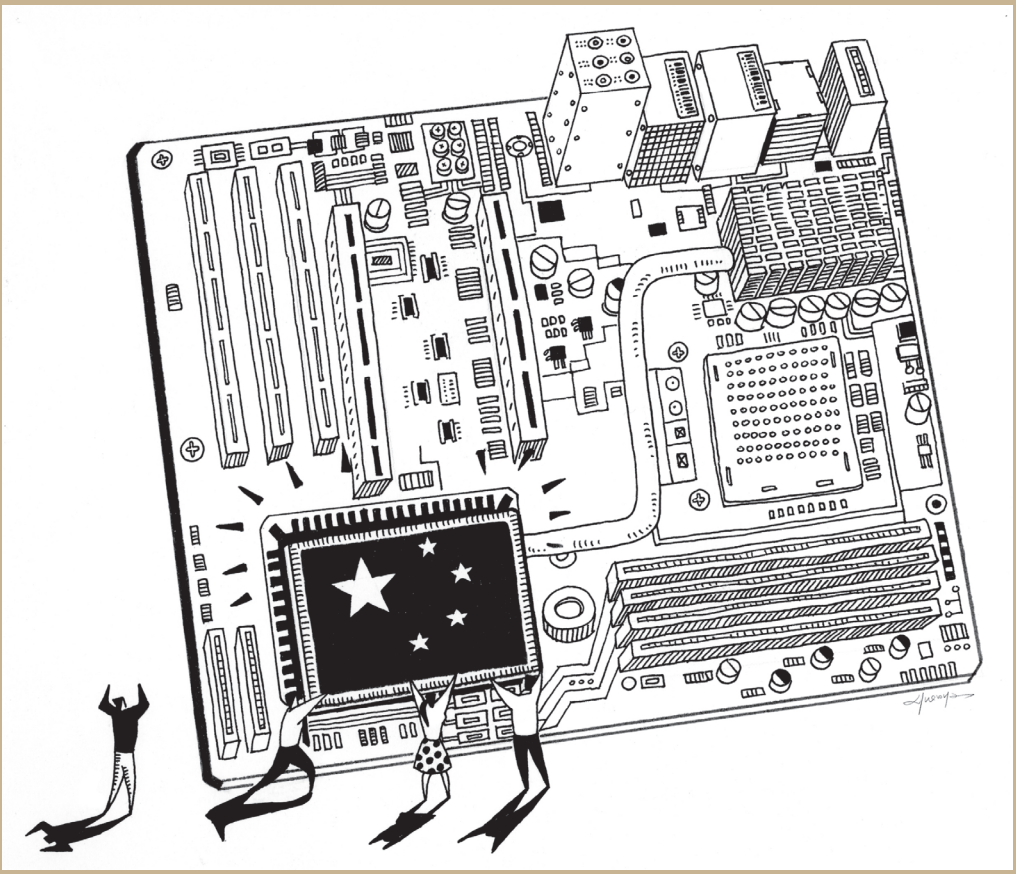


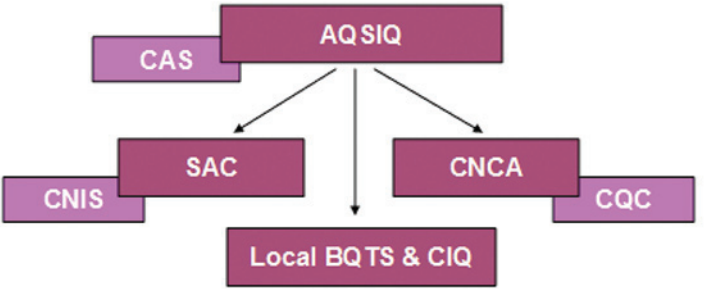
INDIGENOUS INNOVATION AND GLOBALIZATION

The Challenge for China's Standardization Strategy

Dieter Ernst

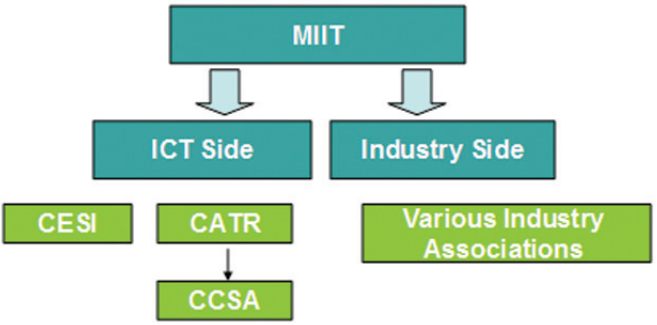
A joint publication of
the UC Institute on Global Conflict and Cooperation
and the East-West Center

Figure 1. *The AQSIQ Standardization Family*



AQSIQ = Administration for Import and Export Control (Ministry)
SAC = Standard Administration of China
CNCA = China National Certification & Accreditation Administration
CNIS = China National Institute for Standardization
CQC = China Quality Centre
CAS = China Association for Standardization

Figure 2. *The MIIT Standardization Family*



MIIT = Ministry for Industry Information Technology
CESI = China Electronics Standardization Institute
CATR = China Academy for Telecom Research
CCSA = China Communication Standards Institute

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Dieter Ernst
East-West Center, Honolulu

June 2011

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iGCC

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About the East-West Center

The East-West Center promotes better relations and understanding among the people and nations of the United States, Asia, and the Pacific through cooperative study, research, and dialogue. Established by the US Congress in 1960, the Center serves as a resource for information and analysis on critical issues of common concern, bringing people together to exchange views, build expertise, and develop policy options. The Center's 21-acre Honolulu campus, adjacent to the University of Hawai'i at Mānoa, is located midway between Asia and the US mainland and features research, residential, and international conference facilities. The Center's Washington, DC, office focuses on preparing the United States for an era of growing Asia Pacific prominence.

About the UC Institute on Global Conflict and Cooperation

Since 1983, the University of California Institute on Global Conflict and Cooperation (IGCC) has facilitated innovative research into the causes of international conflict and cooperation. Founded by nuclear physicist Herbert F. York, IGCC's original emphasis on security and nuclear nonproliferation remains at its core, but its agenda has broadened with time. Today, IGCC researchers study a wide range of topics involving the security, environmental, and economic policies that shape our ability to prevent conflict and promote cooperation. As a research unit serving the entire UC system, IGCC can build project teams from any of the ten UC campuses and the Lawrence Livermore and Los Alamos National Laboratories.

IGCC is committed to educating the next generation of international problem-solvers and peace-makers through its research and teaching activities. IGCC builds bridges between the theory and practice of international policy, injecting fresh ideas into the process by establishing the intellectual foundations for effective policy-making. It provides ways for UC faculty and students to interact with government officials at home and abroad through collaborative, multi-campus projects and through an office at the UC Washington Center.

Executive Summary

The study examines defining characteristics of the evolving Chinese innovation and standards system and explores possible impacts for China as well as the global economy. China considers standardization to be an essential tool for improving its innovative capacity, yet very little is known about this critical building block of China's innovation system. At the center of the analysis is a fundamental challenge for China's standardization strategy: How can China reconcile its primary objective of strengthening indigenous innovation with its leading role in international trade and deep integration into global corporate networks of production and innovation?

Main Argument

1. Recent policy initiatives on standardization and recent developments in three ICT standards projects (TD-SCDMA, IGRS, and AVS) indicate that both the Chinese government and industry are learning from mistakes and are moving to a more flexible and pragmatic approach.
2. China's standardization strategy needs to be viewed in the broader context of its development strategy to catch up with the productivity and income levels of the United States, the European Union, and Japan. To achieve this goal, China's government seeks to move from being a mere standard-taker to become a co-shaper, and in some areas a lead shaper, of international standards.
3. In a "two-track" approach, China is working within the international system with the long-term goal of creating patent-worthy technology essential to global standards. By including Chinese technology into global standards, China seeks to strengthen its bargaining power and to reduce its exposure to high royalty fees. At the same time, however, China seeks to use its increasing geopolitical influence to promote new sets of rules for international standardization, and hence to transform the international standards system itself.
4. Globalization and rising complexity make it necessary for China to combine a government-centered standardization strategy with elements of market-led standardization. China needs to increase the flexibility of policy tools and institutions in order to cope with sometimes disruptive effects of unexpected changes in technology, markets, and business strategies.
5. In its current form, China's policy on information security standards and certification could create unintended disruptive side effects for the upgrading of China's standardization system. An extensive scope of regulation and a lack of coordination between Chinese security and trade policies could create potentially serious trade disputes.
6. China's policies for standardization that were successful during "catching-up" need to be adjusted once the strategic focus shifts to an upgrading-

through-innovation strategy. Any attempt to preserve the status quo ante in the context of globalization and increasing complexity is likely to constrict learning and innovation, the two fundamental prerequisites for sustained industrial upgrading.

7. Change, however, should be constrained by the need to build on accumulated capabilities. "Big Bang" change, which discards the latter, often involves prohibitively high opportunity costs. It may also destroy social consensus—the most fundamental prerequisite for economic development.

Policy Implications

1. The international community should agree that technology-centered competition does not need to be a zero-sum game. However, when this process involves countries at different stages of development, supportive public policies are required to transform technology-centered competition into a positive-sum game.
2. The international community should acknowledge that the challenges faced by latecomers like China are significant; thus, one should not always apply the same criteria to judging the performance of latecomers as one would with the advanced industrial economies. China will need to find its own institutional and legal approaches to develop a standards system that can both foster indigenous innovation and cope with the challenge of globalization and rising complexity.
3. The international community will want to monitor how Chinese policymakers are searching through trial-and-error for ways to reconcile the primary objective of strengthening the innovative capacity of Chinese firms and industries with the country's leading role in international trade and its deep integration into global corporate networks of production and innovation.
4. China should seek to reduce trade conflicts that could arise from its current policy on information security standards and certification. An important trust-building measure would be to improve access to and collection of data that allow for a better assessment of how information security standards and certification can be implemented without disrupting China's integration into the global economy.
5. One concrete suggestion is to create a U.S.–China Institute of Standards and Innovation to train engineers, executives, and technicians, as well as government officials and academics from both countries. Such an institute could also provide technical consulting services to enable both Chinese and U.S. companies to solve problems that arise from dealing with the differing standards systems in the two countries.

Foreword and Acknowledgements

This study is about China's unique approach to standardization as a tool for its indigenous innovation policy, and it explores the challenges this large emerging economy faces in a world of ubiquitous globalization and rising complexity. While the focus is on the specifics of China's case, the analysis builds on research on the general dynamics of innovation in the global knowledge economy, and on the diversity of corporate strategies and policies to foster innovation in the United States, Asia, and Europe. As a result, I have benefited from ideas, comments, and suggestions from a diverse group of scholars, journalists, policymakers, business executives, and analysts in all three of these continents.

For introducing me into the world of international standardization, I owe a particular debt of gratitude to Linda Garcia, Klaus Ziegler, Carl Cargill, Chuck Powers, Michael B. Spring, Wang Ping, Song Mingshun, Michael Ding, Andrew Updegrove, and Gregory Tassey. On the interface between intellectual property rights and standardization, I have benefited greatly from discussions with and the writings of Richard R. Nelson, Joseph Straus, Konstantinos Karachalios, An Baisheng, Yang Lincun, Claudia Tapia Garcia, Ray Alderman, Cliff Reader, Thomas Pattloch, Heinz Goddar, Georg Kreuz, Alan Fan Zhiyong, Wang YiYi, Zhang Yan, and Wu Zhigang. For insights into the dynamics of innovation policy-making in China, I am grateful to Liu Xielin, Xue Lan, Mu Rongping, Gao Xudong, Barry Naughton, Denis Simon, James Fallows, Andrew Batson, Alice Miller, Scott Kennedy, Tai Ming Cheung, Greg Shea, Anne Stevenson-Yang, Duncan Clark, Ted Dean, Julian Wong, Nathaniel Ahrens, Pete Suttmeier, John Chiang, Ingo Liefner, and Jean-Francois Huchet.

The study draws on research undertaken for two collaborative projects: the joint East-West Center/UC Institute on Global Conflict and Cooperation (IGCC) China Innovation project funded by the Minerva program, and the earlier joint National Bureau of Asian Research/East-West Center research project "Standards and Innovation Policy in the Global Knowledge Economy." Key concepts and tentative research findings have been discussed in international workshops in Beijing,[1] in conference calls with standards experts from the United States, China, and the European Union, and in seminars and lectures in universities and research institutes in the United States, China, Europe, and Latin America.

In China, seminars and lectures include inter alia the Chinese Academy of Sciences; the Chinese Academy of Social Sciences; Tsinghua University's School of Public Policy and Management; Tsinghua University's School of Economics and Management; Tsinghua University's Development Research Academy; Peking University's Guanghua School of Management; the China National

1. See proceedings of the October 14, 2009 Beijing conference "Standards and Innovation Policy in the Global Knowledge Economy: Core Issues for China and the U.S.," available at http://cdn.nbr.org/announcements/Email/NBR_200910_ChinaStand.papers.html.

Institute of Standardization; the Intellectual Property Development Research Center of the State Intellectual Property Office; the China Academy of Telecommunications Research, the Ministry of Industry and Information Technology; the Intellectual Property Affairs Center of the Ministry of Science and Technology; the Institute for Advanced Research at the Shanghai University of Finance and Economics; and the School of Standardization and Quality Management at China Jiliang University, Hangzhou.

In the United States, presentations have been prepared inter alia for the SITC project on "Chinese Approaches to National Innovation" at IGCC; the U.S.-China Cooperative Dialogue on Science and Technology Policy, San Diego; the U.S.-China Strategic and Economic Dialogue (background note prepared for David Sandalow, Assistant Secretary for Policy and International Affairs at the Department of Energy); the Council of Foreign Relations Asian Innovation Panel; and the U.S.-China Economic and Security Commission. In addition, presentations have been prepared for the European Patent Office, the OECD, the Center for European Law and Economics Talk Standards blog (http://www.talkstandards.com/); and the Brazilian Ministry of Culture.

I am very fortunate to work at the East-West Center, and I thank Charles Morrison and Nancy Lewis for supporting this research. Thanks also to EWC colleagues, especially Toufiq Sidiqqi and Richard Baker, for brainstorming discussions. The study has greatly benefited from discussions and seminars organized as part of the China Innovation Minerva project at IGCC. I am particularly grateful to Susan Shirk, Barry Naughton, Tai Ming Cheung, and Heidi Serochi. In addition, I would like to express my thanks for support received from the National Bureau of Asian Research, especially from Eric Altbach (now the Deputy Assistant USTR for China Affairs), Raelyn Campbell (now with the Gates Foundation), and Travis Tanner. I was ably assisted by several research assistants, especially Diana Lu, Sheri Martin, and Joe Narus. Most importantly, I owe a debt of gratitude for editorial support to Lynne Bush at IGCC and Elisa Johnston and Carol Wong at the East-West Center.

Introduction: Objectives, Arguments, Findings

This study examines China's attempt to upgrade its standards system as part of its national innovation strategy. Chinese policies on innovation and standards have recently moved high up on the agenda of U.S.–China economic relations, adding further to contentious disputes about exchange rates, trade, and foreign direct investment. Standards are a critical determinant of a country's innovative capacity, but they are also used to create and shape markets and to control competition. Standardization thus has become a highly-contested field of international economic diplomacy, both for government policies and corporate strategies. An analysis of China's standardization strategy is of critical importance for policymakers, corporate executives, and researchers in both countries.

Specifically, this study examines defining characteristics of the evolving Chinese standards system that set it apart from the American standards system and explores possible impacts for China and the global economy.[2] At the center of the analysis is a fundamental challenge for China's standardization strategy: How can China reconcile its primary objective of strengthening the innovative capacity of Chinese firms and industries with its leading role in international trade and deep integration into global corporate networks of production and innovation?

Only a few years ago, China's approach to innovation and standardization barely played a role in international economic diplomacy. With its economic power on the rise, that assessment has changed dramatically. Today, China's innovation policy and its perceived threat to American innovation and competitiveness are a hot topic in U.S.–China economic relations, adding further to contentious disputes about exchange rates, trade, and foreign direct investment. The role of standardization, together with intellectual property rights and government procurement, are at the center of this conflict.

An important objective of the study is to improve the understanding, both in the United States and China, of the role standardization plays in the other country's innovation system and to contribute to constructive solutions to this conflict. A central proposition is that significant differences in the organization and governance of standardization processes exist across countries and industries. For countries, different processes reflect the peculiar characteristics of a country's economic institutions, its level of development, its economic growth model, as well as its culture and history (Kindleberger 1983: 383). Across industries, different standardization processes need to reflect the maturity of

2. A related study focuses on the evolution of the American standards system and recent attempts to develop a new approach to public–private standardization partnerships. See Ernst 2010.

technology and markets, and the resultant specific characteristics of corporate organization and strategy.[3] Unfortunately, a major weakness of standardization theory is that we still lack systematic research that compares the different development trajectories of national and industry-specific standards systems.

