plans call for the development of indigenous national innovative activities (*zizhu chuangxin*) as a measure of technological sovereignty, and with it, national power and international influence.[3] The vision of an innovative China laid out in the plans, and in frequent national policy statements, has clearly captured the imagination of many in China, leading one foreign observer to compare current Chinese enthusiasm for science, technology, and innovation to that of the United States at the time of the initiation of the space race.[4] That this enthusiasm is so tightly linked to standards and IP heightens the interest in standardization as Chinese stakeholders increasingly incorporate standards into their business strategies.

In this study we seek to explore and analyze these two trends and assess their significance for China and for the international community. The study builds on presentations and discussions at the international conference "Technical Standards and Innovation in China: Public Policy and the Role of Stakeholders" held in Beijing in October 2007 and on information obtained through our own research during the past few years.[5] It also incorporates our sense that China's growing activity in standardization is occurring in the midst of remarkable changes in the broader international environment. Although China's greater activism has not yet been matched by widespread international adoption of its standards, or the commercialization of Chinese standards in China or globally, we expect that China's officialdom and industry will continue to advance their standards agenda, with significant consequences for technological innovation and market structures. In the discussion below we explore the factors that will affect the pace at which this will occur and how the global business community, national governments, and international SDOs will adapt to this new entrant to the standards world.

The Context of the Study

China's interest in developing a national standards strategy and promoting its own technology standards is usefully seen in an international context characterized by significant institutional and technological change. Rapid technological progress, especially in ICT, the sector on which this

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[2] For discussions of the MLP, see Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-Year Science Plan: Mapping Research and Innovation Strategies for the 21st Century," *Physics Today* 59, no. 2 (December 2006): 38–43; Sylvia Schwaag Serger and Magnus Breidne, "China's Fifteen-Year Plan for Science and Technology: An Assessment," *Asia Policy* 4 (July 2007): 135–64; and Linda Jakobson, "China Aims High in Science and Technology," in *Innovation with Chinese Characteristics: High-Tech Research in China,* ed. Linda Jakobson (New York: Palgrave Macmillan, 2007): 1–36.

[3] Chinese leaders have taken pains to explain that *zizhu chuangxin* does not entail a retreat from international cooperation. Instead, they suggest that it should be understood as including genuinely "original innovation" (*yuanshi chuangxin*), "integrated innovation" (*jicheng chuangxin*, or the fusing of existing technologies in new ways), and "re-innovation" (*yinjin xiaohua xishou zaichuangxin*), which involves the assimilation and improvement of imported technologies. Originally translated in official documents as "independent innovation," zizhu chuangxin is now rendered as "indigenous innovation."

[4] Christopher Thomas, "China's Invent-It-Here Syndrome," *Forbes*, December 31, 2007, http://www.forbes.com/2007/12/28/china-innovation-patents-tech-enterprise-cx_ct_1231chinadiary.html.

[5] Information was obtained from both written sources and interviews. To protect the anonymity of the sources, no citations are included for interviews. The study also builds on an earlier international workshop held at Tsinghua University in January 2006.

report focuses, increasingly involves the fusion, or convergence, of different technologies, which puts a premium on the achievement of interoperability among components.[6] This is especially so in light of the growing importance of the Internet and the ways in which multiple devices become linked together to create an "Internet of things." Success in achieving interoperability depends critically on standards, and as a result, the importance of technology standards in the strategic economic thinking of governments and corporations around the world has increased, as has interest in the study of interoperability itself and its relationship to innovation.[7]

Changes in technology are closely related to changes in industrial structures involving the creation of global production networks (GPN) and, increasingly, global innovation networks.[8] GPNs both are made possible by and create demands for the modularity of technological systems; progress in ICT facilitates the satisfaction of those demands, as knowledge is codified, digitalized, and diffused throughout the networks. GPNs, however, also require integrators to manage the successful combination of modular components into finished products, a process which calls for the creation of a common technological architecture built around common standards.[9]

With technological change moving at a rapid rate, slow-moving standards-setting processes no longer serve the interests of producers in high technology fields.

In light of the growing importance of standards resulting from both technological change and changes in the global organization of production, it is not surprising that SDOs have also been subject to the forces of change. With technological change moving at a rapid rate, slow-moving standards-setting processes no longer serve the interests of producers in high technology fields. As a result, over the past three decades we have seen both the introduction of accelerated procedures in established SDOs and a proliferation of new, unofficial standards-setting groups—principally standards consortia and alliances—intended to facilitate standards-setting activities. These institutional innovations have been quite successful in a variety of ways, but they have also engendered conflict over inequalities of power and the strategic behavior of the participants, including the ways in which participants deploy intellectual property as a tool of corporate strategy in standards setting. For some observers, international standards-setting institutions are in crisis; for others, while there may not be crisis, there surely are a number of problems occasioned by the factors we are considering here.[10]

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[6] This report focuses on the ICT sector, where China's initiatives have drawn the most concern from the international community. In other sectors there have been minimal tensions.

[7] See Urs Glasser and John Palfrey, "When and How ICT Interoperability Drives Innovation," the Berkman Center for Internet and Society, Harvard University, November 2007, http://cyber.law.harvard.edu/interop/pdfs/interop-breaking-barriers.pdf. For a series of examples of interoperability standards, see Technology Standards and Interoperability, Business Software Alliance, 2008. For a recent expression of Japanese views, see "Japan Must Fight for Say in Shaping of Global Standards," *Nikkei Weekly*, February 12, 2008, http://www.nni.nikkei.co.jp/.

[8] Dieter Ernst and David Hart, "Governing the Global Knowledge Economy: Mind the Gap," East-West Center, Working Paper, no. 93, January 2008.

[9] For an interesting discussion of the importance of modularity and limits to it, see Dieter Ernst, "Limits to Modularity: Reflections on Recent Developments in Chip Design," Industry and Innovation 12, no. 3 (September 2005): 303–35.

[10] Carl Cargill, chief standards officer for Sun Microsystems, is a prominent voice arguing for the crisis interpretation. See "International Open Standardization and China," Sun web log, January 25, 2008, http://blogs.sun.com/dennisding/entry/open_standardization_trend_in_china.

Discussions about the role of patents in standardization have become widespread, and while some progress towards consensus approaches can be seen, conflicts are still much in evidence.[11] Controversies over the relationships between IP and standardization have also pointed to some larger questions about who participates as stakeholders in standardization, the balance between standards as public goods and standards as mechanisms to facilitate private gains, and the ways in which standards support or frustrate innovation. Such questions, in turn, inevitably introduce discussions of the proper role of governments and international organizations in standardization.[12]

Further complicating the contemporary international standards landscape is the appearance of China and other large economies as important new players shaping the global economy, and the diffusion of technological capabilities to new regions of the world as part of the "new geography of science."[13] As the importance of the new large economies grows, so too do these nations' interests in the governance regimes affecting the international economy, including the regimes that concern standardization. While China, India, and other countries have profited from the existence of these regimes, they are not always entirely comfortable with them for both instrumental and philosophical reasons. China's November 2005 submission to the WTO on "IPR Issues in Standardization" illustrates this point, as does China's position on the future of Internet governance at the 2005 World Summit on the Information Society (WSIS).[14] There is a perception within the rising economic powers that existing international regimes favor the established economic powers, and that the gains from participation in global production and innovation networks are skewed toward those who control standards and the intellectual property embodied in them. The emphasis on "strong IP" norms in the established regimes is seen by some as not consistent with innovative efforts that may challenge existing international standards, cultural assumptions about the ownership of knowledge, or beliefs about the ways in which science and technology should be used to serve national development.

This combination of factors—technological and institutional change, the emergence of new large economies into the international system, and the stresses and strains placed on mechanisms for the governance of the international economy—creates a fluid and dynamic environment in which China seeks to carve out its own standards regime to support its technological development and national interest more generally. An appreciation of that fluidity is found in a recent report issued by the European Patent Office (EPO) that sought to better understand the contexts in which intellectual property regimes are likely to evolve in the 21st century.[15] The EPO analysis identifies four possible future directions. In the first, global market forces and the power of multinational

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[11] As Richard Clark (an original member of the committee that established JPEG/MPEG, and JPEG's webmaster) has put it, "Patent declarations to standard bodies vary from vague to deceitful, and are difficult to acquire," adding that "standards use is stuck because of patent issues, leading to frustration, and inertia." Efforts to address these problems in China include the policy developed by the AVS Working Group (http://www.avs.org.cn/en/) and the CESI-developed *IT Standard Drafting Organizations' IPR Policy Template,* according to which, under Articles 11–14, members "shall" disclose IP claims and declare licensing conditions for all owned patents related to the standard on an *ex ante* basis. See Richard Clark (remarks at the European Patent Office Workshop on Patents in the Field of Industrial Standards, September 2006).

[12] Kenneth W. Abbott and Duncan Snidal, "International 'Standards' and International Governance," *Journal of European Public Policy* 8, no. 3 (June 2001): 345–70.

[13] DEMOS, "The Atlas of Ideas: Mapping the New Geography of Science," London, 2007.

[14] In the former, China proposed to expand the domain of the TBT to include problematic cases of IPR in standards by defining excessive royalties charged for the use of standards as a trade barrier and thus a matter of TBT (rather than TRIPS) jurisdiction. In the latter, China objected to having key aspects of Internet governance continue in the hands of ICANN (the Internet Corporation for Assigned Names and Numbers), which it sees as a largely U.S.-controlled entity.

[15] "Scenarios for the Future," European Patent Office, March 2007, http://www.epo.org/topics/patent-system/scenarios-for-the-future/download.html.

corporations (MNC) help reinforce the current regime of strong intellectual property protection. There are no radical breaks from the existing system, but many of the problems with the current system—such as the proliferation of junk patents and patent fences—persist to the detriment of IP harmonization and effective standards-setting processes.[16] In a second scenario, dissatisfaction with the current regime among the emerging large economies leads to an active industrial policy to advance national interests in intellectual property, weakening many of the purportedly universal norms characteristic of the first scenario and reducing chances for harmonization of national patent systems and international standards. The third possible scenario involves a broadening of stakeholder participation, leading to a stronger assertion of social values in IP regimes in support of public interests. The fourth scenario foresees dramatic scientific progress and discontinuous innovation in a variety of fields, which make the hope of a modernized, internationally harmonized patent system, with common standards, impossible.

When we reflect on the discussions occasioned by China's active standards strategy, many of the themes from the EPO study are present. Those in industry and government invested in the international harmonization of standards—including many in China—are committed to the strengthening of the existing regime and the further diffusion of the norms embedded in it. On the other hand, as illustrated in particular by the WAPI case and, more recently, by China's promotion of its own information security standards, there are signs that China intends to follow its own road, even to the detriment of principles of interoperability that serve the interests of many Chinese producers.[17]

The themes of the EPO's third scenario are also evident in discourses over Chinese standardization, as illustrated most clearly in the spirited exchanges over the Open Document Format standard and the status of the Microsoft OOXML as an international standard, the frequent official and unofficial defenses of open-source software more generally, and statements pointing to inequalities inherent in the strong intellectual property rights (IPR) norms articulated by the developed countries. Finally, as China intensifies its commitment to national scientific and technological development in the context of its new MLP, especially in such areas as nanotechnology and biotechnology, we can expect ongoing scientific and technological progress to put pressure on standardization and the development of intellectual property systems in China and, as Chinese innovators seek IP protection elsewhere, on the international patent regime as well.