As the United States and China display fundamental differences in their levels of development and in their economic institutions, they pursue quite different approaches to standards and innovation policy. The American consensus is that market forces and the private sector should play a primary role in innovation and standardization. China, on the other hand, relies much more on the government to define the strategic objectives and key parameters.

In the United States, there is a widespread expectation that further reforms of China's standards system will "naturally" converge to (almost) full compliance with a U.S.–style, market-led, voluntary standards system. That expectation can be found, for instance, in the "United States Standards Strategy," approved by the Board of Directors of the American National Standards Institute (ANSI) on December 8, 2005, which proposes a "universal application of the globally accepted principles for development of global standards" which is based on the U.S. voluntary standards system (ANSI 2005: iv).

Yet, as this study documents in detail, China's evolving standards system provides little evidence that convergence to the American system is likely to materialize. When Chinese reformers argue for a transition to a more market-driven standards system, they emphasize that the government will continue to play an important role as a promoter, enabler, and coordinator of an integrated standards and innovation policy.

China's primary concern is to develop this vast quasi-continental country as rapidly as possible, and to catch up with the productivity and income levels of the United States, the European Union, and Japan.[4] Strengthening China's domestic innovative capacity is considered to be the key to a sustainable transformation of its economy beyond the export-oriented "global factory" model. To achieve this goal, China's government is very serious in its aspiration to move from being a mere standard-taker to become a co-shaper, and in some areas a lead shaper, of international standards.

In turn, China's indigenous innovation policy and its entry into the global standards game as a new contender has raised concerns in the United States that this may erode American leadership and hasten the decline of the U.S. economy. The U.S. government considers China's innovation policy to be "discriminatory,"[5] implying that this policy is used as a trade-distorting ploy to

3. The classic study remains Pavitt 1984.

4. Determinants and impacts of catching-up processes are analyzed in Fagerberg et al. 2004: 514–42.

5. Commerce Secretary Gary Locke, as quoted in "U.S., China Begin Talks on Innovation Trade Dispute," at http://www.reuters.com/assets/print?aid=USTRE66J6SO20100720, accessed October 6, 2010.

challenge American supremacy in the global knowledge economy.[6] A recent report by the U.S. Chamber of Commerce claims that China's innovation policy is "a blueprint for technology theft on a scale the world has never seen before" (McGregor 2010: 4).

These complaints have begun to generate regulatory action. Responding to a request from the U.S. Senate Committee on Finance, the U.S. International Trade Commission (ITC) has started an investigation (No. 332-519) on "China: Effects of Intellectual Property Infringement and Indigenous Innovation Policies on the U.S. Economy," and scheduled public hearings, which started in June 2010.[7] During that first ITC hearing, the U.S. Chamber of Commerce argued that China's innovation policy

> … restricts the ability of American companies to access the market and compete in China and around the world by creating advantages for China's SOEs and state-influenced champions, … [and has] … the potential to undermine significantly the innovative capacity of the American economy in key sectors, and, consequently, harm the competitiveness and livelihood of American business and the workers that they employ.[8]

As for China's standardization strategy, it is viewed in the United States as a critical weapon of China's neo-mercantilist policies to keep American companies at bay. The U.S. Information Technology Office (USITO), which represents the U.S. information and communications technology industry in China, observes "a clear trend to promote indigenous technology which is developed outside the international standards development system" (USITO 2009). And for the chair of the National Academies Committee on Comparative Innovation Policies, China's standardization strategy "raises serious questions of WTO compliance," as it promotes "… [t]he creation and application of a large num-

6. Deputy USTR Demetrios Marantis argues that China's indigenous innovation policies are "very troubling" because they "unfairly favor domestic producers at the expense of foreign firms, … [and]… because of their threat to global intellectual property protections, fair government procurement policies, market competition, and the freedom of U.S. companies to decide how and when to transfer technology." Quoted in Doug Palmer, "UPDATE 2-China trade behavior imperils ties—USTR," at http://www.reuters.com/assets/print?aid=USN1520929420100715, accessed October 6, 2010.

7. This has culminated in a study, published by the U.S. International Trade Commission, entitled "China: Intellectual Property Infringement, Indigenous Innovation Policies, and Framework for Measuring the Effects on the US Economy," Investigation No. 332-514, USITC Publication 4199, Washington, DC, November 2010.

8. Testimony by Jeremi Waterman, Senior Director, Greater China, at the U.S. Chamber of Commerce before the U.S. International Trade Commission Hearing on "China: Intellectual Property Infringement, Indigenous Innovation Policies, and Frameworks for Measuring the Effects on the U.S. Economy" (Investigations No. 332-514 and 332-519), June 15, 2010.

ber of national standards in China, as opposed to use of existing international standards."[9]

Perceptions in China are very different:

> Among Chinese industries and scholars, there is deep frustration with the U.S.–China standards discussions and distrust in the sermon-style arguments propagated by the United States …. [There is concern that] … the disputes between the United States and China on ICT standards and the overarching issue of IPRs [intellectual property rights] in standardization still remain unsolved. The situation may actually be worse in the sense that both sides have noticed the difference but continue to head in their own directions (An 2009: 195).

China's leadership considers the American critique of its innovation policy to be unfair and hypocritical, and suspects that the United States is trying to contain China's rise. A leading official responsible for China's technology policy argued in 2007 that

> …[t]he majority of the market is controlled by foreign companies, most core technology relies on imports, the situation is extremely grave as we are further pressured by developed countries who use blockades and technology controls—if we are not able to solve these problems we will forever be under the control of others.[10]

From the Chinese perspective, reducing dependence on manufactured exports will only be possible if China succeeds in strengthening its domestic innovative capacity.[11] To achieve this objective, China seeks to upgrade its standards system to (i) lessen the "control of foreign advanced countries over the PRC," especially "in the area of high and new technology"; and (ii) increase the effectiveness of Chinese technical standards as important protective measures or barriers to "relieve the adverse impact of foreign products on the China market."[12] The same document by the Standards Administration of China (SAC) adds that China's standardization strategy needs to fill a policy vacuum, as China's accession commitments to the WTO have substantially reduced the use of most other trade restrictions such as tariffs, import quotas, and licensing requirements.[13]

9. A. W. Wolff, "The Direction of China's Trade and Industrial Policies," testimony before the House Ways and Means Committee of the U.S. House of Representatives, Washington, D.C. June 16, 2010, 7. The author is co-chair, International Trade Practice, Dewey & LeBoeuf, and a professor at the Monterey Institute of International Studies.

10. State Councilor Liu Yandong, quoted in McGregor 2010: 17.

11. Many of our Chinese interview partners seem to be genuinely puzzled as to why foreign observers who recommend that China reduce its export dependence to reduce global imbalances fail to acknowledge that this requires substantial improvements in China's domestic innovation capabilities.

12. SAC 2004, preface and part I, section IV.

13. This assessment that China gave away too much in joining the WTO is supported by Alan W. Wolff, who argues that " … [i]n 2001 China joined the WTO. In doing so, China made a

As this study will document, China seeks to develop a "two-track" approach. On the one hand, China is working within the international system with the long-term goal of creating patent-worthy technology essential to global standards. By including Chinese technology into global standards, China seeks to strengthen its bargaining power and to reduce its exposure to high royalty fees. At the same time, however, China seeks to use its increasing geopolitical influence to promote new sets of rules for international standardization, and hence to transform the international standards system itself.

On a global scale, this process is still at the very beginning. But there is little doubt that, in the medium term, China will change not only the international approach towards standardization but also the rules of broader frameworks that govern international trade, including TRIPS (trade-related aspects of intellectual property rights). The emergence of common global challenges like climate change create conflict and negotiation frameworks with dynamically changing alliances, wherein several sub-systems (including standardization, IPR, trade rules, and so on) are exposed to strong scrutiny and where the status quo may no longer be sustainable.

In short, there are vastly different perceptions in the United States and China of what constitutes legitimate goals of innovation and standards policy. This study seeks to provide an objective analysis of these differences. It is hoped that such an analysis will help to avoid a vicious circle of escalating trade conflicts and regulatory confrontations between the United States and China, where each country's public posture on innovation and standardization will increasingly harden, while frantic negotiations are tried to mitigate the damage in the background.

To examine the evolution of China's standardization strategy and its role for indigenous innovation, the author has conducted extensive interviews with corporate executives, government officials, and scholars, as well as case studies of Chinese standards projects in the ICT industry.[14] The study focuses on the information and communications technology (ICT) industry, which serves as a testing ground for China's effort to upgrade its standards system. The generic nature of ICT implies that what happens in this industry has a pervasive impact across major sectors of the economy. In addition, as China is the global ICT factory, its economy heavily depends on this industry. Most important for the purposes of this study, the ICT industry is particularly exposed to the challenge of rising complexity.[15] The study builds on earlier research on China's standards system that explores how actual standards are created and used in a country with economic institutions that differ from those in Western economies. An important focus of that earlier research has been the threat of "Chinese techno-nationalism." The distinction between ideological and pragmatic forms

much more extensive number of specific market liberalizing commitments than had ever been made by any acceding member, and began to transform its economy" (Wolff 2010: 3).

14. See the List of Interviews at the end of this volume.

15. Future research needs to examine how China's standardization policies differ in other industries such as cars, chemicals, food processing, energy, and clean technology.

of techno-nationalism and techno-globalism was a useful attempt to identify stakeholders and their conflicting interests in China's standardization system.[16] But this analysis provides only a partial picture of the dynamics of change in China's innovation system. As Chinese interview partners have argued, the distinction between techno-nationalism and techno-globalism should also be used to study diverse stakeholders in the U.S. standardization system.[17]

This study extends the discussion further. A distinguishing feature is an explicit analysis of the international dimension of China's standardization strategy.[18] Two questions are addressed specifically: What precisely is the challenge that China's innovation and standards policy faces from rising complexity through ubiquitous globalization? And how does China's entry into the global standards game as a new contender affect the positions of the United States, the European Union, and Japan, and China's relations with these three incumbent global players?

To understand precisely what challenges and opportunities China faces in its standards and innovation policy, Chapter One introduces a conceptual framework that firmly places standardization in the broader context of debates on innovation, IPR, and catching-up development. This framework draws on insights from innovation economics, corporate innovation management, and theories of economic development. A central proposition is to emphasize the diversity of standardization processes and stakeholders across countries and industries that reflect unique characteristics of economic institutions, history, level of development, industry structure, and growth strategy.

Chapter Two reviews the historical evolution of China's standardization strategy and describes its objectives. The chapter emphasizes that the challenges faced by latecomers like China are significant and that one should not always apply the same criteria in judging the performance of latecomers as one would to advanced industrial economies. The analysis sheds light on two defining characteristics: (i) The catalytic effect of the Chinese Medium- and Long-Term Plan for Science and Technology Development that defines the role of standards as a tool for indigenous innovation; and (ii) the diversity of stakeholders as a source of fragmentation in China's standards system. The chapter also reviews publicly available information on China's policy initiatives on information security standards and certification and discusses potential negative effects on China's

16. See Kennedy et al. 2008.

17. In fact, Richard R. Nelson and Sylvia Ostry, the two authors who created this distinction, emphasize in their pioneering study that techno-nationalism played an important role in the rise of American technological leadership, and that techno-nationalism continues to coexist in the United States with techno-globalism promoted by U.S. multinational corporations. See Nelson and Ostry 1995.

18. Earlier research has emphasized the need to study "China's Evolving Role in the Global Knowledge Economy" (the title of the report by Kennedy et al. 2008), without, however, precisely examining what constitutes the "global knowledge economy" or its implications for China.

evolving standards system.[19]

Chapter Three examines the dilemma faced by China's standardization strategy, as ubiquitous globalization, combined with rising complexity of technology, business organization, and competitive dynamics, constrain national policies. To assess China's capacity to cope with those challenges, a simple, stylized model is used that distinguishes important tasks of standardization and highlights differences in capability sets and in standardization strategies. The chapter highlights the resultant significant challenges for China.

In the remaining two chapters, the study makes a conscious effort to dig deeper than earlier reports that have provided brief overviews of specific examples of Chinese standards projects. While such overviews are useful, they provide an overly-simplified picture of a more nuanced reality, where key parameters of the Chinese standards system continuously evolve to adjust to a changing and increasingly complex international standardization landscape.

To capture these nuances is critical for effective policy advice. Hence, an important contribution of this study is an in-depth analysis in Chapters Four and Five of recent developments in China's standards system, both with regard to laws and regulations that shape China's standardization strategy and with regard to the organization of important Chinese standards projects in the ICT industry.

Chapter Four examines recent policy initiatives that shape China's standardization strategy. The analysis covers China's policies on the registration of products that contribute to indigenous innovation; the revision of government procurement regulations; and new regulations for patents included in standards. It examines China's response to foreign complaints and its capacity to learn from earlier mistakes. There are signs of gradual progress toward greater openness, transparency, and flexibility. It is argued that China's persistent innovation gap with the United States, Europe, and Japan, and its deep integration into global production and innovation networks may explain why China's government is gradually moving toward greater pragmatism in its innovation policy, despite forces in the security apparatus that seek to slow down these adjustments.

Chapter Five examines recent developments in three major standards projects in the ICT industry (TD-SCDMA, IGRS, and AVS). While earlier developments in these projects have been extensively researched (especially for TD-SCDMA), this study takes a fresh look at these standards development organizations, and asks whether current adjustments in their management have improved China's capacity to cope with rising complexity through institutional innovations and greater organizational flexibility and pragmatism.

The Conclusions summarize main findings of the study, present policy implications, and suggest priority areas for future research.

19. Objective academic research on information security standards and certification remains constrained by limited access (both in China and in the United States) to relevant sources of information. This has prevented a more systematic and in-depth analysis of these issues.

CHAPTER ONE
Standards, Innovation, and Economic Development: A Conceptual Framework

There is an abundance of theoretical and econometric studies of how standards shape market competition, but most of these studies have focused on Western economies, primarily those with Anglo-Saxon institutions. And even for Western economies, fundamental public policy issues of standards setting remain grossly under-researched. According to two leading scholars of standards policy, "… [g]eneral agreement about appropriate public policy toward government standard setting does not exist. The most basic questions remain unaddressed" (Greenstein and Stango 2007: 1–2).

We need a conceptual framework that allows us to study how standards are created and used in a country with economic institutions that differ from those in Western economies. This requires that we place standardization in the broader context of the role of innovation and intellectual property rights as a source of "catching-up" development. To develop such a framework, this volume is based on seven propositions.

Intellectual Property Rights and Economic Development: Lessons for Standardization Research

A first proposition is that the study of standardization needs to be "nested" in a larger technology and economic development context. Specifically, standardization research can learn from recent work on the role of intellectual property rights (IPR) for economic development.[20]

The essence of economic development is catching-up, defined as "the process in which a developing country narrows the gap in productivity and income relative to a leading country."[21] Learning advanced technologies is critical for successful catching-up. The protection of intellectual property rights is a necessary, but by no means sufficient, condition. Detailed case studies of earlier historical experience in the United States, the Scandinavian countries, Japan, Korea, and Taiwan demonstrate that IPR protection can only contribute to economic development if it takes place as part of a multi-faceted innovation strategy that seeks to strengthen absorptive and innovative capabilities of firms, and to develop a broad-based innovation infrastructure (including standards).[22]

20. See, for example, Goldstein and Straus 2009.
21. Odagiri et al. 2010: chap 1.
22. See case study chapters 2–6 in Odagiri et al. 2010.

In fact, a recent study on the relationship between intellectual property protection and innovation highlights its complex nature. A key finding is that, "although stronger IPR protection directly increases the incentive to innovate, it also discourages innovation in the long run by suppressing the process of 'learning by doing.' … This implies that both very strong and very weak IPR policies decrease innovation, so a moderate approach is preferable" (Furukawa 2010).

Of particular interest for the study of standardization is that IPR regimes "significantly vary across industries and across countries of different economic size or different technological capacity." (Odagiri et al. 2010: 12).[23]

Developing countries face a fundamental dilemma: A weak IPR regime may stimulate imitation (without patent holder consent), while discouraging the development of advanced technology through licensing or inward FDI, or through domestic innovation efforts. In a developing country, "utilization of knowledge invented abroad should be given priority over incentive for invention and, hence, a weaker patent regime that targets diffusion … [rather]…than creation should be adopted" (ibid.: 11).