China's standardization ambitions thus are developing in this fluid international environment. As something of a newcomer, China faces a number of challenges to master the intricacies of the environment, as its unpleasant learning experiences in trying to internationalize the WAPI standard have demonstrated. At the same time, China also faces interesting opportunities to introduce standardization practices that are consistent with, and build on, the best of the international legacies (while avoiding the worst) and, in the process, to become a force for progressive reform of the governance mechanisms for the international knowledge economy. Such a role will be reinforced by the enhancement of China's own technological capabilities and its emergence as a technical leader in international standardization.

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[16] Rick Merritt, "Rules Need a Re-write Say IP Experts at Forum," *EETimes,* April 17, 2008, http://www.eetimes.com/news/latest/showArticle.jhtml?articleID=207400128.

[17] Scott Kennedy, "The Political Economy of Standards Coalitions: Explaining China's Involvement in High-Tech Standards Wars," *Asia Policy* 2 (June 2006): 41–62. We should recall that while interoperability is a central objective of a globalized high technology economy, it may not be the only, or prime, objective of technological development for some parties, including national governments.

Trends in Chinese Technology Policy

The rapid growth of China's interest in standards is occasioned by a new commitment to the development of indigenous scientific and technological capabilities, a commitment that derives in part from the changing nature of China's relationship with the international economy following WTO membership. China's economic growth has long been characterized by the mobilization of abundant labor and high levels of investment. This "extensive growth" path has become increasingly unsustainable and needs to be replaced by a growth trajectory based more on productivity gains and innovation. The technological foundation for this more "intensive" growth, however, has yet to be consolidated. Over the past two decades much of the technology enabling the qualitative changes in China's economy has come from abroad. This has been facilitated in part by a "market for technology" orientation in China's foreign trade and investment policies in which market access was facilitated in return for technology transfer.

Chinese officials believe that the usefulness of this policy tool is increasingly limited. China's WTO commitments require that efforts to force technology transfer as a condition of market entry be discontinued. Furthermore, as Chinese industry has become more competitive, the country's leaders worry that foreign corporations are likely to become more discriminating in the levels of technology they are willing to transfer to China. In addition, many of the more advanced technologies China seeks can be considered "dual use"—they have both civilian and military applications—with the result that efforts to transfer them face much closer scrutiny by the export control regimes of foreign governments, especially the United States. Beyond these obstacles, the new emphasis on developing Chinese IP and incorporating it into Chinese standards can be viewed in the first instance as an effort to capture value from national investments in research and development. Reliance on foreign technology is seen by some in China as having reached a level of unacceptable dependency, especially when Chinese producers are forced to pay substantial royalties for the rights to use the technologies and when foreign IP holders control core technologies on which China's digital future and economic security depend. Moreover, a growing concern for information security is also evident in some standards initiatives, as China seeks to strengthen its control of standards used in information security technologies.[18] Lastly, concerns for national prestige through technological achievements are evident in the national standards policy discourse.

These considerations—touching on competitiveness and national security—have led to active debates in China between those who would continue to employ proven technologies from abroad, even in the face of a changing technology transfer environment, and those who believe that China has reached the stage where it should be setting a course to become "an innovative society" that develops its own technologies. The latter view is clearly now in the ascendancy and has become embodied in the new MLP and the package of implementing policies (including direct R&D support, tax incentives, government procurement practices, and competition policies) intended to establish China as a scientific and technological leader by the year 2020.

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[18] The State Encryption Management Bureau, for instance, plays a role in standardization and has been sponsoring work on a domestically developed security chip, the "Trusted Computing Module" (TCM). Recent Chinese "notifications" to the WTO Committee on Technical Barriers to Trade on intended rule-making have included a number of items dealing with technical requirements and conformity assessment procedures for information security products to be used in China. For recent discussions of information security issues in China, see Christine Zhen-wei Qiang, *China's Information Revolution: Managing the Economic and Social Transformation* (Washington: The World Bank, 2007); and Martin Ahlgren, Magnus Breidne, and Anders Hektor, *IT Security in the USA, Japan, and China: A Study of Initiatives and Trends within Policy, R&D, Industry and Technology* (Stockholm: Swedish Institute for Growth Policy Studies, 2005).

Nevertheless, a wide spectrum of attitudes and interests toward a technology policy emphasizing zizhu chuangxin, and its goals of developing Chinese standards incorporating Chinese IP, can be found among government officials, industry representatives, and academics. Within this community of stakeholders, we find considerable variation in thinking about standards—as a function of types of industries and business models with which stakeholders are associated, orientations toward the international economy, relative importance of commercial as opposed to national security concerns, and expectations with regard to the role of government in standardization, technology policy, and economic management more generally. We might categorize membership in this community as being comprised of ideological techno-globalists, instrumental techno-globalists, instrumental techno-nationalists, and ideological techno-nationalists.

The instrumental techno-globalists are those who find it in their economic and professional interests to maintain an open international orientation and active working relations with foreign companies and technology communities.

The ideological techno-globalists, including some liberal economists, government officials, and representatives of the media, are skeptical of the national technology-development project as a whole—on philosophical or theoretical, as well as practical, grounds. According to this view, at this stage of China's development it makes more sense for the economy to continue to rely on imported technologies and to continue to build wealth from the employment of those technologies without making a commitment to indigenous technological development. By extension, the pursuit of a national standards strategy is considered ill-advised.

The instrumental techno-globalists are those who find it in their economic and professional interests to maintain an open international orientation and active working relations with foreign companies and technology communities. They take a market-oriented approach toward standards and do not place great importance on national projects for technological development. Instead technological development is seen as arising from the initiatives of enterprises and from close working interactions with global technology leaders. Instrumental techno-globalists might harbor techno-nationalist sentiments, but these are subordinated to more pragmatic interests in capturing value from international cooperation and increasing opportunities for co-development of standards in technological innovations. Techno-globalists of both camps might also point to failed government-promoted standards initiatives that have contributed very little to the Chinese economy and may have imposed considerable costs on the country, as with the case of TD-SCDMA, China's third generation (3G) mobile telephony standard discussed below.

Instrumental techno-nationalists are doubtful that contacts with the international environment can satisfy China's technological needs over the long run, even though most of the instrumental techno-nationalists would recognize the importance both of sourcing technology from abroad when possible and of opportunities for international cooperation. For reasons alluded to above regarding competitiveness, national security, and technological learning, they believe that national

technology programs linked with positive industrial policies are necessary to satisfy national needs. China, therefore, should promote its own national standards.

The ideological techno-nationalists support many of the same policy initiatives as the instrumentalists, including the promotion of standards, but they do so out of a more adversarial view of international political economy, largely shaped by their view that global capitalism is under the control of large multinational corporations and mostly benefits those companies' home governments. The ideological techno-nationalists consider China's national security to be their primary concern in technological development, including the promotion of technology standards.

Of course these orientations are presented as ideal types. As such they run the risk of oversimplifying a complex reality in which attitudes are mixed together and appeals to techno-nationalist or techno-globalist symbolism are used to serve the strategic and coalition-building interests of different stakeholders. Nevertheless, the play of interests among these four categories is evident in a number of Chinese standards cases and does shape China's approaches to the development of its own national system of standardization and its interaction with international standards regimes. The case of the EVD (enhanced versatile disc) standard is illustrative, but the recent evolution of problems with the TD-SCDMA is an even better example.

Even though China was successful in having TD-SCDMA accepted as an international standard, its share of the patents in the standard are thought to be only 7.3% of the total, and its ability to use that standard as the basis for 3G service in China has been seriously wanting.[19] At the same time, the use—prompted by techno-nationalist sentiments—of the state's power to support the development of the standard and to insulate TD-SCDMA from competing standards has meant that 3G service using other standards has been attenuated. Technical difficulties, bureaucratic conflicts, and inertia, however, have delayed the implementation of the standard. This has been to the detriment of Chinese consumers and Chinese telecom companies with more techno-globalist orientations and has elicited sharp criticism from the media.[20] China thus finds itself the maker of many of the world's 3G phones, "but almost none of the world's 3G phone calls."[21]

Central to the MLP is the establishment of Chinese standards incorporating Chinese intellectual property. As an important part of this effort to strengthen national technological sovereignty, the plan also calls for China's industrial enterprises to become the core of the national innovation system (NIS). The national R&D system has taken standards development as a key task, special R&D programs for standards have been initiated, and tax and procurement policies are being used to incentivize Chinese enterprises to become centers of intellectual property development and standards initiatives. In addition, direct R&D support is being offered to enterprises. In the IT sector, for instance, Huawei and Datang have been awarded new "national laboratories," an institutional designation that leads to preferential funding that had previously been reserved for research institutes and universities.[22]

The MLP includes sixteen major national technology-development projects for which there will be substantial investment. One of these is the initiation of a 4G "Next-Generation Broadband

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[19] Yan Hui, "The 3G Standard Setting Strategy and Indigenous Innovation Policy in China: Is TD-SCDMA a Flagship," Danish Research Institute for Industrial Dynamics, DRUID Working Papers, no. 07-01, 2007.

[20] See Caijing Annual English Edition, December 2007, http://www.caijing.com.cn/English/Cover/2008-02-20/48880.shtml and http://www.caijing.com.cn/English/Editorial/2008-02-20/48880.shtml; and Yan, "The 3G Standard Setting Strategy."

[21] "Consumer Champions—Technology in China and India," *Economist*, November 10, 2007. See also Duncan Clark, "China Misdials on Mobiles," *Far Eastern Economic Review* 170, no. 10 (December 2007): 52–59.

[22] Caijing Annual English Edition.

Wireless Mobile Communications Network Project" with financial support from industry, increasingly wealthy local governments, and the national government. The project is expected to involve next-generation cellular communications, broadband access, and short-distance wireless networks. Government support is expected to be in the order of 20 billion renminbi (RMB) ($2.8 billion), a fourfold increase over the 5 billion RMB reportedly invested in TD-SCDMA over the past ten years. Industry is expected to contribute another 50 billion RMB.[23]

Unlike national R&D projects of the past, in which the Ministry of Science and Technology (MOST) pumped funds into government research institutes and universities with little or no commercial payoffs, the new plan will focus more spending on company laboratories.[24] Still to be answered, however, are questions such as who participates, how funding will be allocated to companies likely to participate—some of which are state owned (Datang, China Mobile), some private or mixed private-public (Huawei, ZTE), and some joint ventures (Shanghai Alcatel)—and how cooperation and competition among companies will be managed. Clearly, however, standards will play a very important role in the development of this ambitious national project.

Standards and Innovation

The close relationship between innovation and standards setting in the MLP—especially the efforts to link R&D and standardization—raises questions about the extent to which China's approaches to the standards-innovation relationship accord with practices elsewhere. The complexity of the situation has received considerable scholarly attention.[25]

On one hand, standards foster and facilitate innovation. Standards, in this sense, represent a kind of platform from which multiple innovative implementations "to the standard" can be made, offering interoperable technologies with expanded functionality. Standards can facilitate market expansion and enhance "market pull" factors influencing potential innovators. Innovation, of course, can also render established standards obsolete; the rise of the Internet as a platform for computing, for instance, raises a whole series of new software standards issues while also threatening the continued relevance of standards based on the personal computer as platform.[26]

On the other hand, standards can stifle innovation, especially where there is a large installed base—and sunk costs—of equipment built around the standard and thus inducing resistance to innovation. The case of the QWERTY keyboard, as a de facto standard, is often cited as an example of how a standard can generate network effects that block change toward technically superior innovation, and it has been suggested that the U.S. National Bureau of Standards refused to write standards to meet the interface needs of the early computer industry for fear of holding back

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[23] Caijing Annual English Edition. Yan reports that government expenditures on TD-SCDMA totaled some 1 billion yuan ($120 million) over the past decade. Yan, "The 3G Standard Setting Strategy."

[24] Caijing Annual English Edition.

[25] Joseph Farrell and Garth Saloner, "Standardization, Compatibility, and Innovation," *Rand Journal of Economics* 16, no. 1 (Spring 1985): 70–83; Robert Allen and Ram D. Sriram, "The Role of Standards in Innovation," *Technological Forecasting and Social Change* 64, no. 2 (June 2000): 171–81; Joel West and Jason Dedrick, "Innovation and Control in Standards Architectures: The Rise and Fall of Japan's PC-98," *Information Systems Research* 11, no. 2 (June 2000): 197–216; Robert L. Mallett, "Why Standards Matter," *Issues in Science and Technology* (Winter 1998–1999): 63–66; Richard Hawkins, Robin Mansell, and Jim Skea, *Standards, Innovation and Competitiveness: The Politics and Economics of Standards in Natural and Technical Environments* (Aldershot: Edward Elgar, 1995); and Andrew Updegrove, "Standards and Innovation (and Standards Degradation)," ConsortiumInfo.org web log, April 2, 2007, http://www.consortiuminfo.org/bulletins/mar07.php#considerthis.

[26] Updegrove, "Standards and Innovation."

innovation.[27] The appropriateness of standardization for innovation is thus also linked to phases of innovation during which nonstandard designs compete in the early stages of a technological trajectory until such time as a "dominant design" becomes standardized.[28]

Central to the standards-innovation relationship is the role of intellectual property in standards. Leading firms in the global ICT sector have taken a range of approaches toward IP that are closely linked to their business models. At one end of the spectrum, some seek to develop a technology that becomes a stand-alone de facto or official standard for which its creator charges a significant royalty to other market participants. A good example is Qualcomm's second-generation cellular telephony technology, code division multiple access (CDMA). A second alternative, exemplified by the DVD player, is to contribute technology to a jointly held standard in which income is derived from royalties and sales of related products. A third option, typified by Microsoft's Windows operating system, is to hope that as a company's technology is widely adopted, others will not pay royalties for its use but rather develop compatible products and services that increase the centrality of one product. The next strategy is to contribute to a standard jointly developed with others in which royalty claims are relatively insignificant and income is derived primarily from the sale of products that include the standard because the standard adds value to their products. The universal serial bus (USB), which connects computers and peripherals and whose development is supported by a large number of companies around the world, is a good example. Other firms are not interested in contributing to new standards at all but rather in building products based on existing standards. Finally, at the far end of the spectrum, is general opposition to a centralized and coordinated standardization process and instead the encouragement of decentralized and continuous contributions to evolving technologies over which no one claims IP rights and where income is derived from other sources. The best example is the open-source software movement.

There is no consensus on which approach most helps or hinders innovation. It is possible that effects depend on when an approach is applied in a technology's life cycle. On the one hand, innovators who can acquire intellectual property rights for novel technological innovations and then incorporate them in proprietary standards can reap huge rewards for their efforts. In this sense, proprietary standards function like strong patents, offering handsome rewards as incentives to innovators. Later on in the innovation cycle, however, proprietary standards may work to block innovation. In addition, the increasingly serious "patent fence" problems in standardization have also discouraged innovation and led to protracted uncertainties as to the establishment of successful standards which might be useful for innovation.[29]

The standards-innovation relationship is also usefully seen in the context of the global production and innovation networks noted above. It is clear that standards play a critical role in enabling the formation of such networks, which have been built upon the ability to codify knowledge to facilitate modular production. Recent research, however, has pointed to the limits of modularity in the face of ongoing technological change. With the increasing complexities of new technologies, simple codification becomes more difficult, with the result that participants in the network become more jointly involved in research, search, and learning, while "flagships" or system integrators are

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[27] David Hemenway, *Industrywide Voluntary Product Standards* (Cambridge: Ballinger, 1975), cited in Joseph Farrell and Garth Saloner, "Standardization, Compatibility, and Innovation," *RAND Journal of Economics* 16, no. 1 (Spring 1985): 71.

[28] William J. Abernathy and James Utterback, "Patterns of Industrial Innovation," *Technology Review* 80, no. 7 (June–July 1978): 40–47.

[29] In Harald Alvestrand's view there are (1) "too many patents," (2) "too many secrets, for too long," and (3) "bad patents." Alvestrand, "IETF Standards Process and IPR" (remarks at the European Patent Office Workshop on Patents in the Field of Industrial Standards, September 2006).

challenged to rethink the properties of the network. With "simple modularity," flagships designed and assumed control of standards; however, as simple modularity gives way to the demands of increasingly complex technologies, it will become increasingly difficult for flagships to control standards without the active participation of others in the network.[30] This may also be part of the reason for increasing interest in ideas such as "open innovation" and in new thinking about proprietary standards and the management of intellectual property.

The implementation of China's MLP, with its objective of linking R&D progress with standardization, thus faces the challenge of sorting through the complexities and contradictions of the standards-innovation relationship. In this challenge China is not alone. In Korea, for instance, the government supports active participation in international standards-setting bodies in areas that have high priority in national R&D projects.[31] In Europe, where the establishment of the global system for mobile communications (GSM) standard is generally considered to have been an essential ingredient in stimulating a technologically progressive European mobile phone industry, the standards-innovation relationship is receiving considerable policy attention.[32]

For instance, recent policy discourse in Europe includes analyses of the role of standards in promoting innovation in both public sector and commercial realms. Reminiscent of China's MLP aspirations, this discourse also includes discussions of how to incorporate R&D results from the seventh EU Framework Program into new standards.[33] European plans call for efforts to incentivize the research community to consider standardization as part of its work, to train research managers and research evaluators in the basics of standardization, and to build new links between those members of the research community doing "standardization-relevant research projects" in EU-determined high priority areas and standardization professionals. In addition, European standards organizations are encouraged to set up "technology watch activities and help desks" to facilitate the transfer of research results from framework programs to standardization, with the possibility that financial support for this activity will be forthcoming from the European Commission.[34] Thus, China's attempts to strengthen the standards-innovation relationship through the linking of R&D and standardization are not unprecedented. Those efforts, however, must be seen against the background of some of the core issues surrounding China's innovative capacities.

China's Innovative Capacities and the Role of Government

Given the close relationship between innovation and standardization in the MLP, questions over China's capacity for innovation pertain directly to the prospects for efforts in standardization. Although China's innovative potential has been widely discussed in recent years, a consensus on that potential has been elusive. On the one hand, skeptics point to significant problems in China's ability to move toward the innovative society to which the country aspires. The skeptics call attention to such factors as serious problems with the protection of intellectual property rights;

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30 Ernst, "Limits to Modularity."

31 Sam Oh (remarks at the Symposium on International Standards, Government Policy, and Innovation, Seoul, March 21, 2008).

32 The recent announcement that the European Commission will endorse the DVB-H standard for mobile TV seemingly follows the GSM precedent of setting a standard in order to move technology forward. On the original case, see Jacques Pelkmans, "The GSM Standard: Explaining a Success Story," *Journal of European Public Policy* 8, no. 3 (June 2001): 432–53.

33 See "Toward an Increased Contribution from Standardization to Innovation in Europe," Communication from the Commission to the Council, the European Parliament, and the European Economic and Social Committee, March 11, 2008 (COM 2008 133 final).

34 Ibid.

weak venture capital and irrationalities in the financing of economic activities more generally; an R&D system plagued by a legacy of commercial failures, problems of misconduct, and derivative research; and an industrial culture built on an abundance of inexpensive labor and lacking a strategic sense of the importance of longer-term investments in innovation. In addition, China's record of assimilating foreign technology has been weak, in this view, and has not benefited from technological spillovers from FDI, including foreign investment in R&D facilities in China. Many of these problems are seen as linked to excessive government control, which weakens or distorts market forces, and the government's ongoing reliance on state-directed innovation initiatives, including the MLP.

More positive interpretations, however, can also be found. These call attention to the remarkable increase in IT penetration, the size and distinctive features of China's domestic market, China's success in penetrating foreign markets, the growing capabilities—in spite of its many problems—of the R&D system (especially in terms of financial support and human resources), and evidence of a change in the culture of industry toward one that is committed to innovation. The positive view also calls attention to China's success in attracting significant R&D activities by multinational corporations and to a belief that technical interactions with MNCs are one of the distinctive features of China's national technological enhancement. This positive interpretation also sees the government's role as characterized by more successful interventions to overcome market failures, especially those associated with the technological weaknesses of Chinese companies.

The positive view also builds on distinctions between different types of innovation, arguing that although China's record with radical innovation may be disappointing, increasing capabilities are evident in incremental, modular, and architectural innovations.[35] In addition, the recent literature on "disruptive technologies" calls attention to the fact that countries like China, with distinctive and complex market conditions and with a demonstrated orientation toward serving second-, third-, and fourth-tier international markets, might very well find trajectories for innovation that have not attracted foreign industry leaders.[36] If so we might also then begin to see Chinese innovations, incorporating Chinese standards, in Chinese products diffusing throughout these non-first-tier markets.[37] Leaders of the Chinese research community are hopeful that disruptive innovations will emerge from the work of the MLP over the next fifteen years as work in the bio-nano-IT fields reaches or surpasses international levels.

From varied discussions of innovation in China, it is clear that disagreements over China's innovative capacity often turn on the relative importance of market forces and market-conforming policies, as opposed to state-directed efforts to promote R&D and standards. The optimists vis-à-vis China's potential tend to cluster around the former while the critics look to innovation failures and see a record of misconceived state interventions. Such a dichotomous view, though, is misleading. The focus on market forces ignores the fact that foreign companies are still in a privileged position to exploit the market and that some degree of government intervention may be necessary to move China toward its "innovative society" ideal. As is often the case, the issue is not government or no government but rather what kinds of government intervention should be considered.

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[35] Dieter Ernst and Barry Naughton, "China's Emerging Industrial Economy—Insights from the IT Industry," in *China's Emerging Political Economy: Capitalism and the Dragon's Lair,* ed. Christopher A. McNally (New York: Routledge, 2008).

[36] Ibid.