Hence, a country's IPR regime needs to evolve with the development of its domestic innovative capacity. "… [T]he relative merits of different IPR regimes change over the stages of economic development…. [Typically], countries try to alter their IPR regime in response to changing needs. In consequence, a country's IPR regime likely coevolves with its economy" (ibid.: 12). As long as a country's innovative capacity is weak, it benefits from a relatively loose IPR regime. Once the country's innovative capacity begins improve, its IPR regime needs to be gradually strengthened.

In addition, there is an important international dimension. In-depth research on Asia's export-oriented economies finds that, while their own IPR regimes matter, of at least equal importance for their economic growth have been the IPR regimes of their main export markets in the United States, the European Union and Japan. That research also shows that a sophisticated domestic IPR regime is important, as it forces Asian firms to "learn about IPR legal issues and … [to] … accumulate capabilities for IPR management" (ibid.: 424).

Patents and Standards

A second proposition addresses the critical role of patents for standardization. Increasingly, standards include technologies that are protected by IPR. In theory, a neat distinction is possible between standards that are a "public good" (free, collective good) and patents that are a "private good" (for private, exclusive use by patent owners).[24] But in reality, tensions are rising between patents

23. Case studies "document again and again the very great differences across industries in the extent to which IPR regimes, indigenous or foreign, affect the catch-up process….[Hence], it makes no sense to talk about the influence of IP on development in general. One has to specify the sector one is concerned with" (Odagiri et al. 2010: 423).

24. Economists typically define "public goods" by two qualities: "non-rivalry in consumption (i.e. they are not depleted by an additional user) and non-excludability (i.e. it is generally difficult or impossible to exclude people from its benefits, even if they are unwilling to pay for them)" (Baumol and Blinder 1991: 617).

and standards: "… (w)hile technical standardization is meant to transform ideas into a public good, patent protection transforms them into a private good" (European Patent Office 2007: 93).

As globalization has increased technology-based competition, the key to competitive success is a broad portfolio of "essential patents," which are necessary to produce any product that meets the specifications defined in the standard.[25]

Research by Knut Blind and associates has documented the use of essential patents as a strategic weapon to prohibit, delay, or obstruct standardization processes.[26] This is the case, for instance, when incumbent market leaders pursue so-called platform leadership strategies through nominally open but de facto proprietary standards that are designed to block competitors and to deter new entrants.[27]

And M. Lemley, in two highly influential studies on the licensing and disclosure of private standard-setting organizations, documents the difficulties of finding fair, reasonable, and non-discriminatory (FRAND) compromises in private standard-setting organizations (Lemley 2002: 1889–91, Lemley 2007). This is especially difficult for industries like the ICT sector, where interoperability standards are required to make products or services compatible with each other in order to maximize the benefits of network externalities.

According to a recent study by the Federal Reserve Bank of Philadelphia, finding fair and non-discriminatory compromises is made even more difficult by "the potential for opportunistic behavior by participants who own patents on a technology essential to the standard. There is a risk that without sufficient transparency and sufficiently strong mutual interests, network participants could make large investments to implement a standard only to be held up by a firm threatening to withhold a key piece of technology" (Hunt et al. 2007). The study argues that

> … in all likelihood some kind of agreement would be reached, but on terms substantially worse than the participants initially expected. Indeed, the risk of such an outcome may discourage firms from adopting a standard or even participating in the standard-setting process. In other instances, awareness of a key blocking patent might lead to the adoption of a standard that poses less risk to participants but which is also technologically inferior (ibid.: 3).

25. Patents are "essential" to a standard "when it is not possible to comply with the standard without infringing that intellectual property right" (Tapia and Ernst forthcoming).
26. Blind et al. 2004. See also the seminal article "Patent Holdup and Royalty Stacking" (Lemley and Shapiro 2007).
27. For example, Intel has attempted to extend its control over microprocessors by creating widely-accepted architectural designs that increase the processing requirements of electronic systems and, hence, the market for Intel's microprocessors (Gawer and Henderson 2007).

In short, the use of "strategic patenting" to generate rents from de facto industry standards has transformed the dynamics of the international standards system.

Different Perceptions of International Standards

A third proposition is that perceptions differ on what constitute "international standards" and on the legitimacy of the existing international standards system. It is important to spell out explicitly these different perceptions, given that compliance with international standards is the principal policy issue influencing the international discourse on China's standards policy.

The Chinese position is straightforward and is derived directly from China's standardization law. For China, an "international standard" is a standard developed under the umbrella of an international institution recognized by China, in most cases the United Nations. Standards developed by U.S. or EU standardization bodies are not recognized, and China does not have a procedure for the formal adoption of such standards.

This study adopts the pragmatic approach used by the European Telecommunications Standards Institute (ETSI), which distinguishes between "international standards," that is, formal UN (or similar multilateral organization) based standards and "global standards" which are de facto globally recognized no matter their origin.[28] Standards developed by consortia are thus often "global standards" but never "international standards." In Chinese eyes these global standards are all informal. They can be copied without formally adopting them.

While these different definitions may sound technical, they have potentially far-reaching implications for China and other emerging economies. These countries are searching for ways to make effective use of the existing international standards system to strengthen their growth potential and their innovative capabilities. However, there is a widespread perception in these countries that the existing international standards system, and especially the non-formal standards deveolpment organizations and consortia, primarily reflect the interests of large global industry leaders from the United States, the European Union, and Japan. The idea that it is natural and normal to adopt the governance formulae of the incumbents, as if these were compulsory and necessary, is not obvious to the new players. Compared to the established leaders, the new players have different needs, institutions, business models, and capability sets.

The resultant tensions are especially prominent for the role of patents in standardization. A recent study by Li Xuan and An Baisheng highlights concerns that play an important role in shaping China's standardization strategy. Li and An argue that "… [p]atent hold-ups, royalty stacking, and refusal to license are the major sources of problems with regards to IPR in standards, and,

28. The ETSI definition was mentioned in an email from Klaus Ziegler (European Standardization Expert for China), dated August 10, 2010.

as a result, many markets have been substantially infected with IPR misuse" (Li and An 2009: viii). This is considered to be "… extremely harmful to developing countries … When IPR is incorporated in standards without appropriate safeguards against IPR misuse, it can further isolate …. developing countries from interconnecting with the rest of the world—a situation that can negatively impact their social and intellectual growth along with their economic prosperity. … IPR in standardization has currently evolved from a mainly competition issue in developed countries into a global issue with profound and complicated North-South implications" (ibid.: 5).

Li and An conclude that, "… even though the correct policy for IPR in standards is to ensure a balance between IPR protection and the integrity of standardization, currently, the essential task should be focused on regulating IPR misuse in standardization" (ibid.: viii).

Irrespective of whether one agrees with this position, it is important to acknowledge that China has its own views on what constitutes an international standard.

Standards Systems Differ

A fourth proposition is that national standards systems differ. Unfortunately, a major weakness of the standardization literature is that we lack systematic research that compares different national standards systems and their divergent development trajectories.[29] Existing comparative studies are focused on the American and European systems, neglecting important developments in Japan, India, Brazil, Russia, and, most importantly, China.[30] An example of this outdated view of the global map of national standards systems can be found in an article published in the journal *World Politics* that argues:

> What emerges from the study of the formal institutions and organizational practices is that there are, broadly speaking, two types of institutional systems at the national level: an American (U.S.) system of standardization, which is fragmented, market driven, and characterized by a high degree of internal competition, and a markedly more hierarchical and highly coordinated system in Europe, which is also publicly regulated and subsidized (Mattli and Buethe 2003).

It is time to move beyond this geographically restricted research agenda, and to take note of important developments in the national standards systems

29. There are, of course, many specialized data bases for engineers that compare technical standards for particular technologies, but little research exists that compares institutional arrangements and strategies that shape different national standards systems. On data bases for engineers, see, for instance, http://www.engineeringtoolbox.com/pipes-codes-standards-t_17.html, accessed April 30, 2010.

30. An interesting comparison of Japanese and U.S. standards systems can be found in Leiponen 2001. See also McIntyre 1997.

of emerging economies. A detailed comparison between the United States and Chinese standards systems is beyond the scope of this study. But, as argued by Andrew L. Russell, "even a cursory comparison shows how national approaches to standardization embody a great variety of choices and tradeoffs that are time and place specific" (Russell 2005: 3).

In the United States, debates on the role of standardization in China are based on the proposition that a bottom-up approach to standardization that is largely driven by market forces and the private sector is desirable in terms of economic efficiency. But Chinese observers respond that "the bottom-up approach … produces outcomes they do not find equitable."[31] And An Baisheng (2009: 197) adds that "in other countries government intervention in standardization has been the normal approach for various reasons, including insufficient private investment in standards that are considered to be quasi-public goods."

Both propositions contain more than a kernel of truth. But research should dig deeper, and address, inter alia, the following questions: What do we know about the historical origins of China's standards system? What were the sources for China's approach to standardization? What features define the current governance of the Chinese standards system? Who are the important stakeholders and what is their role in standards development? And what does this tell us about the efficiency and distributive justice of the Chinese standards system? These questions are discussed in the following chapters.

Standards and Innovation

A fifth proposition is that the relationship between standards and innovation is much more complex than acknowledged thus far in innovation theory. On the positive side, there is no doubt that standards can be a critical enabler of innovation. There is no automatic link, of course, but standards can foster economic growth by reducing transaction costs and achieving economies of scale through interchangeability (Kindleberger 1983). Economic standardization theory has shown that "… [s]tandards affect the R&D, production, and market penetration stages of economic activity and therefore have a significant collective effect on innovation, productivity, and market structure" (Tassey 2000: 587).

That does not imply that standardization per se is good under all conditions. For instance, standards that fail to address critical societal concerns with regard to climate change, health, or product safety may actually give rise to wasteful and even destructive innovation. Standards may also effectively limit innovation and economic growth when they are used as a weapon to block competition (e.g., Lemley 2002).

There is also a fundamental tension between standards and innovation. By freezing a given technology, standards are supposed to provide stability for in-

31. Tim Simcoe, comments on TalkStandards Open Forum: Standards Policy in China, June 25, 2010, at http://www.talkstandards.com/standardisation-policy-in-china-a-path-from-made-in-china-to-innovated-in-china/, accessed June 26, 2010.

dustry and customers, as well as for international trade and investment. Yet, at the same time, innovations continuously upset this stability by introducing new products based on new standards. J. A. Schumpeter's theory of "creative destruction" provides a useful analytical framework. For Schumpeter, capitalism

> is by nature a form or method of economic change and not only never is but never can be stationary. And this evolutionary character of the capitalist process … [is driven by innovation]…, the fundamental impulse that sets and keeps the capitalist engine in motion.… [Innovation] … incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. The process of Creative Destruction is the essential fact about capitalism. … In other words, the problem that is usually being visualized … [by economic and legal theories] … is how capitalism administers existing structures, whereas the relevant problem is how it creates and destroys them.[32]

A Dynamic Perspective: Evolving Tasks of Standardization

A sixth proposition is that a dynamic analysis is required to capture the continuous changes and adjustments in the processes of standardization. A fundamental insight of Schumpeter's "creative destruction" theory is that economic institutions incessantly need to adjust to changes in markets and technology. This implies that there is no one best way of organizing standardization. According to the American Engineering Standards Committee Yearbook of 1925, "… [s]tandardization is dynamic, not static. It means, not to stand still, but to move forward together."[33] This fundamental insight still holds today, but unfortunately there is a tendency in current debates about standardization to neglect this dynamic aspect. Standardization systems are in constant flux, and one needs to apply this fundamental insight to the study of contemporary standards systems, whether in the United States or in China.

To shed light on the evolving tasks of standardization, we first need to open the black box of standards and introduce an operational definition. There are an almost infinite number of standards that differ in their form and purpose. A state-of-the-art definition that serves our purpose well is provided by the National Institute of Standards and Technology (NIST) as part of its Smart Grid Interoperability Standards project (NIST 2010: 19, 20). Standards are: "… [s]pecifications that establish the fitness of a product for a particular use or that define the function and performance of a device or system. Standards are key facilitators of compatibility and interoperability."[34]

32. Schumpeter 1950: 83, 84.
33. Quoted in Russell 2005: 1.
34. For a definition of interoperability standards, see Chapter Three, this volume.

In the literature, standards are normally categorized as proprietary versus open, and as de facto versus de jure (Stango 2004). Proprietary standards are owned by a company that may license them to others, while open standards "are available to all potential users, usually without fee" (Steinfield et al. 2007: 163). De facto standards achieve adoption through standards competition among rival standards consortia. Finally, de jure standards are adopted through consensus, which is sometimes formally expressed through industry committees or formal standards organizations.

At the most fundamental level, standards are necessary to ensure the quality and safety of products, services, and production processes, and to prevent negative impacts on health and the environment. Hence, an important function of standards is to reduce "risks for makers of compliant products and users of these products" (Alderman 2009: 2, 3).

In addition, standards are necessary to reap the growth and productivity benefits of increasing specialization, analyzed long ago in Adam Smith's *The Wealth of Nations* (Smith [1776] 1970, book 1, chap. 3). According to economic historian Charles Kindleberger (1983: 378–79), "… [f]or the most part, standardization was originally undertaken by merchants" to facilitate a progressive specialization through trade."

Today, however, specialization extends well beyond trade into manufacturing and services, including engineering, product development, and research. Equally important is the international dimension. In Chapter Three, the study lays out the new challenges that standards face. As globalization has been extended beyond markets for goods and finance into markets for technology and knowledge workers, standards are no longer restricted to national boundaries. Standards have become a critical enabler of international trade and investment—they facilitate data exchange as well as knowledge sharing among geographically dispersed participants within global corporate networks of production and innovation (Ernst 2005b, Ernst 2005c).

In short, standards are the lifeblood of innovation in the global knowledge economy. Today, standards are necessary not only to reap economies of scale and scope, but also to reduce transaction costs and to prevent duplication of efforts. In addition, standards are required to enable data transfer and knowledge exchange and to facilitate interoperability of components and software within increasingly complex technology systems (for example, in a laptop, a hand set, or a switching system).

Without interoperability standards, it would be impossible to achieve network externalities that shape competition in markets for products and services that use information and communication technologies (Katz and Shapiro 1985). In these markets, "… [a]s the set of users expands, each user benefits from being able to communicate with more persons (who have become users of the product or service)" (Rohlfs 2001: 8). "Network externalities" imply that a company succeeds "when customers expect that the installed base of … [the

company's] … technology [will] become larger than any other," with the result that the customers "adopt that technology to the virtual exclusion of others" (Sheremata 2004: 359).

Developing these interoperability standards is a moving target. The challenge is to allow for a continuous adjustment to cope with technical progress. Take the example of the rapidly evolving processor technology that drives the world's computers. The central processing units (CPUs) made by Intel and AMD under Intel's "x86" designs are now rivaled in importance by graphic processing units (GPUs) as PCs are used for multimedia tasks. For a computer company to use the GPU technology, it needs at least three things: "a license … [from Intel] … to the "x86" design of the CPU, a clear agreement about interoperability between the GPU and the CPU, and finally a strong enforcement mechanism—with clear standards and a timetable for prompt resolution of disputes." [35]

To cope with these critical challenges, standardization has become a complex and multi-layered activity that involves multiple stakeholders who differ in their objectives, strategies, resources, and capabilities. Most importantly, standardization is a highly knowledge-intensive activity that requires well-educated, experienced engineers and other professionals. While engineers originally created this discipline, key concepts are now shaped by legal counselors as well as corporate executives and government officials (Spring 2009). Equally important is that considerable financial resources are required to develop and implement effective standards.[36]

What Is Success?

A seventh and final proposition is that we need a broad definition of what constitutes the success or failure of standardization strategies.

In the United States, success is typically defined by commercial criteria, like market share, return on investment, and rents that innovators can reap from a particular technology. This definition of success is used, for example, by Kennedy et al. (2008). In order to assess how likely it is that a standard project will succeed, these authors examine the role played by the government, the scope and dynamics of supporting industry coalitions, and the market presence of "non-Chinese" standards.