[37] For instance in April 2008, ZTE announced an agreement with Kenya for the construction of a new transmission network to serve the western part of the country. "ZTE to Build National Transmission Network for Kenya," Press Release, April 7, 2008, http://wwwen.zte.com.cn/main/News%20Events/Press%20Clipping/2008040760838.shtml.

Discerning the proper role of government for promoting technological development in support of national interest in a world of global innovation networks is a challenge faced by many countries around the world. Activist technology policies, as practiced by "successful" developmental states such as Japan, are increasingly being questioned.[38] Those who still see the benefits of state involvement emphasize that governments should act primarily as facilitators or enablers of market processes and wise corporate behavior, although what counts as appropriate support may vary according to different political traditions.[39] With regard to standards, negative experiences with industrial policy, including government intervention to support particular technology standards, have led many governments around the world to endorse the notion that standardization should be market-led, voluntary, and performance-based.

China's struggles with the role of government in standards strategy and technology policy more generally are complicated by its own statist tradition and political culture.

Nevertheless, a range of standards issues involving the public interest, and with implications for technological development, continue to make the role of the state a complex matter. These include classical "public goods" issues (e.g., national security, public health and safety, and environmental protection); the setting of regulatory policy in response to ICT innovations pertaining to telecommunications, privacy, and information security; the importance of anti-trust or competition policy for a market economy; and government procurement practices.[40]

China's struggles with the role of government in standards strategy and technology policy more generally are complicated by its own statist tradition and political culture. Though Beijing has embraced principles of voluntary, market-based standards, the implementation of policies to promote an innovative society involves government activism that is in some ways more reminiscent of the traditional developmental state than of an enabler. State-led R&D programs intended to strengthen the capabilities of Chinese companies inevitably suggest a proclivity to "pick winners" among technologies, industries, and companies. Attempts to use procurement and competition policies to reinforce the prospects for promising firms also suggest government action beyond emerging international norms of enabling.

The role of government in China is also complicated by problems of governance arising from failures of government performance. One major problem affecting the implementation of technology policy, and the development of standards, has been governmental "stove-piping" and the failure to achieve inter-agency coordination in the face of jurisdictional conflicts.[41] The prolonged delay in licensing 3G technology is in part due to failures of coordination and

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[38] For example, see Marie Anchordoguy, *Reprogramming Japan: The High Tech Crisis Under Communitarian Capitalism* (Ithaca: Cornell University Press, 2005).

[39] See Peter Evans, *Embedded Autonomy: States and Industrial Transformation* (Princeton: Princeton University Press, 1995); and Dan Breznitz, *Innovation and the State: Political Choice and Strategies for Growth in Israel, Taiwan, and Ireland* (New Haven: Yale University Press, 2007).

[40] On the EU, see "Toward an Increased Contribution"; and "European ICT Standardization Policy at a Crossroads: A New Direction for Global Success," European Commission, discussion document, February 12, 2008.

[41] Kennedy, "The Political Economy of Standards Coalitions"; Richard P. Suttmeier, Xiangkui Yao, and Alex Tan, "Standards of Power? Technology, Institutions, and Politics in the Development of China's National Standards Strategy," The National Bureau of Asian Research, NBR Special Report, June 2006; and Qiang, *China's Information Revolution*.

bureaucratic competition, as are problems in reconciling bureaucratic interests in order to move forward on digital media and other forms of ICT convergence.[42] China's new Ministry of Industry and Informatization is intended to solve some of these stove-piping problems and bring greater coherence to the national effort to develop the ICT industry and diffuse IT throughout the society. Nevertheless, the ministry still faces coordination problems with other central government agencies, including the State Administration for Radio, Film, and Television (SARFT), with its jealous protection of content and prerogatives for media standards setting.

Governance problems are not limited to stove-piping. The strong role of the state in technological development can, and does, result in perverse policy outcomes. The policy preferences called for in the MLP invite classic government failure problems—government-industry collusion and industry rent seeking, with companies focusing more on cultivating privileged relations with the state than on developing competitive in-house research and innovation capabilities.[43] Efforts to build inventories of China's intellectual property by stimulating patenting run the risk of generating an explosion of weak or junk patents and patent applications as companies strive to satisfy state-determined success criteria, in much the same way that there has been a rapid growth of rarely cited published papers from the research community in response to productivity indicators imposed by officials who manage and evaluate national R&D policies. Finally, China's evolving government procurement policy in support of zizhu chuangxin calls for government purchase of "innovative products," but the determination of "innovativeness" requires product assessment by a government that likely has difficulty keeping pace with the rapid selection of innovativeness in the marketplace.

The discussion so far has highlighted that China's push in standards is closely related to its broader industrial policy and the changing role of Chinese companies and, significantly, is coming at an increasingly dynamic moment for the global ICT community. Debates affecting standardization in China—over the sources of innovation, the relationships between innovation and standards and intellectual property rights, and the appropriate role of government—are also becoming increasingly important internationally as a result of the forces noted at the outset. In the following sections we apply these insights to examine more closely the evolving role of Chinese and global stakeholders in China's domestic standards-setting process, the factors that explain the varying trajectories of specific ICT standards initiatives, and China's growing involvement in official international standards organizations and unofficial consortia.

The Role of Stakeholders in China's Standards System

Although the formal standards-setting process in China has remained unchanged since the adoption of the Standardization Law twenty years ago, the dynamics of the standards-setting process, particularly in the ICT sector, have changed dramatically. China's government may want to head a top-down standards system in which all stakeholders follow its lead, but the process rarely follows this scripted path. That is a product of having several agencies with overlapping

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[42] Qiang, *China's Information Revolution.*

[43] Anne Stevenson-Yang and Kenneth DeWoskin, "China Destroys the IP Paradigm," *Far Eastern Economic Review* 168, no. 3 (March 2005): 9–18; and Su Jun and Du Min, "Government Failure and Market Failure in AVS Standard Setting: A Study Based on a Policy Process and Instruments Framework," *Proceedings of Public Administration and Management,* June 2006.

authority, the growing role of domestic and international industry stakeholders in the process, and the complex nature of information and communications technology and markets.

Until its recent absorption into the new Ministry of Industry and Informatization, the State Council Informatization Office (SCITO) helped set general guidelines for linking standards development to innovation. It was not, however, involved in day-to-day regulatory governance. The Standardization Administration of China (SAC) is responsible for adopting the highest authority national standards, whereas the former Ministry of Information Industry (MII) and SARFT set industry standards in the ICT sector.[44] The industrial ministries, along with MOST, also provide funding for associations and industry to develop standards and commercialize related products.[45]

Although SAC is charged with setting broader policies, it is not uncommon for it to be at loggerheads with MII and SARFT and for the latter two to also be in conflict with each other. Their disagreements are borne out of intellectual differences as well as what they believe would best serve their bureaucratic interests. SAC prefers an orderly and cooperative standards process in which national standards predominate. MII is concerned with promoting the economic interests of China's electronics and telecommunications companies (especially those of state-owned firms), whereas SARFT's chief mission is to regulate content. If MII can be somewhat nationalistic, SARFT is more attuned to ideological questions. One implication is that although it is rare for China's government to remain technology neutral on any one ICT standard, it is not uncommon for different standards to be supported by different parts of the bureaucracy.[46]

The actual work of drafting and adopting ICT industry standards in China is primarily carried out by three organizations affiliated with MII and SARFT. (**Table 1** provides a list of recent Chinese standards initiatives.) The China Electronic Standardization Institute (CESI) oversees 23 technical committees for establishing standards on a wide range of information technologies, from video players to radio frequency identification (RFID). The China Communications Standards Association (CCSA) has 11 technical committees, which draft a range of information and telecommunications standards. Created in 2002 by combining several MII working groups, CCSA is formally a membership-based organization, but it has close ties to the telecommunications side of MII. In addition, SARFT's Academy of Broadcasting Science (ABS) is involved in research on communications technologies and has taken a lead in drafting some of China's mobile TV standards. As one can see, the ambit of these three organizations overlaps considerably.[47] The most significant exception to this structure is the Audio-Video Coding Standard Working Group, the developer of China's audio-visual coding standard (AVS). Instead of being under CESI, the group was established in June 2002 by MII and MOST and reports directly to MII's Department of Science and Technology.

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[44] In 1998 the Ministry of Electronics Industry (MEI) and the Ministry of Post and Telecommunications (MPT) merged to become the Ministry of Information Industry (MII). During the next decade, the internal tensions between these two components were never eliminated. In March 2008 the National People's Congress approved plans, set to take effect in June 2008, to create the Ministry of Industry and Informatization, combining MII with SCITO, the Commission on Science, Technology and Industry for National Defense (COSTIND), two industry bureaus from the National Development and Reform Commission, and the State Tobacco Monopoly Administration. It is unclear what impact if any this will have for standards policies.

[45] Development of AVS and TD-SCDMA were two of three key information technology projects listed in the eleventh five-year plan. See "Motorola Supports AVS," *Sinocast China Business Daily News,* March 28, 2006.

[46] For a more detailed overview of the official standards system, see Chaoyi Zhao and John M. Graham, "The PRC's Evolving Standards System: Institutions and Strategy," *Asia Policy* 2 (July 2006): 63–87.

[47] CESI and CCSA have useful Chinese/English-language websites at http://www.cesi.cn/www/en/ and http://www.ccsa.org.cn/english/index.php.

TABLE 1 Selected recent Chinese technology standards initiatives

Technology	Chinese standards	Non-Chinese standards
Audio-visual coding	AVS	MPEG2, MPEG4-3 (AAC), MPEG4-10 (H.264), VC-1
Digital trunking	GoTa, GT800	TETRA, iDEN
Digital video players	EVD, HDV, HVD	Blu-ray, HD-DVD
Document formatting	UOF	ODF, OOXML
Home networking	IGRS, ITopHome	DLNA, UPnP, KNX, ECHONET
Mobile phone charger	YD/T1591-2006	None
Mobile TV	CMMB, T-MMB, CDMB, DMB-T, CMB	DVB-H, T-DMB, MediaFLO
Radio frequency identification (RFID)	NPC	ISO 18000 and others, EPC/GS1, uID
Security computer chip	TCM	TPM
Third-generation cellular telephony (3G)	TD-SCDMA	WCDMA, CDMA2000
Wireless local area network	WAPI	Wi-Fi
Wireless metro area network	McWILL	WiMAX

Chinese enterprises have long participated in setting domestic standards through committees, and the Standardization Law permits companies to establish their own de facto standards when no comparable industry, regional, or national standard exists. But the intensity of companies' involvement has expanded because standards are so closely tied to ICT products and services. Many Chinese companies see standards as part of a broader business strategy and are beginning to invest considerable resources in them. By 2006 there were more than 1.26 million company standards registered in China.[48] One of the industry leaders appears to be Shenzhen-based telecommunications equipment maker Huawei. In addition to a clear commitment to R&D, Huawei has a distinct standards division and three hundred employees across the company involved in standards.[49] It participates in 60 groups involved in developing standards related to the next-generation Internet.[50] Not only have major firms such as Lenovo, Haier, ZTE, and China Telecom followed suit, but even smaller ICT companies, such as Datang Telecom Technology Corporation, the leading promoter of TD-SCDMA, see standards as an opportunity to advance their interests. In this way, Chinese companies are following in the footsteps of the world's leading firms.