Kennedy et al. (ibid.: 25) argue that "successful commercialization depends much more on the character of the … [supportive industry] coalitions and the prominence of rival technologies" than on government support. Using this framework, the authors conclude that China's experience with standardiza-

35. David Balto, a former antitrust attorney at the Federal Trade Commission, quoted in "Intel Nears Settlement in Market Abuse Probe," *Financial Times*, July 21, 2010, 15.
36. See the stylized model of complexity and cost of standardization in Chapter Three, this volume.

tion has produced mixed results. TD-SCDMA and WAPI are considered to be costly failures, because they have not generated effective demand and industry support. On the positive side, AVS and IGRS are believed to have a significant potential for success, although this potential has not yet been utilized.[37]

However, China is not the only country where standards fail. And standards may also fail when the government does not play a role. Take the United States, where standards are shaped primarily by private firms. For all practical purposes, for every successful standard in the United States there will always be standards that fail. Examples include the persistent failure of Microsoft and Intel to establish their proprietary technologies as de facto standards for games and mobile handsets respectively. Another interesting example of failure is Qualcomm's attempt to establish its MediaFLO standard for digital mobile TV as an international standard.[38] This standard received considerable support from the U.S. government, as the MediaFLO system was allowed to use frequency spectrum 716–722 MHz, which was previously allocated to UHF TV channel 55. And Qualcomm has poured hundreds of millions of U.S. dollars into its FLO TV service, building a network infrastructure and striking content deals in the United States. Qualcomm chips and service are embedded in Verizon and AT&T phones and its own personal TV device. Nevertheless, Qualcomm's MediaFLO standard has made little impression overseas. Worse yet, few customers in the United States have shown interest in this service, and Qualcomm's CEO admitted that "take-up of the service had been disappointing," signaling that this standard might have been an expensive flop.[39]

A Broader Definition of Success

This study uses a definition of success that links standardization to the broader challenges of innovation and economic development. In essence, a standards project will be considered a success if it:

- maximizes learning effects and standardization capabilities;
- avoids strategic patenting by owners of essential patents that could block innovation;
- reduces licensing costs to avoid getting caught in the so-called patent trap;

37. For a more nuanced and positive assessment, see Chapter Five, this volume.
38. MediaFLO is a proprietary technology, developed by Qualcomm, to transmit video and data to portable devices such as mobile phones and personal televisions, used for mobile television. The "FLO" in MediaFLO stands for Forward Link Only, meaning that the data transmission path is one way, from the tower to the device. The MediaFLO system transmits data on a frequency separate from the frequencies used by current mobile telephone networks.
39. Paul Jacobs, CEO of Qualcomm, quoted in "Qualcomm Buoyed by Global Growth in 3G," *Financial Times,* July 22, 2010, 17.

- broadens the scope for innovation to avoid technology lock-in by not blocking foreign standards;[40]
- protects confidentiality, integrity, and availability of data through information security industry standards;
- facilitates and broadens the diffusion of best-practice productivity-enhancing generic technologies;
- initiates open and transparent standardization processes that are in line with WTO and other international regulations;
- helps to adjust the governance mechanisms and institutional architecture of international standards-setting bodies;
- and develops a capacity for flexible and fast adjustments, in cases where policies do not produce the expected results.

This broader definition of success has important implications for China's standardization strategy. A flexible approach to standards and innovation policy is required that balances elements of top-down and bottom-up policies and that looks forward and avoids fighting old battles. Both the Chinese government and industry need to combine a unified strategy with a capacity for flexible adaptation and timely correction of unintended side effects of policy decisions. Increased flexibility is needed to engage multiple stakeholders (both domestic and foreign) in the standardization process and to accommodate their often conflicting interests. China's standard system needs to move away from a purely government-centered, top-down system towards a more decentralized and market-driven approach.

40. Brian Arthur (1989) provides the classic analysis of "technology lock-in." He shows that the economy, over time, can become locked in by "random" historical events to a technological path that is not necessarily efficient, not possible to predict from usual knowledge of supply and demand functions, and not easy to change by standard tax or subsidy policies.

CHAPTER TWO
China's Strategy: Standards as a Tool for Indigenous Innovation

In the United States, there is a widespread belief that a "voluntary standards system" is capable of accomplishing public policy objectives better than any other standards system, especially systems that are heavily reliant on the government. Hence, the American standards system should serve as a "best practice model" and other countries should strive to replicate it. This chapter takes issue with this belief and argues that while some partial convergence to some aspects of the American system will occur, the Chinese standards system will remain distinctively different.

Objectives

Earlier research has argued that China's standards system still carries the legacy of the planned economy.[41] But since the country's opening-up to the international economy, substantial changes have occurred in China's standardization strategy, its institutions, and its management practices. In a very short time, China has significantly improved its capacity to develop and implement standards and to participate in international standard development organizations. According to the EU's Standardization Expert in China, "China's standardization system has matured considerably. Today, China has more standards than Europe, covering more aspects of economic operations than any industrialized country" (Ziegler 2010: 1).

Nevertheless, China still has a long way to go to establish a fully developed standards system. A good proxy indicator is that China has not yet published a new and revised version of its standardization law that was promulgated in 1988, during the initial phase of the country's opening-up. The existing law fails to address the very different standardization requirements resulting from the fundamental transformations that have occurred since then in China's economy. It simply does not provide the legal tools and regulations that would enable China to better cope with the challenge of rising complexity.

Under the planned economy, the central government exercised overall control. Each of the industrial ministries (e.g., the Ministry of Machinery Industry) was responsible for standardization within the large state-owned enterprises under its jurisdiction. National and ministerial standards were compulsory and were enforced by the government.

41. See, for instance, Suttmeier et al. 2006.

That system came under pressure once Deng Xiaoping's economic reforms gathered momentum, culminating in China's application to enter the World trade Organization (WTO). From China's perspective, its entry into the WTO in 2003 was a wake-up call and has pushed the international dimension of standardization right into the center of policy debates. This was somewhat unexpected. China's government had focused its attention on the benefits its economy would enjoy, since WTO membership would make it much easier for its products to penetrate international markets, but it didn't take long for Chinese exporters to encounter problems with high licensing fees for essential patents included in standards for DVDs and mobile handset and telecommunications equipment.

According to a recent authoritative study of China's standardization strategy commissioned for the China standards project,

> China had considered technical standards a means to facilitate world trade, but it turned out that the first barrier it encountered when its products entered the international market was technical regulations and standards. The competitiveness of China's enterprises met with severe challenges and the Chinese government had to reconsider the significance and role of technical standards.[42]

In anticipation of the resulting new challenges, The Ministry of Science and Technology (MoST) allocated RMB 200 million to promote two major studies. MoST's 2002 Study on the Strategy of Technical Standards Development was followed in 2006 by SAC's Outline of the Eleventh Five-Year Development Plan for Standardization. These studies, and an intense dialogue among diverse standardization stakeholders from research institutes, industries, and government agencies, has resulted in serious efforts to develop a unified strategy with an explicit focus on the following priorities:

1. Fostering economic development remains critical, with the result that the state will continue to play an important role as a promoter and coordinator of an integrated standards and innovation policy.
2. Standardization should help to reduce the cost of licensing essential patents for both Chinese manufacturers and consumers. Access of foreign companies to Chinese standards development organizations should create a quid pro quo: Foreign companies can participate in technical committees in exchange for technical contributions, including disclosure of essential patents and acceptance of fair, reasonable, and non-discriminatory (FRAND) licensing conditions.

42. Wang et al. 2010: 7. Wang Ping is executive vice governor, Science and Technology Committee, China National Institute for Standardization (CNIS). Wang Yiyi is vice director, Sub-Institute of Standardization Theory and Strategy, CNIS. John Hill is a former senior standardization manager at Sun Microsystems and vice chair of the International Cooperation for Education About Standardization (ICES).

3. A defining characteristic of China's standardization strategy is to use standardization as a platform for indigenous innovation.[43]
4. "Enterprises" are encouraged to be the "main players in formulating standards" (Wang et al. 2010: 8). This leaves open the question of what role, if any, foreign enterprises are supposed to play. An important objective, however, is to use homegrown standards to develop innovative "national leaders" and to protect domestic industry.
5. Standardization should focus on priority sectors and should reflect sector-specific requirements.[44]
6. Effective standardization requires a complementary set of certification and conformity assessment regulations, such as the China National Certification and Accreditation Administration's Compulsory Certification (CCC) scheme; and the Ministry of Industry and Information Technology's (MIIT) Network Access License (NAL) and the Network Access Identifier (NAI) regulations for telecommunications. These conformity assessment regulations are essential for controlling access to the Chinese market.
7. Standardization should take a decentralized approach, in order to reduce the urban–rural gap and to encourage dispersed local industrial development.
8. As a latecomer to standardization, China should pursue a dual-track strategy that combines the adoption of international standards with the insertion of indigenous innovations into domestic and international standards.
9. The role of the voluntary standards should substantially increase, "where the need for standards comes from the market, enterprises are the main drafters of standards, and the implementation of standards relies on the market mechanism" (Wang et al. 2010: 5).
10. Outward Chinese foreign direct investment should be facilitated through the promotion of Chinese standards practices and processes in overseas markets.
11. Finally, China's role in international and regional standards development organizations and consortia should substantially increase, enabling Chinese enterprises and research institutes to move from being standards takers to become standards co-shapers and ultimately to standards setters in some areas.

In principle, a unified strategy has important advantages. It facilitates the quick mobilization of resources for massive investments in standardization infrastructure. If the objectives are clear and uncontested, this facilitates rapid

43. For a precise definition of "indigenous innovation," see the second part of this chapter.
44. Note, however, that the list of the "eight key areas for standardization" is quite comprehensive, and covers most sectors of the Chinese economy. This comprehensiveness indicates the daunting challenge faced by China's standardization strategy, as it still lacks a highly diversified production and innovation system.

learning. In addition, a unified strategy makes it easier to create nation-wide markets based on a single mandated standard.

However, given the short period of time that China has had to develop its standardization strategy, an effective implementation of that strategy still faces substantial challenges. Witness the plea for patience by Wang Ping from CNIS: "I hope that our foreign colleagues understand that to bring about such far-reaching changes requires some time, especially in a country as large and diverse as China" (Wang 2010).

In addition, China's standardization strategy keeps evolving in order to cope with the challenge of globalization and rising complexity that this study describes in Chapter Three. Over the last few years, new objectives have been added. This includes, for example, the strengthening of safety standards in occupational health, mining, traffic, fire protection, food, and consumer products. Greater priority is also now given to standards and certification measures to improve public and national security, including the control of cyberspace and media content. Most important, arguably, are current efforts to develop robust standards and certification measures for environmental protection, China's "smart grid," reduced energy consumption, and alternative energies.

Implementing this increasingly demanding standardization strategy will not be easy. There is a broad consensus in China that fundamental reforms are needed in the institutional set-up of the Chinese standards system, including the development of robust yet flexible policy tools and regulations.

According to Wang et al. (2010: 14),

> the development of standardization in China should break through the restriction of the traditional system where the government is the only main body to organize and preside over standardization activities. On the one hand China should make enterprises the main players in standardization and, on the other hand, China should give full play to the industrial consortia and alliances, through institutional and managerial innovation.

But reforming China's standards system does not "naturally" imply convergence to U.S.-style standardization. In the transition to a more market-driven standards system, the government will continue to play an important role as a promoter, enabler, and coordinator of an integrated standards and innovation policy. In other words, an incremental approach to reform is suggested rather than the "shock therapy" of a quick and full-blown convergence to the American voluntary standards system. According to Wang et al (2010: 14, 15), this implies that

> …[v]oluntary national standards should still be managed and coordinated by the SAC in a centralized way and the main bodies for formulating these standards should be extended to all stakeholders by improving the system of standardization technical committees. (Association

standards should be conceived and developed in the market economy to become a supplement in the existing system of national standards and an important element in activating market activities.

The Catalytic Effect of the Medium- and Long-Term Plan for Science and Technology Development[45]

It is worth emphasizing the catalytic effect that the Medium- and Long-Term Plan for Science and Technology Development (MLP) had on China's standardization strategy. Of particular importance is that the plan and its related supporting policy documents (especially the 11th Five-Year Plan for Standardization Development, issued in 2006 by SAC) lay out in quite some detail the key principles that government agencies should follow when implementing indigenous innovation.

A brief discussion of the strengths and weaknesses of MLP serves to highlight the challenge ahead for China's standardization strategy. The plan calls for utilizing science and technology to support and lead future economic growth, especially in areas such as energy, water and resource utilization, environmental protection, and public health. It also calls for "leapfrogging" to research frontiers in key scientific disciplines, such as biotechnology and nanotechnology.

The plan's defining characteristic is a focus on "indigenous innovation" to redress China's weak record of innovation in commercial technologies (i.e. weak firm-level innovative capabilities). Strong domestic innovative capabilities are considered critical to upgrading China's development model. The challenge, in the words of Premier Wen Jiabao, is to overcome "an irrational economic structure, the over-production of low-quality goods, low rates of returns, and increasingly severe constraints resulting from energy and other resource scarcity and severe environmental degradation."[46]

China's efforts to strengthen its innovation capacity are part of a global "innovation arms race" in which no country dares to fall behind the others in the creation and use of new products and processes (Baumol 2004). Hence, China's innovation policy should not come as a surprise. It is part and parcel of intensified global competition, and China has no choice but to participate in this race. China needs innovation to upgrade its economy, so that it can raise wages and living standards. China also needs innovation to improve its international competitiveness and to catch up with incumbent global industry leaders.

One should also remember that innovation policy nearly everywhere "has been tarred with a protectionist brush."[47] Again, China is no exception. But the implementation of these policies is still shaped by China's legacy of the planned economy. An additional constraining factor is that China, as a latecomer to the

45. This section draws on interviews, and on Schwaag Serger and Breidne 2007; Cao et al. 2006; Stevenson-Yang and DeWoskin 2005; Gu and Lundvall 2006; and OECD 2008.
46. Wen Jiabao, "Speech at the National Science and Technology Conference," Beijing, January 9, 2006, quoted in Cao et al. 2006: 78.
47. Ahrens 2010: 1. For evidence, see Nelson and Ostry 1995; and Ernst and O'Connor 1992.

global innovation race, still has a long way to go to catch up with the incumbent global leaders.

There is no doubt that the MLP contains techno-nationalist notions of self-reliance. This reflects the initial objective of Chinese policymakers to reduce China's dependence on foreign companies' intellectual property and the resultant high patent licensing fees. For instance, the MLP states that by 2020, China should reduce its dependence on technology from other countries to 30 percent or less (down from 50 percent today, as measured by the spending on technology imports as a share of the sum of domestic R&D funding plus technology imports). Some parts of the MLP express a concern that reliance on other countries—especially the United States and Japan—could be a threat to Chinese national and economic security. The MLP calls for China not to purchase any "core technologies in key fields that affect the lifeblood of the national economy and national security," such as next-generation Internet technologies; high-end, numerically controlled machine tools; and high-resolution earth observation systems.

For semiconductors, China's MIIT has stated that

> … [we will] significantly increase the self-sufficiency ratio to over 70 percent for integrated circuits used for information and national defense security, and to over 30 percent for integrated circuits used in communications and digital household appliances…. We should basically achieve self-sufficiency in the supply of key products.[48]

As the semiconductor industry is one of the most globalized (Ernst 2005b), it is difficult to see how such an ambitious target would ever be realized.[49]

But the plan also states that sustained economic growth requires establishing a proper balance between domestic innovation and the use of imported technology. In fact, the MLP uses a broad definition of "indigenous innovation" that highlights three inter-related objectives:

- produce original innovations (i.e. new products and services);
- develop "integrated innovation," defined as a process in which diverse technological innovations are integrated, culminating in the creation of a new product; and
- foster "re-innovation," defined as new products that are created on the basis of acquiring and absorbing imported technologies.

Translated into the language of innovation theory, these are, in fact, quite well-established notions. "Originality" is necessary for patenting everywhere,

48. Ministry of Information Industry, August 29, 2006.

49. The 16 mega-projects of the MLP provide other examples of arguably somewhat exaggerated targets for technological independence. For instance, China's Next Generation Wireless Broadband mega-project is called the "1225 strategy" as it seeks to capture 10 percent of global patents, 25 percent of the telecom semiconductor market, 20 percent of the global broadband hardware market, and 50 percent of the domestic market.

and "integrated innovation" comes very close to the concept of "technology diversification."[50] The focus is on recombining mostly known components (which can be easily acquired) to create a new product architecture.

Finally, "re-innovation" is little different from the concept of "incremental innovation" that takes both the dominant component design and architecture for granted, but improves on cost, time to market, and performance. Building on imported technologies, "incremental innovation" seeks to exploit as much as possible the potential of a given "design," by introducing relatively minor changes to an existing product or process (Nelson and Winter 1982). These innovations do not require substantial inputs from science, but they do require considerable skill and ingenuity, as well as strong entrepreneurial and management capabilities.

In short, the MLP signals the commitment of China's leaders to acquire the knowledge and to develop the capabilities necessary to solve or ameliorate the problems of its "global factory" development model before they become overwhelming. The question, of course, is to what degree an effective implementation of the MLP will help to achieve these objectives.

Effective implementation has two dimensions, a domestic and an international one. China's leading role in international trade and its deep integration into global networks of production and innovation indicates how important the international dimension is. Unfortunately, China's Science and Technology Plan has become a highly controversial issue in international economic diplomacy. Foreign observers are concerned about the impact of the MLP on international trade and access to the China market. According to the European Standardization Expert for China,

> not the basic policy is controversial but the impact on trade and market access. We would wish that China is more sensitive regarding this link and chooses to a) better communicate its policies, b) better coordinate between ministries, c) allow foreign companies and governments …[to provide].. feedback, and d) carefully measure the impact on trade.[51]

The litmus test for the MLP is whether domestic institutions and support policies have been developed that facilitate effective implementation. The plan attempts to introduce gradual improvements, but it does not initiate a radical departure from earlier strategies. For instance, an extensive dialogue among China's social elite has been used to temper the still prevalent top-down approach that believes that innovation can be "decreed" or steered by government. But the private sector and consumers still have little influence in this dialogue.[52]

50. As defined in Ernst 2007a.
51. Email from Klaus Ziegler, August 10, 2010.
52. In fact, China's bureaucracy remains in charge. While the MLP claims that the business sector should become the driving force of R&D and innovation, "this fifteen-year plan is still a product by and for civil servants" (Schwaag and Breidne 2007: 157). The plan fails to enable private entrepreneurs to be the "implementing actor."

The plan continues to focus on supply-side policies for research and education, but neglects to link those to markets and demand patterns of customers. The plan also displays a persistent "high-tech bias" and neglects the development of complementary "soft" entrepreneurial and management capabilities.[53] Most importantly, the plan neglects the development of institutions that foster firm-level innovation and reduce innovation barriers. In fact, there is little detail on what changes in institutions and policies are necessary to address root causes of China's weak social capital, such as an educational and organizational culture that discourages dissent and individualism, while at the same time intense "winner-takes-all" competition obstructs trust as a base for collaboration.[54]

In short, China's 15-year Plan for Science and Technology has been an important catalyst for considerable improvements in China's innovation system, but it leaves untouched major weaknesses. Hence, there is ample scope for improving China's policies so that it can develop its own domestic innovation capacity, while at the same time reaping the benefits of international linkages.

For China's innovation strategy to succeed, maintaining open markets and international linkages is of critical importance. This is in line with earlier research on the challenge of globalization for innovation policy in developing countries.

> As globalization poses new opportunities and challenges that local firms are ill-equipped to address on their own, public policy must continue to cajole and assist these firms by signaling opportunities, reducing risks, engaging in R&D. The key to success is to catalyze, not replace, the private sector and to monitor and to hold firms accountable for their use of incentives and subsidies. Once the initial catching-up phase is over, equal treatment should be provided to domestic and foreign firms, subject however to one important exception: the promotion of risk-taking and innovative smaller companies (Ernst 2002a).

Taiwan, Singapore, and Malaysia in Asia, as well as the Nordic countries and the Netherlands in Europe provide excellent examples of successful policies to encourage domestic innovation while still keeping markets open. A study of these examples also demonstrates different approaches are possible to innovation policy in an open economy.

Nevertheless, there is reason for cautious optimism. The MLP indicates a strong willingness to change and to move away

> from a science and technology policy focusing primarily on creating world-class high-tech labs and scientists toward an innovation policy seeking to create an environment conducive to translating knowledge

53. For a conceptual framework of innovative capabilities, see Ernst 2009a: chap. 3.
54. Woolcock (1998) defines "social capital" as the willingness and likelihood to share knowledge and information, based on shared values, norms, and trust.

and ideas into economic and social gains (Schwaag and Breidne 2007: 162).

It is this gradual shift towards a more demand-oriented innovation system that will act as a strong catalyst for upgrading China's standards system.

Diversity of Stakeholders and Fragmentation

Chinese policymakers are still searching through trial-and-error for ways to protect China's interests while minimizing possible negative effects on its integration into the global economy.

In fact, standardization in China today is a hybrid system. The government remains in charge as the main driver and final arbiter of China's standardization strategy. Yet, the diversity of stakeholders has increased. According to Wang et al. (2010: 15), "the real standardization strategy is the comprehensive result of implementing all the standardization strategies by different government agencies … [and local governments]."

This has resulted in a fair amount of diversity in the definition of the strategic goals and their implementation. However, this diversity of approaches is overwhelmingly restricted to central and local government agencies. Industry and especially private firms and final users continue to play a limited role.

China's government documents on standardization all emphasize "openness, transparency, and impartiality." But as China has no tradition of an independent "civil society,"[55] standards-making bodies, industry associations, research institutes, and consumer organizations remain dependent on the government. Instead, local governments act as pace setters for a more decentralized approach, establishing local standards as a constituent building block of the Chinese standards system. Pioneered by the Shenzhen government in 2007, the governments of Shanghai, Beijing, Jiangsu, Zhejiang, Shandong, Henan, and Shaanxi have all issued their own local standardization strategies.[56]

On the positive side, these local strategies are presumably better customized to the specific requirements and capabilities of the industrial sectors in their respective localities, and to the regions' level of economic development

55. The concept of "civil society" refers to institutional forms of un-coerced collective action that include, for instance, tax-exempt public charities, foundations, development non-governmental organizations, community and grassroots organizations, women's organizations, faith-based organizations, professional associations, trade unions, self-help groups, social movements, business associations, coalitions, and advocacy groups.

56. See, for instance, Outline of the Standardization Development Strategy of Shanghai (2007 C2020), April 2007, 上海市标准化发展战略纲要(2007~2020), available at http://www.shanghai.gov.cn/shanghai/node2314/node2319/node10800/node11408/node16796/userobject26ai10444.html; and Notice on the Implementation of Shenzhen Standardizations Strategy (2006 C2010) from Shenzhen Municipal Government, May 18, 2007, 深圳市人民政府关于印发深圳市标准化战略实施纲要(2006~2010)的通, at http://www.34law.com/lawfg/law/1797/3122/law_258909093846.shtml.

and the needs of their citizens. The potential advantages of decentralized self-government are well-established in theories of innovation and organization.[57]

There is, however, a negative side to Chinese-style diversity. In fact, China's standards system is overly complex and displays signs of fragmentation. Ambiguity is a fundamental source of such fragmentation. Key concepts are loosely defined and often differ from the definition of these concepts in other countries. Even China's definition of "standards" deviates from the definition used in the United States and the European Union, which focuses on voluntary consensus standards.[58]

For instance, China's Mandatory National Standard Management (Trial): Exposure Draft, issued by the SAC for public comments on May 15, 2010, seeks to establish "Compulsory National Standards" firmly as "a separate set of technical regulations, situated below administrative provisions, but well above the soft regulations defined by voluntary standards. There are concerns that "the total lack of options to achieve compliance with these regulations could signal that the pendulum is swinging back to increasing inflexibility."[59] Similar concerns are provoked by constraints established in this Exposure Draft to the adoption of international standards that contain intellectual property rights.

There is also typically a lack of clarity about the boundaries and the division of labor between competing national, industry, ministry, and provincial standards. Table 1 highlights the fragmented nature of the Chinese standards system.

Equally important sources of fragmentation are inter-agency rivalries and turf battles among different ministries and their respective stakeholders. As highlighted in Figures 1 and 2, China's standards system consists of two institutional clusters: the AQSIQ Standardization Family and the MIIT Standardization Family (see page 30 and inside front cover). Even for Chinese standards experts, it is sometimes difficult to understand the precise division of labor between the two.

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57. Decentralized and flexible institutions, developed by participants who are "… intimately knowledgeable about details of their activities, are likely to be more workable than blueprints developed by policy analysts and imposed by politicians and bureaucrats" (Axelrod and Cohen, 1999: 22) And Elinor Ostrom, the 2009 Nobel laureate in economics, argues that "… [i]t is difficult for a central authority to have sufficient time-and-place information to estimate accurately both the carrying capacity of a … [public good, like standards]… and the appropriate … [incentives and fines] … to induce cooperative behavior" (Ostrom 1990: 17).
58. Email communication, dated June 17, 2010, from Klaus Ziegler, EU Standardization Expert in China. Ziegler writes: "In our understanding there is only one level of standard: the voluntary one. We do not consider mandatory standards being 'standards'." In the United States, the Office of Management and Budget (OMB) defines "voluntary consensus standards" as "standards developed or adopted by voluntary consensus standards bodies, both domestic and international. These standards include provisions requiring that owners of relevant intellectual property have agreed to make that intellectual property available on a non-discriminatory, royalty-free or reasonable royalty basis to all interested parties,"(OMB Circular A-119, 1998, available at http://www.whitehouse.gov/omb/rewrite/circulars/a119/a119.html, accessed June 18, 2010.
59. Email exchange on June 21, 2010, with an industry expert who has requested anonymity.

Table 1: *The Fragmented Chinese Standards System*

I. National Compulsory Standards

- 3,000–4,000
- Part of technical regulations related to safety, security, occupational health, environmental protection, consumer protection, etc.
- These compulsory standards must pass China's Compulsory Certification scheme, the most important market access scheme for China.
- Compiled by CNIS and 70+ associations and research organizations
- SAC in charge to ensure compatibility with ISO and IEC standards, while MIIT in charge to ensure compatibility with ITU standards
- China is obliged to provide TBT notification to WTO

II. National Voluntary

- Around 25,000 standards, owned by SAC
- Covers all areas of standardization, including products, processes, and services, except military standardization
- Sometimes used in combination with compulsory testing requirements to control market access
- Compiled by CNIS and 70+ associations and research organizations
- SAC in charge for harmonization with international standards

III. Sector/Industry/Ministerial

- For market participants (especially in the ICT industry), these standards are as important as the National Standards.
- Estimates range from 40,000 to 100,000 standards. Probably only 20 percent are actively used
- Owned by ministries (e.g., MIIT, SARFT, MoH, MoR, MoF, MoST, MPS)
- Compiled by dedicated ministerial units, industry associations, research institutes, and testing bodies
- About 15 percent of these standards are compulsory, and are often used in ministry-based market access regulations
- Harmonization with international standards depending on the ministry. In general, no procedures are in place

IV. Association

- Similar to sector/industry standards
- Only a few hundred

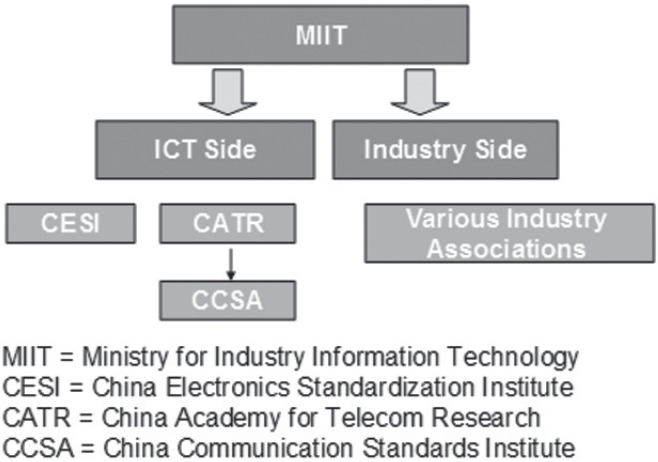
V. Provincial

- Around 20,000 standards
- 20 to 30 percent of these standards are compulsory
- Owned by local governments
- Developed by local organizations of the Administration for Import and Export Control (AQSIQ)

Sources: Interviews; email correspondence with Wang Ping of CNIS; and Ziegler 2009b.

Figure 1. *The AQSIQ Standardization Family*

Figure 2. *The MIIT Standardization Family*



Inter-agency rivalries reflect the conflicting interests of major Chinese stakeholders in innovation and standardization. Three main stakeholders are seeking to impose somewhat conflicting objectives on China's standardization strategy and, more broadly, on the country's innovation policy.

First, China's export industry is a strong supporter of attempts to close gaps with international standards and to comply with WTO commitments. This position reflects China's deep integration into global corporate networks of production and innovation. A good proxy indicator for China's integration into global production networks is that foreign-invested enterprises dominate China's manufactured exports. They account for 58 percent of China's total exports and 88 percent of its high-technology exports (Ernst 2008). As for integration

into global innovation networks, China is the third most-important offshore R&D location for the 300 top R&D spending multinationals, after the United States and the United Kingdom. Today, China is the largest "net importer" of R&D, and foreign investment enterprises account for US$24.7 billion in R&D spending, about one-quarter of China's 2007 R&D spending.

Support for greater compliance with international standards also comes from leading Chinese ICT firms that have accumulated a critical mass of intellectual property rights, like Huawei in telecom equipment. With 42,623 PCT applications (most of them submitted over the last few years), Huawei is now number two on the World Intellectual Property Organization's list of Patent Cooperation Treaty applications. In addition, Huawei has accumulated a broad portfolio of essential patents in important technologies (IPv6 and beyond; next-generation mobile communications; and convergence of fixed and mobile networks) (Ernst 2011a). And, as we will see in Chapter Three, these firms are now playing a more active role in technical committees and on executive boards of international standards-setting organizations and consortia.

Second, strong support for using standards as a tool to reduce technological dependence and to develop China's indigenous innovation capabilities can be found in research labs, parts of the domestic high-tech industry with limited export exposure, and in the military, the CCP, and large parts of the general public. This coalition of domestic stakeholders is supporting, for instance, policies on patent licensing for standards that seek to reduce licensing fees to foreign patent holders, as embodied initially in the Draft Rules on Patents Included in Standards, issued by the SAC in November 2009.[60]

Third, China's security and military establishment and top leadership echelons view information security and certification regulations as an integral part of China's ongoing modernization. Recent policy initiatives, especially China's National Information Assurance Policy Framework Multi-Level Protection Scheme (MLPS), issued by the Ministry of Public Security in June 2007, and CNCA's Information Security Testing and Certification Regulations, are driven by fears that China's critical information networks provide an easy "target of attack, sabotage, and terrorism by hostile forces and elements."[61] A strategic assumption is that control over standards and a strong Chinese information security industry are necessary to protect China. [62]

It is difficult for outsiders to assess which of these three stakeholder coalitions has the most leverage in shaping decisions on China's standardization strategy.[63] There are, however, indications that the balance of power between

60. For details, see Chapter Four, this volume.

61. Vice Minister Lou Qingjian, Ministry of Information Industry, BOAO Forum 2006, at http://www.boaoforum.org/AC2006/yjgE.asp, accessed July 6, 2010.

62. See analysis on China's Information Security Standards and Certification below.

63. For example, arguments for a growing role of security considerations are presented in Policy Issues Arising in China's Development of State-Sponsored Domestic Standards for Trusted Computing, June 2009, a study prepared for the Trusted Computing Group by Dewey & LeBoeuf LLP.

these three stakeholder coalitions is somewhat in flux. This raises an important question for future research: To what degree does China's deep integration in international trade and global corporate networks of production and innovation induce China's government to move towards greater pragmatism in its innovation policy and standardization strategy?[64]

A Big Unknown: Information Security Standards and Certification[65]

Objectives and Rationale

China's policy on information security standards and certification seeks to protect China-based information systems against perceived threats to national and public security. Economic objectives are important, but they are secondary to national security concerns. The underlying strategic rationale provides an example of Susan Shirk's (2007) description of China as a "fragile superpower." There is a widespread concern among China's leadership, especially in the military and the Ministry of Public Security (MPS), that China is exposed to "nontraditional and asymmetric threats to national security." Information technology is viewed as a double-edged sword. China's resurgence both as an economic and military power challenges incumbent global and regional leaders.

It is believed that Western IT systems use product backdoors, system loopholes, and Trojan horses to steal China's national secrets, and to slow down China's rise as a global economic power.[66] There are also fears that persistent

64. See Chapters Three and Four, this volume.

65. Unless indicated otherwise, this section draws on interviews with Chinese and China-based foreign industry experts who have requested anonymity. Debates in China on information security issues are generally concealed, and frequently Chinese experts are reluctant to discuss these issues. The same, unfortunately, has also been true for informed foreign organizations that follow Chinese discussions on information security standards and certification. Chinese military journals are addressing some of the underlying strategic debates, but the limited resources available for this project have not allowed a systematic review of these sources. In addition, some of China's key military journals are restricted. For instance, China's Academy of Military Science (AMS) has its own publishing house (*Junshi kexue chubanshe*) and publishes an estimated 50 books a year. Its open source journal is *Zhongguo junshi kexue* (*China Military Science*), published by the AMS editorial board. However, its most important journals, like *World Military Trends* and *Military Thought*, are restricted.