Chinese industry representatives constitute the largest proportion of members on CESI and CCSA technical committees, but exactly how they participate in these domestic groups and in international bodies (discussed below) is directly affected by their business strategies. As with broader debates in China, it is helpful to initially distinguish between the techno-nationalist and

48 "Trade Policy Review China: Report by the Secretariat," World Trade Organization, WT/TPR/S/199, April 16, 2008, 64.

49 Julian Goldsmith, "Huawei's R&D Pot Rivals Western Firms," *BusinessWeek,* September 11, 2007.

50 Huawei's intensive involvement is similar to that of Intel and Microsoft. All have standards offices embedded within their technology strategy divisions, and each participates in several hundred standards groups globally. For more information on Huawei, see http://www-cnc.huawei.com/technology/standards.do; for Intel, see http://www.intel.com/standards/; and for Microsoft, see http://www.microsoft.com/standards/.

techno-globalist strategies discussed earlier. Companies focused on the domestic market hope to obtain the government's official endorsement of their standard to block both domestic and foreign rivals and to aid their collection of royalties from those who adopt these standards in related products and services. This is most relevant for telecommunications standards because of the government's role in spectrum licensing, but some electronics companies still seek official endorsement of their standard as a new road to greater profitability and innovation even when there is no equivalent regulatory hook to provide protection against rivals. By contrast, companies oriented toward overseas markets tend to see a positive-sum relationship with their foreign counterparts. They are stronger advocates for either incorporating existing international standards domestically or at least welcoming foreign participation in China's standards process when they seek to promote a new distinctive standard.

By 2006 there were more than 1.26 million company standards registered in China.

The nationalist/globalist distinction serves as a good initial guide to delineate among companies, but as Chinese firms develop their own technologies, file related patents and copyrights, and gain market share, it is increasingly helpful to draw finer distinctions that parallel variations in business models rooted in the different approaches, noted above, that firms take toward intellectual property rights. Although international attention to China's standards system has focused primarily on China's attempts to use control of a standard's IP to generate revenue, there is no one business model among Chinese firms. Some firms do consistently follow one of the approaches discussed above. Datang's unwavering promotion of TD-SCDMA has defined that company for almost a decade. It is increasingly common, though, for Chinese companies to pursue multiple strategies at once, including adopting already existing standards and in some manner seeking to leverage their technology contribution to new standards. This is certainly true of Huawei, Lenovo, and Haier, among others.

Even where IP is part of the business model, there is wide variation in the IPR policies of standards groups and companies. The AVS Working Group took the lead, issuing a detailed IPR policy in 2004 that addresses patent disclosure, licensing, and other issues. Most observers believe the 2004 policy, having benefited from the suggestions of multinational corporations, is sufficiently detailed, balanced, and open.[51] More recently CESI drafted an IPR policy that draws heavily on the one created by AVS, though it is unclear to what extent the newer policy would apply to the various standards groups under its umbrella or to participating companies who developed IPR policies subsequent to the standard being issued.

Accompanying the trend of a variety of approaches toward intellectual property rights is greater complexity in the organization of standards development and commercialization. Chinese companies have begun to emulate their global counterparts by creating standards consortia. Internationally, companies have created consortia in reaction to the slower-moving official standards bodies, which were outside their control. U.S. companies were particularly attracted because in official international SDOs, the United States carries only one vote, whereas companies from the European Union benefited from the fact that each European country has a separate vote in state-based SDOs. Consortia, composed of companies up and down the project chain, may

[51] The text of AVS's IPR policy is available at http://www.avs.org.cn/en/.

draft standards, popularize the standards' brand names, and accredit products as complying with the standards. Initially consortia were rivals to official SDOs, both in terms of bypassing SDOs and in adopting more rapid, but less transparent and unbiased, procedures. More recently, many consortia, particularly those with broad agendas, have moved to adopt rules akin to those of the official SDOs and to coordinate their activities with these SDOs by drafting standards and then submitting them to SDOs for fast-track approval. By 2008 there were at least 460 ICT consortia with membership from companies around the world.[52]

The first Chinese consortium, or industry alliance (*chanye lianmeng*), was TDIA, founded in 2002 by promoters of TD-SCDMA. By late 2007 there were at least a dozen such consortia, including consortia for audio-visual coding, home networking, digital video players, RFID, wireless LAN, and open-source software.[53] Chinese consortia appear to leave formal standards development to standards committees and instead focus on encouraging product commercialization. Some consortia are well developed with a large number of members including MNCs, but it is unclear how autonomous consortia are from MII, SARFT, and the related standards organizations. In some instances the membership of the alliances closely resembles that of the relevant standards technical committee, and one common task of consortia is to keep in close communication with government regulators. Domestic stakeholders occupy the largest number of seats in Chinese standards committees and consortia, but room at the table is gradually being made for foreign industry participants. Though not yet routine, permission to join Chinese standards committees is more common than in the past. Multinational corporations participate either through their local subsidiaries or through Chinese joint venture partners.[54] Similarly, MNCs are members of Chinese-based standards consortia, including those for mobile phones, audio-visual coding, and home networking. In some instances foreign companies have voting rights as regular members; in other cases they are only observers. In no domestic standards committee does a foreign company representative hold a leadership position.

The main obstacle to participation has been China's opposition to allowing foreign involvement in what are supposed to be efforts to promote distinctive Chinese standards that contain their own intellectual property. Gradually, though, barriers have been reduced in response to complaints by foreign companies and intervention by their industry associations and governments. One U.S. association reports that whenever it has brought a case regarding membership or voting rights to the attention of the SAC, the issue has been resolved amicably. One countersign to this trend is a rule recently issued by the SAC implying that direct MNC involvement in committees would not be permitted. It is unclear, however, how the rule will be implemented and whether it would apply to the local subsidiaries or joint venture partners of MNCs. Beyond direct membership in committees and consortia, larger MNCs also interact extensively with relevant government agencies, associations, standards committees, consortia, and research institutes in order to obtain information and provide their perspectives. Thus, even when formally blocked from

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[52] This figure comes from the leading source for information on standards consortia, ConsortiumInfo.org, a website maintained by the Boston-based law firm of Gesmer and Updegrove. Their list of consortia is available at: http://consortiuminfo.org/links/. In our discussions, one expert estimated the number of consortia at over seven hundred. Neither source likely includes regionally based consortia, especially ones that do not operate in English. Hence, the actual figure could be higher.

[53] Another indicator of Chinese interest in consortia is that China has become the second-most frequent visitor to the ConsortiumInfo.org website. During the first half of 2007, the website logged 1,046,559 U.S. visitors (63.7% of users), followed by visitors from China (134,870, or 8.2%), the United Kingdom (54,182, or 3.8%), Canada (36,941, or 2.3%), and Germany (26,804, or 1.6%). Andrew Updegrove, "Who Cares About Standards?" *Standards Today* 6, no. 6 (June–July 2007): 8.

[54] On the obstacles foreign industry faced five years ago, see Ann Weeks and Dennis Chen, "Navigating China's Standards Regime," *China Business Review* 30, no. 3 (May–June 2003): 32–38.

participating, foreign industry is still able to communicate its views within China's standards policy community.

Once on committees, some multinational corporations contribute ideas and technologies to standards. Others, because of concerns over the terms under which their contributions are made, do not. There has been some concern that contributing patented technologies could lead to illegal dissemination and copying, and in 2004 an SAC official floated the idea of requiring contributors of patented technology to a standard to make that contribution irrevocable so that they could not later withdraw their technology from the standard or renegotiate the terms on which it was contributed. Since then no policy or regulations have been issued. It is unclear if such rules would trump agreements reached within individual standards bodies or between individual companies and other parties, but the concern still lingers. Additionally, some MNCs have hesitated to contribute because of inadequate financial incentives, such as royalty fees.

Aside from government intervention and concerns over contribution terms, another major reason for limited contributions emerged from interviews: many MNCs never intended to contribute to the standard in the first place. MNCs are often already committed to non-Chinese alternative technologies. They participate in order to obtain information, demonstrate goodwill toward their Chinese partners and the government, and be better placed to take advantage of opportunities in the event that a local standard achieves commercial success. Joining a committee in order to collect information or hedge is not unique to China, as companies often join standards consortia for what could be called defensive purposes.

Just as the options for multinational corporations have grown, foreign standards committees and consortia have also found it easier to operate in China. For example, EPCGlobal/GS1, which promotes a package of standards for RFID; the Institute of Electrical and Electronics Engineers (IEEE); and OASIS, a consortium aimed at promoting open information technology standards, have opened offices in China to recruit members and popularize their technologies. The arrival of these groups is the last piece of evidence confirming how much the playing field and players in China's standards-setting scene have evolved.

Chinese ICT Standards Initiatives: Common Themes and Case Variation

Leading MNCs from the West have a large advantage over their counterparts from developing countries in creating innovations that are commercially successful. This is particularly true for standards. Standards are major innovations that can affect an entire production network, and having an industry adopt one's standard reflects industry leadership. China's overall commitment to developing distinctive ICT standards is virtually unparalleled among developing countries.[55]

At the same time, substantial variation among China's various standards initiatives has resulted in different outcomes. No single Chinese standard has come to dominate a market segment, yet some show more promise than others. Three factors have shaped the trajectory of these efforts. The first is the role of the government. In no instance has China adopted a position of pure technology neutrality, yet the nature of government involvement is not consistent across cases. In some instances Beijing has strongly encouraged local industry to develop a new standard while simultaneously erecting barriers to block foreign-based standards from gaining

[55] For a discussion of Japan's original focus on standards as part of its industrial policy, see John R. McIntyre, ed., *Japan's Technical Standards: Implications for Global Trade and Competitiveness* (Westport: Quorum Books, 1997).

a foothold in China. In other cases Beijing has encouraged local initiatives but permitted foreign alternatives as well.

The second factor is the breadth of the industry coalitions created to support a standard. In some cases the proponents comprise a narrow band of Chinese companies, while in others a broader industry coalition that includes a substantial foreign presence is formed. Broader coalitions tend to have a much greater chance of success because they include a wider swath of industry participants, which is critical both when adopting a standard and when commercializing it.[56] Broader coalitions are more common when the Chinese technology is relatively well developed and the Chinese firms are building on existing ties with foreign companies as part of their participation in global production networks.

The third factor is the extent to which non-Chinese alternative standards are entrenched in the global marketplace. In almost every instance there are parallel foreign standards, yet only a portion have achieved significant commercial success themselves. The more competing technologies are popularized, the less likely that Chinese standards will be widely accepted in China and beyond.[57]

As indicated in **Table 2,** the combination of these three factors yields eight possible scenarios, five of which have actually unfolded in China during the past decade. The first category of cases involves strong government support for the domestic alternatives and regulatory protection from foreign rivals, a relatively narrow coalition of industry backers, and the widespread dissemination of alternative standards beyond China. This situation applies to Chinese standards for 3G cellular technology, wireless LAN, metro area networks, mobile TV, and RFID. Not coincidentally, all are in telecommunications, where the government has easily accessible regulatory hooks. Most famously, the global rivals to TD-SCDMA have been unable to obtain licenses to broadcast in China. Although the TD-SCDMA technology involves contribution from Siemens, and some foreign companies indirectly participate in the TD-SCDMA industry consortia, the TD-SCDMA coalition is narrow, centering on Datang. Several of China's service providers and equipment manufacturers have given only tepid support to TD-SCDMA because their business interests lie with the rival technologies. For example, China Mobile runs a second-generation GSM network and would find it easiest to roll out a third-generation WCDMA network.[58] Similarly, Huawei equipment has been designed to be compatible with foreign standards.[59]

The same dynamics have been repeated in several other telecom standards. For example in 2003 the State Council mandated the adoption of WAPI over Wi-Fi to help a small group of Chinese companies, some of whom had connections to China's security apparatus. SARFT has used its control of content approval to block non-Chinese mobile TV standards, the Europe-based DVB-H standard, and Qualcomm's MediaFLO while the agency finishes drafting the CMMB standard and carrying out trials in a few cities.[60] For several years MII dragged its feet on allocating spectrum for RFID to inhibit the adoption of EPC. Yet in all of these cases, domestic support for the Chinese

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56 Kennedy, "The Political Economy of Standards Coalitions."

57 In addition to these three factors, two others—technological maturity and domestic bureaucratic conflict—play a role.

58 In early 2008 China Mobile began the rollout of a TD-SCDMA 3G network. In the wake of the restructuring of China's telecom service providers, the pace of the rollout will expand, yet it still appears China Mobile is not satisfied with the outcome and will continue to pursue other technologies.

59 Clark, "China Misdials on Mobiles," 52–59; and Gabriel Wildau, "Premature Obsolescence," *China Economic Quarterly* 12, no. 1 (March 2008): 51–56.

60 The other complicating factor behind mobile TV is that MII and SARFT support alternative Chinese standards, and each can block the other's preferred option. The difficulty of forging cooperation toward one of the standards, or a compromise, further hurts the chances of any of the Chinese options. See Mike Clendenin, "Mandating China Mobile TV Spec a Mistake, Analysts Say," *EE Times,* December 4, 2006; and Junko Yoshida, "China Narrows Final Mobile TV Spec to CMMB, TDBM," *EE Times,* September 7, 2007.

TABLE 2 Patterns in Chinese ICT standards initiatives

	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5
Government role	Support and protection	Support and protection	Support	Support	Support
Supportive industry coalition	Narrow	Narrow	Narrow	Broad	Broad
Market presence of non-Chinese alternatives	Spreading	None	Spreading	Widespread	Limited
Representative cases	TD-SCDMA WAPI McWILL CMMB RFID	Cell phone charger	EVD HDV HVD UOF	AVS	IGRS ITopHome

option has been far from unanimous, and the foreign options have already come to the market elsewhere. Wi-Fi is globally ubiquitous, and the mobile TV standard DVB-H and RFID standard EPC/GS1 are used by consumers and companies on several continents.

Because of the broader coalitions supporting alternative technologies already operating beyond China, government intervention has at times delayed the introduction of foreign products but has not been able to ensure commercial success for China's own standards. As a result, the government has gradually relented and permitted some of the contested foreign technologies into China. Most obvious is the quiet commercial death of WAPI and the continued spread of Wi-Fi across the country.[61] Although it has yet to abandon TD-SCDMA, the government appears to have quickly given up hope on Datang's metro area network standard, McWILL. China opposed the bid to make WiMAX a 3G standard (which it became in October 2007), but for the Olympics MII has permitted China Mobile to build a WiMAX network, a technology in which China's telecom equipment providers are deeply involved globally.[62] China also finally allocated UHF spectrum for RFID in mid-2007 and recently began allowing small-scale trials of EPC standards in the Pearl River Delta. In sum, the extent of government intervention in these cases shows that there can be a large gap between official intentions and market outcomes even in a country with as strong a government as China's.

The primary exception to this first pattern—the pattern of opposition and likely failure despite a government mandate of some sort—comes in the case of China's cell phone charger standard, which reflects the second pattern listed in Table 2. Since the summer of 2007, cell phones sold in China have been supposed to use a common charger interface in order to make chargers for different models compatible and reduce waste. As in the first category of cases, there was not a large supporting industry coalition. In fact, the impetus for the standard originated not with any of the industrial ministries but with an environmentally conscious deputy of the National People's Congress. Unlike the other telecom products described above, there has been no uniform international standard against which the Chinese option was competing, and industry resistance

[61] Kennedy, "The Political Economy of Standards Coalitions"; and Yu Zhou, "State and Commercial Enterprises in China's Technical Standards Strategies," *China Review* 6, no. 1 (Spring 2006): 37–65.

[62] Mike Clendenin, "China Fields a WiMax Rival," *EE Times,* May 21, 2007; Caroline Gabriel, "China Opposes WiMAX as a 3G Standard but Supports It for Olympics," *WiMAX Trends,* August 2007, http://www.wimaxtrends.com. On ZTE's investment in WiMAX, see "ZTE Notes Position in Global WiMAX Market Including 21 Trials," Optical Keyhole, November 2007, www.opticalkeyhole.com.

has been far less intense. In fact, some domestic and international cell phone producers welcomed the unexpected initiative.[63]

In the third type of case, reflected in several of China's video player formats and its Uniform Office Format (UOF) document standard, the government has encouraged local Chinese initiatives, and comparable foreign rivals have limited market presence, but the Chinese industry coalitions in support of these efforts have been relatively narrow. In the 1990s Chinese companies, with support from a couple of U.S. video-compression chipmakers, developed the video compact disc (VCD) player and then the Super VCD player as alternatives to the video cassette recorder and then the DVD player. The companies supporting these initiatives were diverse, and they managed to sell several million players in the latter half of the 1990s, but sales could not be sustained against the more broadly backed and higher quality DVD player, which overtook the local options as soon as the price fell and bootleg DVD discs became available.[64]

The high expense of royalties to the DVD Forum sent Chinese producers back to develop new alternatives to compete with the next-generation Blu-ray and HD DVD formats. Chinese manufacturers backing EVD (enhanced versatile disc) created the Beijing E-World company in Beijing, while HVD supporters created an HVD consortium in Shanghai.[65] Yet none of the three Chinese standards and related products had substantial foreign sector participation, and Beijing-based Kaicheng High Definition Electronic Technology Corp, the promoter of HDV, believed its technology so superior to any of its rivals that it expected consumers to naturally embrace its product. EVD received the strongest official support, garnering some R&D funding and approval as a national standard in February 2005, but none enjoyed the protection given the telecom standards. The conflict between Blu-ray and HD DVD and their high prices provided the Chinese formats a brief opportunity to reach the public, but as the more powerful and higher quality global competitors gathered Chinese companies into their coalitions and the Blue-ray coalition won the global war, the window for EVD and the other local formats closed.[66] In early 2008 EVD players were withdrawn from store shelves in Beijing.[67]

In the fourth pattern, represented by China's audio-visual coding standard (AVS), the government has provided substantial encouragement but no protection against foreign rivals, and the domestic options have gained legitimacy by being supported by extensive Chinese coalitions. The spread of international alternatives has created obstacles to the standard's widespread commercialization, however. The impetus for the AVS standard for audio-video compression came from researchers at the Chinese Academy of Sciences. Borrowing on their own involvement with the Moving Pictures Experts Group (MPEG), they attempted to attract as much industry involvement in their standards working group as possible. Approximately 30 of the group's 175 members are foreign companies and research organizations, and they control about 10% of AVS's

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63 Another similar case is China's recent mobile phone battery standard, whose initiative is also from the government, which may block noncompliant foreign batteries. Unlike in the charger case, there is widespread opposition from international industry because of the potential limiting effect on phone designs. If this paper's analysis holds, this opposition should result in a substantial modification of the original requirements.

64 Greg Linden, "China Standard Time: A Study in Strategic Industrial Policy," *Business and Politics* 6, no. 3 (2004); and Scott Kennedy, *The Business of Lobbying in China* (Cambridge: Harvard University Press, 2005): 119–25.

65 Anthony Kuhn, "China's EVD Video Push Is a Bid to Climb Electronics Food Chain," *Wall Street Journal,* February 19, 2004.

66 "Chinese to Launch CNY 5,000 Blu-ray DVD Players," *SinoCast China IT Watch,* January 14, 2008.

67 "Local High Definition EVD Line Fails, Leaves Consumer Electronics Market," *Beijing Daily,* February 29, 2008.

patents. Although directly attached to MII, the group has adopted the best practices of standards bodies elsewhere.[68]

With the adoption of AVS as a national standard in April 2005, there was optimism AVS would be widely commercialized. One of its key attractions is an inexpensive and simple licensing scheme of one RMB per use. By contrast, MPEG4 originally had a complicated licensing system, and some observers believed there would be a natural resistance by the industry to employ Microsoft's VC-1 standard because of the company's market dominance.[69] These initial expectations have yet to be realized. Within China most users of codec standards have adopted the less advanced but internationally widely disseminated MPEG2. A pledge from China Netcom to use AVS in its IPTV network was welcome news, but an exception to a broader trend.[70] Internationally, VC-1 and MPEG4, which simplified its licensing mechanism, have been adopted into both Blu-ray and HD DVD players, digital TV, and other technologies.

The prospects for China's home networking standards, which represent the fifth and final pattern outlined in Table 2, are somewhat brighter. Like in the fourth scenario, Lenovo and Haier, the leading proponents of IGRS and ITopHome, respectively, have assembled large coalitions of Chinese and foreign companies, up and down the product chain, that are genuinely involved in the initiative.[71] Both consortia focus on popularizing the standard in products and having the standards gain greater legitimacy by being adopted by international SDOs. The difference is that whereas the alternatives to AVS have grown stronger, particularly by their inclusion in high-definition video players, the non-Chinese home networking standards are mature technically but have not been widely purchased by consumers in the leading markets. Hence there is little in the way of entrenched technology for IGRS or ITopHome to overcome. IGRS reported that by fall 2007, it had released over twenty compliant products, which had achieved a combined three million units in sales. Although the significance of this figure is debatable (it is unclear what features were the key selling point of the products), it at least suggests that home networking standards have already achieved far more than any of the telecom standards that enjoyed much more extensive government support.

The range of scenarios suggests that government commitment to a Chinese standard is far from enough to ensure its success. Government can at most block foreign alternatives (and as in the case of Wi-Fi, even that is not assured), but successful commercialization depends much more on the character of coalitions and the prominence of rival technologies. That does not mean government support is irrelevant but rather that it has been most successful when fostering existing industry initiatives and promoting deeper linkages across sectors within China and between Chinese and global industry leaders.

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68 The head of AVS's IPR Working Group, Cliff Reader, previously served as the chair of an MPEG4 working group.