66. A *backdoor* is a secret or undocumented means of getting into a computer system. Many programs have backdoors placed by the programmer to allow them to gain access to troubleshoot or change the program. Some backdoors are placed by hackers once they gain access to allow themselves an easier way in next time or in case their original entrance is discovered. A *loophole* is a weakness or exception that allows a system, such as a law or security, to be circumvented or otherwise avoided. Loopholes are searched for and used strategically in a variety of circumstances, including taxes, elections, politics, the criminal justice system, or in breaches of security. The *Trojan horse*, in the context of computing and software, describes a class of computer threats (malware) that appears to perform a desirable function but in fact performs undisclosed malicious functions that allow unauthorized access to the host machine, giving them the ability to save their files on the user's computer or even watch the user's screen and control the computer. Trojan viruses can be easily and unwillingly downloaded.

leadership in IT provides ample opportunities for "Western powers" to use export controls, control over technical standards, and high licensing fees to stifle China's development and force reliance on Western technology. As a latecomer to the global race in information and communications technology, China has weak capabilities in information system management, and there is a general lack of knowledge and institutions that are capable of protecting China's critical information systems.

To counter these threats, the China State Informatization Leaders Group (SILG), a high-level Chinese leadership body, developed in 2003 China's five-year National Cyber Security Strategy(SILG Document 27) to address threats to information systems and networks through an indigenous national assurance system under firm domestic control. Apparently this confidential document contains a comprehensive strategy, with its priorities reaching just about every aspect of information security technology.

Recent policy initiatives (especially the MLPS and CNCA's Information Security Testing and Certification Regulations, issued in August 2007) are driven by three objectives that are unlikely to change in the foreseeable future: (i) a modernization of security and safety infrastructure, that is, making Chinese infrastructure more robust against any type of security threat (which is in line with established practice in other countries); (ii) fostering domestic innovative capabilities, specifically for information security software; and (iii) developing a domestic industry for such products (Ziegler 2009: 5, 6).

A key assumption underlying these policies is that full (or at least very substantial) control over information security standards and certification is necessary to improve national and public security. A related assumption is that China needs a well-developed domestic information security industry not only to strengthen information security but also to foster indigenous innovation capacity.

Extensive Regulation: The MLPS

The MLPS is one of the top priorities of China's cyber security strategy. Its main objective is to protect "national security, economic sustainability, and social order." "National security" is broadly defined to include "national competitiveness and the strength of the economy, science, and technology." "Social order" includes the "stability of any type of economic activity" as well as "the research, development, and production of any industry." These definitions are vague and leave wide room for the Ministry of Public Security (the lead agency) and other government agencies to make non-transparent decisions as to what level of protection an information system requires.

At the same time, there is a complementary industrial and technology policy agenda. Policy instruments like the MLPS are meant to be used to foster domestic innovative capabilities in information security management and to develop a Chinese information security industry.

A defining characteristic of the MLPS is the extensive scope of regulation. China has extended this regulatory framework well beyond sensitive military and government agencies to cover all non-government end users. Strategic information systems include those that handle

> state affairs (party and government), finance, banking, tax administration, customs, audit administration, industry and commerce, social services, energy, transportation, national defense industry, and other information systems that are related to the national economy and people's livelihood including education, state science and technology institutions, public telecommunications, television broadcasting and other basic information networks.[67]

Under the MLPS and its Implementing Measures, the core intellectual property of all products, systems, and information security management technologies used in "critical infrastructure" such as banks, ports, and utilities must be Chinese.

Another unique characteristic of the MLPS is that it seeks to micromanage corporate information networks. MLPS imposes very strict multi-level security requirements and dictates how an organization structures and implements information security management. Critics argue that such stringent requirements will have disruptive effects on the management and coordination of the global corporate networks that integrate China with the production and innovation systems of other countries. In addition, the excessive complexity of the MLPS requirements is likely to drastically increase the cost of network coordination. [68]

MLPS distinguishes five levels of information systems. Most industries are classified as Level 3 and above systems.[69] The same is true for critical IT infrastructure in public research institutes. For example, the IT backbone network of the Chinese Academy of Social Sciences apparently is also classified as Level 3 infrastructure.

According to the MLPS Administrative Measures, information security products that are graded at Level 3 or above must meet the very demanding security requirements of the U.S. Department of Defense TCSEC or "Orange Book" standard.[70] The Administrative Measures also provide that products

67. Unofficial translation of excerpt of MLPS document provided by industry expert who has requested anonymity.
68. Ernst (2005a, 2005b) demonstrates that, even without such information security regulations, the cost of coordinating global corporate networks of production and innovation are already high and that they keep rising.
69. See Ernst and Martin 2010a.
70. Trusted Computer System Evaluation Criteria (TCSEC), frequently referred to as the "Orange Book," is a U.S. Department of Defense standard that sets basic requirements for assessing the effectiveness of computer security controls built into a computer system. The TCSEC was used to evaluate, classify, and select computer systems being considered for the processing, storage, and retrieval of sensitive or information. Initially issued by the National Computer Security Center, an arm of the National Security Agency, in 1983 and then updated

containing encryption technology must be approved by the Office of Security Commercial Code Administration (OSCCA), and no imported products with encryption functionality can be used without approval.[71]

China-based organizations that are classified as Level 3 and above systems must seek compliance with an extensive array of demanding technical standards and guidelines ranging from physical to technical security. In many cases, this requires significant changes in their current information infrastructure and systems. The new system must be certified by an authorized certification body. In addition, all systems above Level 3 are directly managed by government regulatory authorities.

The enforcement of encryption requirements is among the most problematic aspects of the MLPS. The Shanghai Environmental Monitoring Center (SEMC) is one of the few organizations in China that is accredited with the China National Accreditation Committee for Laboratories. As the agency in charge of enforcing encryption requirements, SEMC

- uses manuals that are not publicly available;
- can carry out unannounced cryptographic inspections on any system level;
- has the full right to exercise complete control over any cryptographic technology used in MLPS systems;
- can access key management and other cryptographic protocols;
- has complete authority to subject violators of cryptographic regulations to administrative punishment; and
- requires, through OSCCA (SEMC's commercial encryption office) that a significant portion of cryptographic source code must be handed over.

Potential Trade-Distorting Impacts

There are concerns in the international business community that China's policy on information security standards and certification has an implicit industrial and technology policy agenda. Critics claim that the requirements detailed above constitute an aggressive attempt to develop a local Chinese information security industry.

Foreign observers emphasize that the MLPS may have significant negative effects on China's international competitiveness.

> The combination of these requirements may significantly restrict the use of foreign information security products in systems classified at Level 3 or higher under the MLPS. It does not strain the imagination to think that were this system of requiring that only Chinese products with

in 1985, TCSEC was replaced with the development of the Common Criteria international standard originally published in 2005.

71. Ministry of Public Security, Notice on Grading Work of National Important Information System Security Multi-Level Protection, Gong Xin An [2007] No. 861.

> Chinese intellectual property be used for education, banking, insurance, etc., not only would the interests of China's trading partners be severely compromised but China's economic development would be smothered (Wolff 2010: 8).

In our interviews, some foreign observers emphasized that it is still too early to judge whether the trade-distorting impact of the MLPS is the result of a deliberate mercantilist strategy, or whether it reflects a combination of weak implementation capacity and inter-agency rivalries. One observer, for example, argued that the MLPS

> … [w]ill have a major impact on trade and … [is] … the potentially most damaging document for foreign companies. MPLS is rooted in Chinese safety and security needs and as such certainly a viable policy. However, there is a *serious lack of coordination between Chinese security policies and Chinese trade policies which has the potential to create a major trade dispute*" [emphasis added].[72]

This shows how important it is to move beyond brief overviews that fail to capture the subtleties and nuances of the complex process of policy-making. For research to provide sound policy advice, it is necessary to study in depth the motivations of different Chinese stakeholders in innovation and standardization. Such an analysis will show that, from the perspective of Chinese policymakers, the MLPS and related policies are a somewhat belated attempt to correct earlier mistakes of excessive open-door policies. In this view, it has been a mistake to hand, in effect, especially the higher-end information security market to global industry leaders. MLPS is an attempt to counter this trend by requiring that Chinese critical information infrastructure should buy Chinese information security products.

Key requirements of MLPS include the following:

- The information security products must be developed and manufactured by companies that are "invested or owned by Chinese citizens or legal persons, or the state ...."
- The core technology and key components of those information security products must have "indigenous" intellectual property rights. Depending on how this requirement is implemented, this could prevent the usage of foreign information security products for systems classified at Level 3 and above. In other words, incumbent global market leaders in the information security market could face significant entry barriers to the China market for critical information infrastructure.
- The product developers and manufacturers must be owned by Chinese citizens, legal persons, or the state, and have independent legal personality in China;

72. Foreign industry expert, who has requested anonymity.

- The product developers and manufacturers must state that they "do not intend to leave or set programs and functions such as loopholes, backdoors, and Trojan horses."
- To add yet another level of complexity, systems operators must follow detailed guidelines for product procurement.
- Products that have been listed in the CNCA catalogue of information security products must acquire a certificate issued by the National Information Security Center.
- Without a mandatory "CCC Mark" certification, a wide range of IT products will not be allowed to be shipped out of the factory, sold, or imported.
- Encryption testing requires the sharing of source code encryption keys.
- All products must comply with Chinese national standards.
- Chinese labs must carry out complicated encryption testing and equally complicated post-market factory inspections.
- Adding even further to complexity, a Level 3 system is required to procure a Level 3 information security product. China-based exporters thus would need to meet extremely stringent product requirements that are unnecessary for commercial success. In addition, this would require significant financial resources to implement the policy correctly.

In response, foreign firms have voiced strong concerns about trade-distorting and anti-competitive effects of China's information security policies. The main concerns are:

- Regulations to protect critical infrastructure may include a mandatory requirement to use domestic intellectual property. "Such regulation will result in pushing most foreign companies out of the market" (Ziegler 2009a: 6).
- OSCCA certification rules for cryptographic products exclude foreign companies from application for certification. Again, this would largely exclude foreign-made products from competing in the China market.
- New customs tariff classifications for cryptographic products allow blocking of any products that do not have OSCCA certification.
- To obtain OSCCA certification, firms have to accept forced disclosure of critical software components, such as security keys, software design, and parts of the source code. Foreign industry players argue that "such unusual and far-reaching disclosure requirements do not only endanger the very security of the product being tested, it also might lead to leaks of the design of the software to competitors" (ibid.: 6).
- Smart cards and their supporting hardware (semiconductors) and software (especially operating systems) are the products that are going to be most severely controlled by OSCCA and CCC regulations.

- Of particular concern is a medium-term threat: "Since many manufacturers—Chinese or foreign—will eventually have to include Chinese information security measures into globally marketed products, it is highly likely that … Europe will be confronted with Chinese security measures included in our products to which we have no access and to which the cryptographic tools are unknown" (ibid.: 7).

Implementation Constraints

In light of China's deep integration into the international economy, it is difficult to see how the demanding requirements of China's policy on information security standards and certification can be effectively implemented.

For instance, the MLPS information security product requirements are extremely complex. In addition, much of the required information security technology is still largely unproven. Thus the above policy, ironically, may well lead to the decreased security of China's information systems. The very demanding security requirements for Level 3 and above information systems may simply not work, due to the excessive complexity of technologies and administrative procedures.

An additional implementation constraint is China's still-weak policy implementation capacity in this particular field. Thus far, China has developed only a limited number of technical product standards and certification specifications referencing the demanding GB17589 standard. Furthermore, China's information security product market is still at an early stage of development, and product performance levels do not match those of leading global competitors. According to Chinese experts, the majority of China's information security products can only meet Level 2 classification requirements.

Probably the most immediate implementation constraints are inter-agency rivalries over MLPS jurisdiction and enforcement. In fact, leading promoters of MLPS, like Fang Xingbing (the president of the Beijing University of Post and Telecommunications and former director of China's National Information Security Crisis Coordination Center), have identified inter-agency rivalries as a major impediment.

Take, for example, the turf wars between the MPS and the MIIT. In 2007, MPS was tasked by China's State Council to act as the "lead agency and coordinator" for MLPS. Since the creation of MIIT, MLPS activities have been stalled. This has frustrated long-term supporters within the security establishment.

When MIIT was created, it took over the function of the former State Council Informatization Office and created a new department, the Information Security Coordination Department, which claims responsibility for the coordination and promotion of MLPS development.

But it seems that the rivalry with MPS continues. According to interview sources, MPS will fight to keep control over the information security product

licensing regime, as this has enabled it to reap hefty profits. MPS held a large "Industry End Users Conference" on December 21, 2008, and announced that it will begin licensing information security products that correspond to the five levels of MLPS. Some observers fear that, as a result, the criteria for CNCA product certification could become even more demanding.

Caveat: No Information on Recent Developments

Research based on information available in the public domain makes it impossible to assess whether recent developments in China's policy on information security standards and certification have further intensified the demands of earlier regulations or whether there has been some relaxation. This study suggests that an important trust-building measure for the U.S.–China standardization dialogue is to improve access to and collection of data that allow for a better assessment of how information security standards and certification can be implemented without disrupting China's integration into the global economy.

Of particular importance is information on recent changes in the CNCA Information Security Testing and Certification regulations. For instance, is it correct that, in response to considerable external pressure (from the U.S. government, the European Union, and business associations), China agreed in April 2009 to reduce the scope of the regulations from products in the commercial market to products procured by government entities under China's Government Procurement Law?

Equally important are updated information and data points on the following issues:

- Regulations to protect critical infrastructure may include a mandatory requirement to use domestic intellectual property.
- OSCCA certification rules for cryptographic products may exclude foreign companies from application for certification. Again, this would largely exclude foreign-made products from competing in the Chinese market.
- New customs tariff classifications for cryptographic products may allow blocking of any products that do not have OSCCA certification.
- To obtain OSCCA certification, applying firms may have to accept forced disclosure of critical software components, like security keys, software design, and parts of the source code.

On the MLPS, updated information is required to address the following questions:

- What changes have occurred since the Administrative Measures for the Multi-Level Protection of Information Security issued in June 2007?
- Will foreign security products largely remain excluded from bidding for "critical infrastructure systems" (MLPS Level 3 and above)?

CHAPTER THREE
China's Dilemma: Globalization and Rising Complexity Constrain National Policies

China's innovation and standards policies face a fundamental dilemma: How can China reconcile its primary objective of strengthening the innovative capacity of Chinese firms and industries with the country's leading role in international trade and its deep integration into global corporate networks of production and innovation?

To answer that question, this chapter introduces the new world of international economics shaped by ubiquitous globalization, and describes the challenge of rising complexity that defines China's dilemma. To assess China's capacity to cope with those challenges, a simple stylized model is used that distinguishes important tasks of standardization and highlights differences in capability sets and in standardization strategies.

Ubiquitous Globalization: The New World of International Economics

Rising complexity and increasing uncertainty are two defining characteristics of the new world of international economics shaped by ubiquitous globalization. To most economists, that world seemed to be fairly predictable, at least until the worst crisis since the Great Depression disrupted international trade and investment. This crisis has changed established perceptions quite dramatically.

How much the intellectual climate has changed became obvious when Alan Greenspan famously confessed that he had put too much faith in the self-correcting power of free markets. Basic assumptions of economic theory are being revisited, and market regulation is again becoming an accepted policy tool to contain the risks of unfettered markets and excessive innovation.

"Ubiquitous globalization" now reaches beyond markets for goods and finance into markets for business services, technology, intellectual property rights, and knowledge workers (Ernst 2011b).[73] The result is an increase in the organizational and geographical mobility of knowledge. However, the new geography of knowledge is not a flatter world where technical change and liberalization rapidly spread the benefits of globalization. Instead, a handful of new—yet very diverse and intensely competing—manufacturing and R&D hubs are emerging in Asia.

73. As demonstrated in Ernst 2009a. For an indepth analysis, see Ernst 2011a.

Overall, technology-based competition is intensifying, and competitive success critically depends on control over intellectual property rights and on "a capacity to control open but owned architectural and interface standards" (Ernst 2002a: 330). It is hardly surprising that, under such conditions, as John Alic puts it, "firms may be tempted to seek profits through collusion rather than technological innovation. And when innovations do result, the costs may be high" (2009: 3).

This process has increased the economic importance of standardization. Standards are used everywhere to create and shape markets and to control competition. This has transformed standards development from an arcane technical and legal subject into a highly-contested field of corporate strategy and public policy. As a result, a company's approach to standardization has become a strategic management tool. Standardization also is of critical importance for government policies to foster innovation and competitiveness.