69 MPEG4 consists of 23 separate standards related to audio-video coding. The primary alternatives to AVS are MPEG4-Part 3, also known as advanced audio coding (AAC), and MPEG4-Part 10, for advanced video coding (AVC), which is identical to the International Telecommunications Union's H.264 standard. VC-1 was adopted as a standard by the Society of Motion Picture and Television Engineers (SMPTE). On AVS's development, see Su Jun and Du Min, "Double Failure in the AVS Standard Setting: A Study Based on a Policy Process and Instruments Framework," *China Soft Science Magazine* 6 (2006): 39–45.

70 Mike Clendenin, "IPTV Win Boosts Prospects for Chinese A/V Codec," *EE Times,* November 20, 2006. EVD player makers also said they would adopt AVS but in practice used MPEG2.

71 For the respective consortia membership and other information on IGRS and ITopHome, see http://www.igrs.org/en/index/index.asp and http://www.itophome.org.cn.

China and the International Standards Scene

China's standards efforts at home have received the vast majority of attention by observers, but it is in activities abroad, in global standards bodies, that China may have the most significant effect on ICT innovation in the years ahead. Chinese companies have long been members of international SDOs, but their active participation is of more recent vintage. The pace at which this transition is occurring is remarkably rapid. Nevertheless their influence at the global level to date has been hindered by their incomplete familiarity with the informal norms of the standards world, their representatives' limited facility in English, the limited amount of highly valued patented technologies that could be used as bargaining leverage in negotiations with partners and competitors, and the sheer cost of consistent participation in standards bodies around the globe.

The depth of China's involvement in international standards setting is unprecedented for developing countries. This reflects positively on the breadth and depth of scientific and engineering talent in China and on China's explicit efforts to bridge technological research with commercial development. Yet it is important to recognize that in order to cross that bridge, much more than technological sophistication is needed. Global standards organizations are communities in which the participants share norms of behavior that guide their involvement. The most successful stakeholders and officials in meetings both are knowledgeable about technical issues and are skilled diplomats in the art of negotiation.

This element of standards setting caught many in China by surprise. They began with the assumption that good technology should speak for itself, and that skillful diplomacy, which depends on understanding norms and having material clout, was not relevant. One well-placed observer opines that at the international level, the Chinese are "babes in the woods" because they have only gradually recognized that standards setting is not just a mechanical exercise. One sign is that China typically sends relatively young technical specialists to standards gatherings, whereas Western MNCs and governments send seasoned representatives, further along in their careers, who are part of the "old boy's network." Much of the real decision-making occurs before meetings and outside meeting rooms. Chinese participants are also handicapped by their limited English, as English is the common language for all international standards bodies.

China has begun to recognize these deficiencies. Chinese participants have learned the hard way through trial and error and have worked on their diplomatic skills. Some Chinese companies have hired overseas Chinese who are more comfortable with Western cultural norms, as well as engineers and standards experts who formerly worked in Western companies and can serve as effective ambassadors for their employers. Our sense is that the rate at which companies move up the learning curve is directly proportional to the degree of their involvement with the global business community and their interest in exporting. The more integrated the Chinese company is into global production networks, the more quickly it adapts to this environment.

Conversely, there has been hesitancy by some Western incumbents, both in industry and government, to welcome Chinese participants to the negotiating table as equals. This is in part a reflection of a long habit of operating within this network with very little involvement from developing countries, which have essentially been standards takers and not standards makers, and a negative reaction to the Chinese lack of familiarity with the norms of the system. Hence, a representative from one standards organization in 2006 admitted, "Our membership doesn't get it that China deserves a place." Nevertheless, just as the Chinese are learning how to participate,

the incumbents are increasingly adapting to China's involvement, and some even enthusiastically welcome these relative newcomers.

China's government and industry have become regular participants in the three most important official international SDOs that set ICT standards: the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the International Telecommunications Union (ITU).[72] These three organizations to some extent overlap in function. To promote cooperation, the ISO and IEC have formed a common joint technical committee (JTC1), which has subcommittees and working groups to develop ICT standards. As **Tables 3**, **4**, and **5** show, China has joined a large number of technical committees in each of these organizations, but is only beginning to take on a leadership role, as indicated by the low number of committee secretariats China hosts relative to the advanced industrialized countries. Officials from the SAC, MII, CESI, and CCSA most commonly officially represent China in meetings. People from Chinese companies regularly attend meetings when their standards are being considered, and some firms, such as Huawei, ZTE, and Lenovo, send large delegations. Overall though, China's corporate participation has been limited to a handful of companies. The exception is when meetings are held within China, at which point a wide swath of industry can be expected to turn out.

Of these three SDOs, China is most deeply involved in the ITU, which it originally joined in 1920. China's participation has gradually expanded during the Reform era. In the 1980s the Chinese were largely passive observers, but in the 1990s they began to offer comments and make submissions. The most important submission came in 1998, when China offered TD-SCDMA as a 3G standard, which was adopted in 2000.[73] In the last five years China's participation has expanded significantly. By 2004, according to ITU officials, China was sending the largest number of government participants to ITU meetings, while Huawei and ZTE were sending the seventh and eighth largest delegations among "sectoral" members (from industry and research organizations). By 2006, although China did not occupy the chair or host the secretariat of any ITU committee, referred to as "study groups," Chinese were vice chairs in five of them (telecommunications management, signaling requirements and protocols, next-generation networks, optical and other transport network infrastructures, and security, languages and telecommunications software). On some occasions Chinese proposals occupy the largest proportion of meeting time. On the other hand, observers note that high quantity typically has been offset by low quality, with most suggestions dismissed. China's involvement in the ITU has been eased by the presence of Houlin Zhao, who worked for China's telecom regulator in the early 1980s before joining the ITU. In 2007 he became the ITU's deputy secretary-general. Industry insiders believe that Zhao has not provided any special treatment for China but that his presence has made the Chinese feel more comfortable.

In addition to these organizations, China has begun to participate in some regional standards bodies. Most significant is the European Telecommunications Standards Institute (ETSI). Although its mandate is to set standards for the European Union, given its membership, ETSI's standards have global significance. ETSI has 669 company and organization members from 62 countries. The most

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[72] "Official" SDOs are those whose primary participants are involved as part of a national organization that represents a country, and where voting is by national committee. In addition, the ISO, IEC, and ITU require member countries to be widely recognized sovereign nations. Hence, Taiwan is not a member of these groups.

[73] At just about the same time, the ITU also accepted China's proposed standard for "IP over SDH (Synchronous Digital Hierarchy)." Initially developed by the Wuhan Post and Telecommunications Academy, the standard eased the operation of Internet Protocol traffic over high-speed fiber-optic networks. See "ITU Adopts Chinese IP Standard," Xinhua News Agency, April 7, 2000.

TABLE 3 Participation in the International Organization for Standardization (ISO), 2008

Rank	Country	Membership in ISO technical committees and subcommittees	Host secretariat of technical committees and subcommittees	Host secretariat for JTC1 (IT) subcommittees
1	France	730	75	1
2	Germany	724	136	2
3	United Kingdom	722	84	1
4	South Korea	700	12	3
5	China	695	23	0
6	Japan	668	57	4
7	Italy	661	16	0
8	Spain	660	11	0
9	Poland	633	5	0
10	United States	620	127	6
13	India	595	8	0
23	Brazil	441	6	0

SOURCE: ISO website, http://www.iso.org.

TABLE 4 Participation in the International Electrotechnical Commission (IEC)

Rank	Country	Participatory member in technical committees and subcommittees	Host secretariat for technical committees and subcommittees	New projects submitted
1	Germany	167	25	26
2	Japan	166	12	26
3	China	165	3	2
4	United Kingdom	165	25	4
5	Italy	162	12	0
6	France	155	25	4
7	United States	151	24	20
8	Russia	141	2	0
9	Sweden	141	6	1
10	South Korea	131	3	3
26	India	55	0	0
39	Brazil	14	0	0

SOURCE: Data on membership and host secretariats is from 2004, obtained from IEC website, http://www.iec.ch. Data on new projects is from 2006, obtained from International Electrotechnical Commission, *IEC Performance 2006,* 28.

TABLE 5 International Telecommunications Union (ITU) organizational members, 2008

Country	Members
United States	148
Japan	59
United Kingdom	55
France	40
Germany	26
Italy	21
Israel	18
South Korea	15
China	14
India	14
Spain	14
Brazil	5

SOURCE: Data on membership is available from the ITU's website, http://www.itu.int.

NOTE: Members include government agencies, companies (sectoral members), and research organizations (associates).

prominent non-European members are from the United States (58); participation from Asia is more modest: Taiwan (9), Japan (7), China (6), and India (6). Huawei and ZTE are the most prominent Chinese industry participants.

Apart from official SDOs, Chinese firms have begun to ramp up their involvement in global unofficial standards bodies and industry consortia based in the United States and Europe.[74] As above, the number of companies appears to be relatively limited, but the wide swath of organizations is impressive, among them the Internet Engineering Task Force (IETF), the Digital Living Network Alliance (DLNA), the Wi-Fi Alliance, the Bluetooth Special Interest Group, OASIS, and the WiMAX Forum. Chinese companies join in order to have their products accredited, to contribute to further development of related standards, and in some cases simply to observe their competitors, just as multinational corporations do in Chinese consortia.

The most prominent way Chinese companies have become involved in international standards setting in the ICT sector so far has been in efforts to have standards initially adopted in China recognized as international ones. Although this has garnered the most headlines, their record of achievement is surprisingly slim. The most successful Chinese companies have been those with the deepest ties to the global economy. They better understand the unwritten "rules of the game," and they naturally have more business allies from elsewhere who will be more likely to lobby national representatives to vote in these companies' favor and then cooperate to commercialize the Chinese standard.

[74] For a discussion of the difficulties faced by China and other emerging economies in consortia, see "The Current State of ICT Standardization Consortia: Leveling the Playing Field for Developing Nations," 79 Brinkburn, December 2007, http://blogs.sun.com/dennisding/resource/3%20The%20Current%20State%20of%20ICT%20Standardization%20Consortia(English).pdf.

The most ignominious failure was the effort to have China's own wireless standard, WAPI, adopted by a JTC1 subcommittee.[75] By contrast, China has had some success with home networking standards in international SDOs. Both IGRS and ITopHome were submitted to the ISO/IEC committee that sets standards for home electronics systems (JTC1 SC25). It made sense for China to submit multiple standards since IGRS and ITopHome operate differently; yet this has also affected how the standards have fared. IGRS is a standard for self-configuring networks in the style of UPnP (universal plug and play), which was first developed by Microsoft and is central to the family of audio-visual home networking standards promoted by the Digital Living Network Alliance (DLNA), composed of over two hundred information, communications, and consumer appliance companies, such as Sony, Intel, and others.[76] ITopHome is a command-control protocol that turns on and off elements of a network, making it most similar to KNX, which was developed primarily by Siemens and was adopted as a European standard before being approved by the ISO.

Given the existence of widely backed alternatives, it is no surprise the Chinese standards have faced a stiff challenge from the national committees of the other alternatives.