At the same time, however, new challenges have emerged for standards and innovation policies. Peter Cowhey talks of an "inflection point" that requires a reconsideration of strategy and organization.[74] Root causes for these new challenges to standards and innovation policy include a rise in complexity, not only of technology, but also of business organization and the competitive dynamics of the global market place.

But while the importance of standards has increased, there has been little public debate about the critical role of standardization for national innovation policies. This is especially the case in the United States, where standardization is left to a small community of experts in the private sector. As Chapter Two documents, China now seeks to develop a more activist approach to standardization.

Technology

Innovation theory shows that innovation depends increasingly on science and on interactions of multiple and very diverse stakeholders through geographically dispersed innovation networks that extend the boundaries of industries and nations.[75] Hence, innovation requires "… complex systems that are characterized by the heterogeneity of agents with different functions, different endowments, different learning capabilities and different perspectives, and most important, different locations in the multidimensional spaces of geography, knowledge, technology, and reputation" (Antonelli 2011: 11).

This is especially the case in the ICT industry, where competition is centered on the increasingly demanding performance features for electronic systems. Whether we look at laptops, smart phones, or mobile base stations, these devices all need to become lighter, thinner, shorter, smaller, faster, and cheaper, as well as having more functions and using less power. To cope with these de-

74. Cowhey et al. 2009. Peter Cowhey is a former senior counselor to the USTR.
75. Arthur 2009; Lester and Piore 2004; Ernst 2005; and Hildrum et al. 2011.

manding performance requirements, engineers have pushed modular design and system integration, with the result that major building blocks of a mobile handset are now integrated on a chip.[76]

Design teams also need to cope with the accelerating pace of technical change. Essential performance features are expected to double every two years, time to market is critical, and product life cycles are rapidly shrinking to a few months. Only those companies thrive that succeed in bringing new products to the relevant markets ahead of their competitors. Of critical importance is that a firm can build specialized capabilities quicker and at lower cost than its competitors (Kogut and Zander 1993).

Technological complexity increases even in the slow-moving, very-low-profit-margin TV industry. Google and Intel are pushing radical innovations simultaneously in three areas—3D, Internet connectivity, and LED backlighting (enabling thinner sets that use less power)—transforming TV sets into complex technology systems.

Arguably, the most important manifestation of rising technological complexity is the convergence of ICT infrastructures for the Internet, wireless, and mobile communications, and cloud computing that culminates in ubiquitous networks (or the "Internet of things"). Take for instance the convergence of networking gear, servers, and storage equipment that has forced companies like HP, Cisco, and Oracle to capture control over intellectual property in all three product markets through acquisitions of semiconductor and software companies.[77]

In fact, Oracle, after acquiring Sun Microsystems's server and microprocessor business, is now seeking to acquire a semiconductor firm to customize its SPARC microprocessors precisely in accordance with demands of its clients. Control over key intellectual property needed to diversify into related product markets also seems to have motivated HP's acquisition of networking equipment vendor 3Com and IT services company EDS, and Cisco's move into computer servers.

For all three companies, the main rationale for their acquisitions is to broaden their portfolio of essential patents that are needed for main standards in these three markets. The result will be an increasing concentration of control over intellectual property rights and the proliferation of "patent thickets."[78] This

76. For an economic analysis of the impact of these new chip design methodologies, see Ernst 2005a.

77. At the Openworld 2010 conference, Larry Ellison, CEO of Oracle, said, "You are going to see us buying chip companies. [We want to] own more of the intellectual property that underpins computer chips." Quoted in A. Ricadela and I. King, "Oracle Plans to Acquire Chipmakers, Industry-Specific Software," Bloomberg.com, September 23, 2010.

78. According to a study by the European Patent Office, "patent thickets" are "multiple upstream patents, where overlapping rights may impede the commercialization of a product or a process." Companies use 'patent thickets' to "… ring-fence technologies or to prevent other parties from either researching or commercializing their inventions" (European Patent Office 2007: 17).

has important implications for standards development. Take the unprecedented standardization challenge faced by the Smart Grid Interoperability project in the United States (Ernst 2010: 48–55). To upgrade the existing patchwork of the North American power system grid, more than 75 existing major standards need to be reviewed, adjusted, and approved so that they can work together. In addition, to master the transition to a smart grid, hundreds of new standards, specifications, and requirements need to be created in priority areas, such as energy efficiency, energy storage, electric transportation, advanced metering infrastructure, distribution grid management, cyber security, and network communications.

Rising complexity in the case of the smart grid project results from the inherent limitations of disparate and uncoordinated networks. In the United States, 3,100 utilities and more than 15 standards development organizations are involved in the electric power system grid. To top it all off, the project needs to establish effective cooperation within a very short time frame between two industries (the utility industry and the providers of information hardware and software for integrating the grid) whose business models and strategies could hardly be more different.[79] According to one observer, trying to make these two players work together is "… like, over the next week or so, let's solve the Palestinian–Israeli problem."[80]

It is obvious that such rising complexity drastically increases requirements for interoperability standards. A state-of-the-art definition is provided by the National Institute of Standards and Technology (NIST) as part of its Smart Grid Interoperability Standards project (NIST 2010: 19, 20):

> Interoperability … [is] ... the capability of two or more networks, systems, devices, applications, or components to exchange and readily use … meaningful, actionable information—securely, effectively, and with little or no inconvenience to the user. … [Specifically, these standards] define specifications for languages, communication protocols, data formats, linkages within and across systems, interfaces between software applications and between hardware devices, and much more.… [These] standards must be robust so that they can be extended to accommodate future applications and technologies.

In fact, each of the major interoperability standards in the ICT industry is protected by multiple patent families, giving rise to patent thickets. With

79. The utility industry moves slowly, at least partly because of the complex regulatory environment. But equally important for the slow pace of change in this industry is the highly fragmented ownership structure. On the other hand, the providers of information hardware and software for integrating the grid are all from the fast-moving ICT industry, where profits depend on speed as well as on strategic patenting.

80. Bob Gohn, senior analyst at Pike Research, quoted in T. Harbert, "The Not-so-smart-Grid," EDN, May 25, 2010, 1, 2, at http://www.edn.com/article/print/509094-The_not_so_smart_grid.php, accessed June 1, 2010.

increasing complexity of technologies, these patent thickets become denser. For instance, for the GSM standard (for second-generation mobile telecommunications systems), 140 essential patents were claimed by their respective patent holders (Bekkers et al. 2002).[81]

For the third-generation mobile standards, the number of essential patents has substantially increased. For example, W-CDMA (one of the three competing 3G standards) is protected by more than 2,000 patent families comprising more than 6,000 individual patents from some 50 companies and consortia (Davey 2006). At the same time, the number of standards required for a single mobile device has grown exponentially. Today's typical smart phone combines hundreds of standards coming from dozens of standard-setting organizations, for camera, video, web browser, PDA, WiFi, Bluetooth, Linux, USB, and so on. As a result, smart phones have become the latest patent battleground. In 2010, nearly 8,000 patents held by 41 companies apply only to the 3G wireless communications capabilities of a typical smart phone.[82]

Business Organization: Global Corporate Networks

The root cause for these increasingly demanding requirements for technology development is the emergence of a "winner-takes-all" competition model, described by Intel's Andy Grove (Grove 1996). In the fast moving ICT industry, success or failure is defined by return on investment and speed to market, and every business function, including R&D and standard development, is measured by these criteria.

Intensifying technology-based competition has provoked fundamental changes in business organizations. No firm, not even a global market leader like IBM, can mobilize all the diverse resources, capabilities, and repositories of knowledge internally. This indicates how much the world has changed since Edith Penrose argued in her path-breaking study *The Theory of the Growth of the Firm* that " ... a firm's rate of growth is limited by the growth of knowledge within it" ([1959] 1995: xvi, xvii).

Corporations have responded with a progressive modularization of all stages of the value chain and its dispersion across boundaries of firms, countries, and sectors through multi-layered corporate networks of production and innovation (Ernst 2003). The complexity of these global networks is mind-boggling. According to Peter Marsh, the *Financial Times'* manufacturing editor, "…[e]very day 30m tones of materials valued at roughly $80 billion are shifted around the world in the process of creating some 1 billion types of finished products."[83]

While the proliferation of global production networks goes back to the late 1970s, a more recent development is the rapid expansion of global innovation

81. A fundamental criterion of essentiality is that it is not possible to comply with a given standard without infringing that particular patent.
82. Confidential interview with smart phone company.
83. P. Marsh, "Marvel of the World Brings Both Benefit and Risk," *Financial Times,* June 11, 2010, 7. For a detailed case study of the multi-layered global production networks in Asia's ICT industry, see Ernst 2004.

networks (GINs), driven by the relentless slicing and dicing of engineering, product development, and research (Ernst 2007). Empirical research documents that this has further increased the complexity of global corporate networks. GINs now involve multiple actors and firms that differ substantially in size, business model, market power, and nationality of ownership, giving rise to a variety of networking strategies and network architectures (Ernst 2009a). The flagship companies that control key resources and core technologies, and hence shape these networks, are still overwhelmingly from the United States, the European Union, and Japan.

However, there are also now network flagships from emerging economies, especially from Asia. Huawei, China's leading telecommunications equipment vendor, and the second largest vendor worldwide, provides an example of a Chinese GIN that can illustrate the considerable organizational complexity involved in such networks (see Figure 3, next page and inside back cover).

For standardization, the proliferation of global corporate networks of production and innovation poses daunting challenges. A defining characteristic of these networks is the sharing of data, which requires interoperability standards. Within these networks, information must flow and knowledge must be exchanged between groups that are isolated from each other, whether by methodologies, geography, or culture. This requires standardization of diverse network interfaces.[84]

As these networks link national production and innovation systems across borders, it is necessary to "harmonize" national standards and innovation policies. Diverse network participants may share a common objective, but they use highly dissimilar vocabularies. To effectively coordinate multiple network interfaces requires shared definitions of the data that need to be exchanged, of the formats and protocols that govern data transfer and interpretation, and of the product specifications.

In fact, the challenge for standardization now is no longer technology alone. Equally important is the challenge to standardize the interactions of people who create and use the technology within these networks. In other words, standards need to be developed for the work practices and business routines that enable these networks to grow and adjust to changing requirements of technology and markets.

Competitive Dynamics

At the same time, globalization is shifting economic power from west to east.[85] China's resurgence not only as the global factory but also as the predominant growth market in the post-crisis recovery creates new opportunities and poses new challenges, and the United States, like the European Union and Japan, is

84. The resultant challenges for standardization in chip design are analyzed in Ernst 2005b.
85. As emphasized by Peter J. Katzenstein (2005: 13), it is important to distinguish between "internationalization" which refers to economic transactions across borders among established actors, and "globalization," which "highlights the emergence of new actors and novel relations in the world system."

Figure 3. *Huawei's Global Innovation Network*

Source: Courtesy of Huawei Technology Co. Ltd.

searching for ways to adjust to this new world of interdependence. For Paul Volcker, the outspoken former chairman of the Federal Reserve, the rise of China and other emerging economies is "symbolic of the less dominant position the United States has, not just in the economy, but in leadership, intellectual and otherwise."[86]

The financial markets illustrate the erosion of U.S. economic leadership. Since the end of the Second World War, the United States has been the undisputed source of power in global finance. This may no longer be the case. According to recent research by the Bank of International Settlements (BIS), the United States now ranks third (after Greece and Italy) among leading industrialized countries in its dependence on non-domestic sovereign bond holders, selling almost half of its debt to non-Americans, many of whom are in Asia.[87]

International economics still needs to come to grips with the resultant rise in complexity in international trade and investment and its policy implications. With new players entering the game, established rules are challenged, and market structures are transformed. As a result, global competition intensifies and outcomes become much more uncertain. As Stephen Roach (the former chairman of Morgan Stanley Asia) puts it somewhat mischievously: "In an increasingly complex and integrated world, trouble has an unpredictable way of mutating."[88]

Economic history shows that whenever a major new economic power appears in world trade, there are dislocations.

> This was true of the United States flooding England with low-priced grain in the mid-nineteenth century, was true of the formation of the Common Market and the rise of industrial Japan in the last third of the 20th century in terms of their impact respectively, and is true of China's emergence as the world's largest exporting country … and third largest importer …. (Wolff 2010: 1, 2)

Until recently, the international standardization system was shaped by competition between three alternative approaches to standardization: the U.S., the EU, and the Japanese approaches. Conflicts about standardization had to be resolved among these three major players. China's entry into the international standards game as a new contestant implies the international standardization system is now moving decisively beyond a trilateral towards a multi-polar architecture.

By definition, system stability will now be more difficult to achieve. In addition, the United States may have less influence in determining international

86. Interview with Paul Volcker, *Financial Times,* November 12, 2009, 7.
87. BIS data are quoted in G. Tett, "Asia Pulls Strings Behind Scenes as Eurozone Does Bank Test U-Turn," *Financial Times,* July 15, 2010, 2. For other indicators of the erosion of U.S. leadership, see Tay 2010.
88. S. Roach, "The New Lesson for Resilient Asia," *Financial Times,* June 9, 2010, 9.

standards development as interdependence defines its economic relations with China, as well as with India, Brazil, Russia, and other emerging economies. For the new players, standards are important instruments for industrial and economic development. Compared to the established leaders with a long history in standardization, the new players have different needs and institutions, business models and capability sets.

Companies from the emerging economies are thrown into this game without much preparation. The new players are thus experimenting with new approaches to standardization. Some of the new players may choose to adopt existing standards as fast as possible so that they can sell products with the standard's technology quickly. This first group is actually quite heterogeneous, and includes Taiwanese ODM suppliers, but also leading global ICT players like Huawei. The Taiwanese approach is summarized by the chairman of MSI, a leading Taiwanese PC maker: "It is not up to us to push any particular operating system, we just follow what the customer wants."[89] And Huawei emphasizes "customer-centric innovation" where the service delivery platforms requested by the telecom operators define Huawei's choice of technology and standards.[90]

For other new players, a primary concern may be to reduce their dependence on foreign technology and to avoid being held hostage to high patent royalties.[91] The classic case is DVD players, where Chinese producers in 2004 had to pay US $15–20 in patent royalties for each player with a retail value as low as US $60.[92] At 25 to 33 percent of retail value, this share is much higher than the 15 percent that makers of PCs and fax machines had to pay for licensing fees when these technologies were still new.[93]

Another prominent example is the licensing fee charged for the dominant MPEG-2 and MPEG-4 standards for audio-video coding/decoding devices (codecs). For the MPEG-2 standard, for instance, Chinese producers of audio-video equipment initially had to pay US $4 for each device.[94]

The resultant increasing diversity of stakeholders in standardization and of standards strategies adds yet another level of complexity. Required are laws and regulations that help to create appropriate governance mechanisms for standardization. To cope with the increasing diversity of stakeholders, these governance mechanisms would need to reconcile "efficiency" with fairness, equity, and sensitivity to differences in economic development, institutions, and capabilities.

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89. Joseph Hsu, chairman of MSI, quoted in the *Financial Times*, June 7, 2010, 7.
90. Huawei Corporate presentation, May 5, 2010, courtesy of Huawei.
91. As shown in Chapter Two, breaking out of this "patent licensing fee trap" has been an important motivation for China's standardization strategy.
92. Deloitte, "Technology Firms Risk Losing Advantages as China's Influence on Global Standards Reaches Critical Levels," August 2004, quoted in A. Updegrove, "The Yin and Yang of China's Trade Strategy," Standards Today, April 2005, at http://www.consortiuminfo.org/bulletins/pdf/apr05/feature.pdf, accessed June 10, 2010.
93. Data are courtesy of Fairfield Resources International, a U.S. firm based in Darien, Connecticut that helps clients like Nokia and TI evaluate and license patents.
94. For recent developments, see the case study on China's AVS standard in Chapter Five.

There is broad agreement in the standardization community that this would require "open" standards. Yet, according to the RAND Corporation's Martin Libicki, "all vendors pay lip service to open systems, but agreement ends here. The computer industry needs as many words for 'open' as Eskimos need for snow" (Libicki 1995: 35). An in-depth RAND Corporation study on "Standards and Standards Policy for the Digital Economy" finds that

> … [m]arket leaders are rarely friendly to open standards when they dominate and eager to see them when they do not…. Market leaders are also friendly to standards in layers above and below them so as to use the competition among others to increase choices, lower costs, and broaden the market" (Libicki et al. 2000: 111).

For Libicki (1995: 42), the elusiveness of the concept of "open standards" implies that a neutral form of public governance is needed "to avoid the Scylla of chaos and the Charybdis of monopoly." In short, market-led standardization needs to be complemented by public policy to channel "the struggles of competing vendors and their technologies and the power of vendor versus user."