Given the existence of widely backed alternatives, it is no surprise the Chinese standards have faced a stiff challenge from the national committees of the other alternatives. Pushed by Siemens and others, who saw it as a direct threat to KNX, ITopHome did not make it through even the first of the six stages, being rejected as a "new work item proposal."[77] Faced with that setback, China focused on an alternative venue, the IEC's independent Technical Committee for Information Technology (TC100). In late 2006 China persuaded this committee to consider a somewhat different ITopHome specification as a new work item proposal. A few months later, China persuaded another IEC committee (TC59) to establish a new subcommittee devoted to home networking. In addition, the ITopHome consortia also forwarded the standard to the IEEE. Finally, ITopHome continued to reach out to the other standards consortia in an appeal for cooperation. ITopHome's supporters are taking a productive approach, and there is a real chance that at least one of their proposals will eventually be adopted.

IGRS is closer to achieving a successful outcome. Its key opponents, who argue that having another standard alongside UPnP will limit interoperability within and across home networks, have tried to rally opposition, but the Chinese delegation, composed of representatives from CESI, MII, and IGRS, has been persistent. It has gradually learned the informal rules of the game and has achieved some positive results. The delegation submitted IGRS in seven parts, and each is winding its way through the ISO process. As of March 2008, one component had been adopted as a final

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75 China submitted WAPI to ISO/IEC JTC1 Subcommittee 6. For an account of the process, see Kennedy, "The Political Economy of Standards Coalitions."

76 The UPnP Forum has over eight hundred members. For more information, see UPnP Forum (http://www.upnp.org) and DLNA Alliance (http://www.dlna.org).

77 The six stages are: (1) new work item proposal, (2) working draft, offered to a working group, (3) committee draft, offered to a JTC1 subcommittee, (4) final committee draft, (5) final draft international standard, and (6) publication.

committee draft (stage 4), four others as a committee draft (stage 3), and two others were still only new work item proposals (stage 1).

Although IGRS and ITopHome still have a chance of being adopted at the international level, their advocates have followed the example of their non-Chinese counterparts in hedging their bets. Lenovo, Huawei, and ZTE are part of the DLNA Alliance; nineteen Chinese companies, including Lenovo and Haier, have joined the UPnP Forum; and three Chinese firms are members of the KNX Alliance. Such ties raise the chances for ITopHome and IGRS to find avenues of cooperation, and also give Chinese supporters a second-best option in case their original plans do not come to fruition.

In addition to pushing for adoption of their own independent standards, China has also become active in two other ways internationally. First, Chinese delegations are trying, without much success, to play a greater role in influencing voting on non-Chinese submissions to international SDOs. In 2007 China unsuccessfully fought to keep WiMAX from being recognized by the ITU as a 3G standard. One reason China's official opposition rang hollow is that some within Chinese industry support WiMAX and are working on WiMAX networks outside of China. Similarly, China could not rally adequate support to stop Microsoft's OOXML from being adopted as a document format standard by the ISO in March 2008. The contest really pitted Microsoft versus IBM, Sun Microsystems, and others who support the alternative Open Document Format (ODF) standard. The conflict became quite heated, as OOXML's opponents charged Microsoft with being heavy-handed. China did not have a central role because its own software industry is weak and has little international presence. China recently adopted its own Unified Office Format (UOF) document standard, which placed it tactically on the same side as the ODF advocates. Some Chinese argued that OOXML, unlike ODF, is only compatible with Microsoft's proprietary Office suite and runs counter to the goal of developing open-source standards. Although the rhetoric within China had a techno-nationalist flavor at times, Chinese discussions also reflected technical concerns over the suitability of Microsoft technology for China's needs. On the other hand, many of China's software companies write Windows applications and have no commercial reason to strongly oppose Microsoft.[78]

China also appears to be playing a more productive role in contributing individual suggestions to broader international standards efforts when it has a clearly defined stake in the outcome. The most significant area is China's involvement in promoting development of the next-generation Internet. The world's current dominant Internet Protocol (IPv4) is running out of addresses. In the 1990s efforts were launched to create a new standard, IPv6, which could accommodate more addresses. There initially was some support in China to support an entirely different solution, IPv9, but China's leading research organizations and companies have rallied around the more popular IPv6. They have been quite active in the Internet Engineering Task Force (IETF), the IPv6 Forum, and the ITU. As an example, China successfully proposed a solution to the IETF to facilitate data transfer between old IPv4 networks and new IPv6 ones.[79]

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[78] Madeline Bennett, "Office Open XML Gets Thumbs Up from ISO," *IT Week,* April 7, 2008; and "OOXML, ODF, and UOF: What's Up in China?" *Standards Today,* August–September 2007, http://consortiuminfo.org/standardsblog/article.php?story=20070817070419313. For the critics' view of OOXML, see the "No OOXML" website, http://www.noooxml.org.

[79] John Leyden, "China Disowns IPv9 Hype," *Register*, July 6, 2004; Ben Worthen, "China Builds a Better Internet," *CIO Magazine,* July 15, 2006; and William Foster and Xiangyu Liu, "China's Next Generation Internet: The Adoption of IPv6" (unpublished paper, August 23, 2006).

The above review of China's efforts to promote distinctive Chinese standards internationally, affect the chances of standards proposed by others, and cooperate in joint standards efforts shows that the story of China and standards is no longer only about what transpires within China and that China's global role is growing. Nevertheless, China's involvement in the global arena is still in its early stages. As Chinese participants internalize the informal norms and sell more Chinese technology abroad, they likely will occupy a more central seat at the table.

Conclusion: The New World of Standards

In this report we have called attention to the serious commitments China is making to technological innovation and the importance it attaches to standards setting in its innovation drive. Chinese initiatives are occurring in an international context where global production and global innovation networks play a major role in structuring the international economy, a process that puts a premium on interoperability and increases the international importance of standardization. The rise of China, and of other large economies, is occurring within this international system, but is also providing an occasion for challenging the distribution of power and influence in the system's governance regimes.

Efforts to judge China's record of standards setting to date require attention to the currency used for measuring success. China's involvement in standards setting—both through active R&D efforts and through building new standards-setting forums domestically and growing activism internationally—clearly points to substantial learning and growing capabilities. On the other hand, the record of market successes of Chinese standards is thus far quite limited. Efforts to make standardization a central feature of the zizhu chuangxin agenda must face the complexities of the standards-innovation relationship and the difficulties others have experienced in using standardization as a tool of technology policy. Expectations that China's sheer size could provide sufficient leverage to have its standards widely accepted have so far proven unfounded. Moreover, China's efforts have the potential for distorting processes of innovation occurring within established standards and could work to the detriment of market interactions that would sharpen the innovative capabilities of Chinese companies and facilitate their participation in international standards bodies.

Implicit in our discussion above is the possibility that we are heading for a much more conflictual international economy, with concerns over technology-based economic and security advantages leading to greater economic nationalism. In this trajectory we might see greater exclusivity of standards bodies and fragmentation of standards setting. Greater involvement by China, along with other developing countries, could lead to more tension with incumbents in standards committees and consortia. The risk to China from such a development would include the possibility of serious technological cul-de-sacs reminiscent of Japan at an earlier age, in which producers and consumers bear excessive costs of misguided technology choices. Given that China is so much larger than Japan, though, the risk of disrupting the international system is likely to be much greater in this negative scenario. There are thus good reasons for all stakeholders to work toward a more inclusive, globalist future in which all parties can play within the system and work within its norms to see to its flexible evolution.

Hence, as elsewhere, a central question facing China is how to define the proper role of government in promoting technological development. Comparative experience suggests that governments should focus on improving the "ecology" of innovation by serving as enablers. In

China this would include finding the right balances between the domestic R&D system and the role of MNCs and between public research entities and the business sector, enhancing support for investigator-driven basic research, strengthening intellectual property protection, fostering an education system that emphasizes creativity, and ensuring that the financial system allows for risky venture financing. It also means overcoming enduring problems of governance, including bureaucratic sectionalism, weak inter-agency coordination, and political interference in the economy. Moreover, Chinese officials could adopt a liberal, techno-globalist interpretation of zizhu chuangxin. Novel products and components, production processes, and means of service provision that utilize standards developed domestically and internationally should also be seen as fulfilling the independent innovation mandate.

Governments and industry from the United States, the European Union, and other incumbent standards leaders need to continue emphasizing a cooperative approach that emphasizes further integrating China into the international standards community. Ostracism or threats of sanctions are likely to be counter-productive. International SDOs and consortia can also be of immense help in several ways. They can expand initiatives to provide training to new members with regard to both official rules and informal norms. Given the growing importance of consortia, there needs to be greater clarification of their relationship with official standards organizations and the appropriate division of labor.

Finally, in light of China's submission to the WTO's Committee on Technical Barriers to Trade about the treatment of intellectual property rights in standards and the substantial lack of consensus globally about these issues, there needs to be greater discussion between governments, standards bodies, industry, and researchers on all sides, in both official and informal settings, about the most effective and fair ways to balance the interests of innovators and consumers as standards are adopted and commercialized. Identification of this issue is not to prejudge the positions, but simply to recognize that there is far from a consensus on these issues and that inadequate discussion and debate will likely generate greater contention in the future.

Although it is unclear which trajectory the global standards regime will take in the years ahead, we expect China will have a lot to say about the direction in which it evolves. The extent to which Chinese stakeholders and the global standards community adapt to each other will have a profound effect on innovation in China and the world more broadly.

APPENDIX Acronym Key

Acronym	Definition
3G	third generation telephony
AAC	advanced audio coding
AVS	audio-visual standard
CDMA	code division multiple access
CESI	China Electronic Standardization Institute
CMMB	China mobile multimedia broadcasting
CCSA	China Communications Standards Association
DLNA	Digital Living Network Alliance
DVB	digital video broadcasting
EPC	electronic product code
EPO	European Patent Office
EVD	enhanced versatile disc
FDI	foreign direct investment
GPN	global production network
GSM	global system for mobile communications
HD-DVD	high-definition digital versatile disc
HDV	high-definition video
HVD	high-clarity video disc
ICT	information and communications technology
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Commission
IETF	Internet Engineering Task Force
IGRS	intelligent group and resource sharing
IPR	intellectual property rights
IPv6	internet protocol version 6
ISO	International Organization for Standardization
ITU	International Telecommunications Union
McWILL	multi-carrier wireless information local loop
MII	Ministry of Information Industry
MLP	National Medium- and Long-Term Program for Scientific and Technological Development
MNC	multinational corporation
MOST	Ministry of Science and Technology
MPEG	Moving Picture Experts Group
NIS	national innovation system
NPC	national product code

Appendix continued

Acronym	Definition
ODF	open document format
OOXML	open office XML
RFID	radio frequency identification
SAC	Standardization Administration of China
SARFT	State Administration of Radio, Film, and Television
SCITO	State Council Informatization Office
SDO	standards development organization
TC	technical committee
TD-SCDMA	time division synchronous code division multiple access
UOF	uniform office format
UPnP	universal plug and play
VC-1	video codec 1
VCD	video compact disc
WAPI	wireless LAN authentication and privacy infrastructure
WCDMA	wideband code division multiple access
Wi-Fi	wireless fidelity
WiMAX	worldwide interoperability for microwave access
WSIS	World Summit on the Information Society
WTO	World Trade Organization

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