For China's standardization strategy, globalization and rising complexity thus provide an argument for retaining some role for the government. However, as argued in Chapter Two, the government's role now needs to be complemented by a greater reliance on market forces.

The Challenge for China's Standardization Strategy

One way to capture the challenge for China's standardization strategy is to examine its impact on the cost of standardization. It seems plausible to assume that this will increase the cost of standardization. While this may be true for all countries, our interest is to find out whether these cost increases will actually be higher or lower for a relative latecomer to standardization like China.

A Stylized Model

To understand the cost impact of rising complexity, I suggest using a stylized model that distinguishes important tasks of standardization, and that highlights differences in capability sets and in standardization strategies.

Standardization tasks

Based on the author's interviews with leading standards experts in the United States, the European Union and China,[95] we use a taxonomy of standardization that involves, but is not restricted to, the following tasks (Table 2).

Typically, tasks 1, 3 and 4 are the most costly, but in case of litigation, legal costs in the United States can easily run into the hundreds of millions of U.S. dollars. In China, however, while costs of patent litigation are rising, they still remain significantly lower than in the United States.

95. See List of Interviews at the end of this volume.

Table 2: *A Taxonomy of Standardization Tasks*

1. Develop the technology to support the standard
2. Cost-benefit analysis of whether to adopt existing international standard or whether to create a new standard
3. Licensing fees for essential patents (both for existing standards and for newly created standards)
4. Pass testing, conformity assessment, and certification
5. Membership fees for formal and informal standard development organizations
6. Logistics (travel etc.)
7. Cost/risk of including one's own patents into a standard
8. Patent pool management
9. Back-end support
10. Legal (litigation)
11. Lobbying

Source: Ernst 2010a: 9.

Top judgments (or settlements) range from RMB 30 million to RMB 157 million. Top cases include domestic firms against foreign firms, with only one top case of foreign firm against domestic (using a design patent).[96]

Capability sets

As for capability sets, I suggest to distinguish between two countries. Country A (the "innovator") has a long history of standardization, a proven ability to operate successfully within standardization bodies, a fairly diversified production and innovation system, and a broad base of accumulated knowledge and IPR. In country A, a primary concern of law and policies is the protection of IPR, and "openness" of standards is subordinated to IPR protection.

Country C (the "global factory"), on the other hand, is a relative latecomer to standardization, and it still has to learn how to operate successfully within standardization bodies. Most importantly, country C still has a long way to go to establish a fairly diversified production and innovation system and a broad base of accumulated knowledge and IPR. In country C, laws and policies are focused on economic development and the diffusion of knowledge inherent in IPR. Standardization is viewed as an enabling platform for innovation and economic development.

Standardization strategies

In principle, countries and companies can choose one of the following standardization strategies described in Table 3 (or a combination of them).

96. Interview with Zhang Yan, IBM senior counsel international property law, April 8, 2010.

Table 3: *Standardization Strategies*

Free rider: Let others develop standards and save costs
Fast follower: Get existing standard fast so that products with the standard's technology can be deployed quickly
Co-shaper: Adjust existing international standards to suit your needs and deploy in current and future products
Leader: Create new standards and embed own essential patents

Country A and its leading firms are likely to pursue standards leader or co-shaper strategies, while country C and its leading firms will initially focus on free rider or fast follower standardization strategies.

Analysis: Impact on Chinese Firms

This framework has been used in our interviews. Based on the responses, we can highlight a few illustrative examples of how Chinese firms might be affected. Further econometric research is needed to nail down how the cost impacts differ across standardization tasks, capabilities, and strategies.

For free riders, like Shenzhen's assemblers of illegal "Shanzhai" handsets, ubiquitous globalization has opened up vast new opportunities, as they can use ready-made chipsets from specialized chip design companies like Taiwan's MediaTek to churn out low-cost smart phone copycats of the iPhone and Google's Android. While this may enable some of the Shanzhai makers to grow, it is still unclear how this will affect China's innovation capacity.

For fast followers, rising complexity is likely to increase licensing fees for essential patents charged by the global industry leaders. In fact, Chinese producers are caught in a "patent trap": The more they sell, the more they pay in licensing fees. According to MoST research, Chinese firms typically pay foreign patent holders 20–40 percent of the price for each cell phone made in China; 30 percent for each PC; and 20–40 percent for each CNC machine tool.[97] This results in low domestic value-added. According to Arthur Kroeber, "… [t]he Chinese value share is generally estimated at 10–15 percent—and the majority of the value is captured by the Asian subcontractors of multinational firms, not by domestic companies."[98]

In addition, membership fees and travel costs are also likely to increase, as fast followers now need to participate more often in a greater number of consortia and standards development organizations. Costs of litigation are also likely to rise, reflecting the rising stakes involved in such legal conflicts. But there may also be significant cost savings due to improvements in equipment and procedures, for instance, for testing, conformity assessment, and certification.

97. MoST data quoted in *China Daily,* May 15, 2006.
98. Kroeber 2007: 37, 38. One interview source estimates that, for a laptop exported from China, the Chinese assembler typically does not earn more than 2.5–5.0 percent of the average export price.

However, the main challenge for China is that remaining a fast follower is an increasingly unattractive option in a world of ubiquitous globalization. As they face rising licensing fees, Chinese companies may well be forced into a "very-low-profitability" trap. This implies that, sooner rather than later, Chinese companies may need to upgrade their capabilities to become co-shapers of international standards. Chinese companies may be particularly vulnerable to the impact of rising complexity at this stage.

As co-shapers of international standards, Chinese firms need to substantially increase and upgrade their participation in both formal standards development organizations and informal private standards consortia. Entering the closed circles of these organizations is a major challenge for Chinese firms, as Chinese engineers are only now beginning to become members of the informal social peer group networks of international standards experts. One way to overcome this barrier is to recruit foreign engineers who are well-respected in the international standards community.

This is precisely what Huawei, China's leading telecom equipment supplier, is trying to do.[99] However, this strategy comes at a substantial cost, not only in terms of the high salaries paid to the foreign experts, but also in terms of adjusting Huawei's management practices.[100] Today, Huawei is a member of more than 120 international standards organizations, and the company occupies 148 leadership positions in the most important of these organizations such as the ITU, IETF, 3GPP, the WiMAX Forum, OMA, IEEE, ATIS, and ETSI. In addition, Huawei is a board member of OMA, IEEE, ATIS, IETF, and the WiMAX Forum.

To understand what it takes for a Chinese company to establish itself in these leadership positions, take Huawei's prominent role in the Internet Engineering Task Force (IETF), which develops and promotes Internet standards in close cooperation with the W3C and the ISO/IEC standards bodies.[101] From a complete outsider position only a few years ago, Huawei now holds 21 leadership positions in the IETF, occupying two powerful area director positions for transport and routing,[102] four chairs and six co-chairs of IETF working groups,

99. For a case study of Huawei's corporate innovation strategy, see Ernst 2008.

100. Information provided by Huawei by email, May 4, 2010. For an analysis of Huawei's participation and influence in international standards development organizations, see Ernst 2011b.

101. The World Wide Web Consortium (W3C) is the main international standards organization for the World Wide Web. The International Organization for Standardization (ISO) is an international standard-setting body (composed of representatives from various national standards organizations) that promulgates worldwide proprietary industrial and commercial standards. The International Electro-technical Commission (IEC) is a non-profit, non-governmental international standards organization that prepares and publishes international standards for all electrical, electronic, and related technologies.

102. Area directors (ADs) are expected to shape the agendas of IETF working groups and participate in the Internet Engineering Steering Group (IESG) that is responsible for the overall technical of IETF activities and the Internet standards process. Note however that these powerful positions are somewhat constrained by procedures that "ensure that an AD's 'pet

and acting as a member of the Internet Architecture Board that oversees the technical and engineering development of the Internet.

Can China Cope with the Complexity Challenge?

China's capacity to cope with rising complexity faces substantial constraints, both from outside and from within its own standards system. External constraints are aplenty for China, as for any other developing country. As highlighted by Peter Drahos and others, the existing international system for intellectual property and standards reflects the interests of a relatively small number of companies and business organizations from the United States, European Union, and Japan.[103] Latecomers have different needs and institutions, capabilities and business models, but their interests are not addressed in the existing system. This reflects a serious governance gap in the global knowledge economy (Ernst and Hart 2008). Attempts to adjust the existing rules and procedures are costly, conflict-ridden, and time-consuming and face resistance from incumbent global industry leaders.

China's capacity to cope with rising complexity also faces internal constraints that reflect possible limitations of a government-centered standardization strategy. As Carl Cargill puts it in his pioneering study *Information Technology Standardization,* regulatory standards "are ponderous, like a juggernaut, they are hard to start and steer, require vast throngs of people to keep them moving, and seem to acquire a life of their own once they get going—once rolling, they are usually difficult to stop" (1989: 18).

As complexity and uncertainty rise, and as the speed of change accelerates, attempts to "pick winners" and to promote national champions may easily fail or be bypassed. A top-down, government-centered standards system is not conducive to open standards and may constrain flexibility and learning, especially from foreign sources of knowledge. Add to this the negative impact of interagency rivalries discussed in Chapter Two of this volume.

Like other latecomer societies before, China is determined to increase the sheer number of patents granted and standards issued. This focus on quantitative parameters makes sense, at least initially. But such a strategy is ill-equipped to cope with the new challenges for standards and innovation policy that result from the rise in complexity through globalization. Quantitative achievements should not come at the cost of carefully considering important qualitative parameters, such as the importance (essentiality) of certain patents and the factors that shape the chances of successful implementation of a standard.

In other words, China faces a particularly serious challenge. As a latecomer, China needs simple strategic objectives that are relatively easy to implement.

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project' doesn't make it onto the standards track if it will have a negative effect on the rest of the IETF protocols and that an AD's 'pet peeve' cannot indefinitely block something" (Hoffman 2009: 4).

103. See, for example, Drahos and Braithwaite 2002; Yu 2009; Karachalios 2010; and Li and An 2009.

This helps to mobilize resources and to create a critical mass of capabilities in a very short period of time. But such simplified objectives do not fit well with the rapid change in the international standardization landscape and the resultant rise in complexity and uncertainty.

China obviously needs to rethink some basic assumptions of its innovation and standards policies when global corporate networks integrate national production and innovation systems across sector and geographic boundaries. Specifically, how should one measure indigenous innovation—a core concept of China's innovation policy—when the actors and sources of innovation are spatially dispersed, and few if any products are developed in a single territory?

Another fundamental challenge is to identify the appropriate role for national public policies. As globalization becomes ubiquitous, what are inherent limitations of such policies? How should one define the interests of a country? Are interests of the country and of its corporations aligned, or are there fundamental conflicts?[104] Is competitiveness through productivity-enhancing innovation the main objective—an objective that became almost an article of faith before the 2008 global economic crisis highlighted its limitations? Is the fundamental objective job creation and increasing welfare?

On a fundamental level, China's challenge is to align the often divergent interests of multiple stakeholders across different locations with rapid changes in technology, business organization, market structure, and regulations.[105] This implies that China's standardization strategy has to cover more than standards development, i.e. the development of the underlying technology, of negotiated specifications, and of supporting infrastructure for testing and conformity assessment. Equally important are policies and strategies for standards implementation.

In short, to cope with globalization and rising complexity, adjustments are required in Chinese government policies and business strategy. The key to success is to combine a unified strategy with a capacity for flexible adaptation and timely correction of unintended side effects of policy decisions. Increased flexibility is needed to engage multiple stakeholders in the standardization process (both domestic and foreign), and to accommodate their often conflicting interests. China's standards system needs to move away from a purely government-centered, top-down system towards a more decentralized and market-driven approach.

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104. See, for example, the testimony of Ralph E. Gomory (a former IBM senior vice president of science and technology and president emeritus of the Alfred P. Sloan Foundation) to the U.S.-China Economic and Security Review Commission, March 24, 2009, in which he argues that the growing divide in the U.S. labor market indicates that "the interests of many of our global corporations and the interests of the nation have diverged."

105. For an excellent analysis, see Garcia et al. 2005.

CHAPTER FOUR
Toward Greater Pragmatism? China's Recent Policy Initiatives

Moving Toward an Integrated Strategy

An important finding of our research is that China is making serious efforts to move toward a more coordinated and integrated approach to standards and innovation policy. From general statements by ministries such as the Ministry of Commerce (MofCOM) and MoST, to model policies by MIIT and interpretations by the Supreme Court of China, the process has now led to a series of legal documents that are meant to develop standardization into a platform for independent innovation.

As a result, China's recent policy initiatives on standardization appear to be better aligned with the general government focus on indigenous innovation, and the related revision of patent law and the public procurement legislation. One missing component, however, is the long-expected official announcement of China's revised Standardization Law. According to CNIS's Wang Ping, "… [i]n light of the complex issues to be addressed, this should not come as a surprise. In Europe, it took decades to work out a robust legal framework for standardization" (Wang 2010: 4).

Today, China's standardization strategy draws on a set of key legal documents (see Table 4) that have been developed since the State Council issued the Medium- and Long-term National Plan for Science and Technology Development in 2006. The length of the list indicates the intensity of China's efforts to establish an integrated approach to standards and innovation policy. But the flurry of recent policy initiatives also shows how much still remains to be done.

To understand how China seeks to adjust its standardization strategy to cope with globalization and rising complexity, let us review three of China's recent policy initiatives:

1. The registration of products that contribute to indigenous innovation.
2. The revision of government procurement regulations.
3. New regulations for patents included in standards.

Registration of Products that Contribute to Indigenous Innovation

The Notice on the Promulgation of the 2009 National Indigenous Innovation Products Accreditation Program (Notice 618) was jointly issued by MoST, the

Table 4. *China's Standardization Strategy: Key Documents*

- Medium- and Long-term National Plan for Science and Technology Development (2006–2020), issued by the State Council on February 9, 2006
- Selected Supporting Policies for the 2006–2020 Medium- and Long-term Science and Technology Development Plan (2006)
- 11th Five-Year Plan for Standardization Development, issued in 2006 by SAC
- China's National Information Assurance Policy Framework Multi-Level Protection Scheme (MLPS), issued by the Ministry of Public Security, June 2007
- Anti-Monopoly Law, effective since August 1, 2008
- Action Plan on IPR Protection 2009, issued in April 2009 by the State Intellectual Property Office (SIPO)
- Revision of Patent Law, effective October 1, 2009
- Draft Telecommunications Law, issued by MIIT for public review and comment, October 2009
- Draft Rules on Standards and Patents, November 2, 2009, issued by SAC
- Notice on the Promulgation of the 2009 National Indigenous Innovation Products Accreditation Program (Notice 618), November 15, 2009, jointly issued by MoST, NDRC, MoF
- Draft Implementation Rules for the Government Procurement Law, January 11, 2010
- CNIS Disposal Rules for the Inclusion of Patents in National Standards, January 21, 2010, issued by the General Administration of Quality Supervision, Inspection and Quarantine, and the SAC
- Draft Notice on the Launch of the National Indigenous Innovation Product Accreditation Work, issued by MoST, NDRC, MoF, April 10, 2010
- Mandatory National Standard Management (Trial) Exposure Draft, issued by SAC for feedback, May 15, 2010
- Decisions of State Council on Accelerating the Cultivation and Development of Emerging Strategic Industries [G.F. No. 32 (2010)], October 29, 2010

National Development and Reform Commission (NDRC), and the Ministry of Finance (MoF) on November 15, 2009. Initially, there was considerable concern in the international business community that Notice 618 would create entry barriers to the China market for foreign companies. Many expressed concern that an "indigenous innovation product" must be produced by a company which has full ownership of the intellectual property rights in China, and/or which has a trademark that is owned by a Chinese company and is registered in China.

A few months later, however, MoST, NDRC, and MoF jointly issued the Draft Notice Regarding the Launch of the National Indigenous Innovation Product Accreditation Work for 2010. The April 10 notice provides more details on the requirements that products must satisfy to be eligible for national indigenous innovation product accreditation. Most importantly, it indicates a more pragmatic definition of indigenous innovation. According to an assessment by the U.S.-China Business Council, dated April 12, 2010, "There are several noticeable and welcome changes between the 2009 and 2010 accreditation requirements, many consistent with recommendations proposed by the U.S.–China Business Council" (U.S.-China Business Council 2010).

In an update on China's foreign investment regulations in May 2010, the *China Business Review* concludes that "… [p]ossibly in response to a wave of criticism from foreign business associations, the PRC government released draft provisions … [in April 2010] … that would make most products made by foreign companies in China eligible for accreditation as indigenous innovation products—and for preference in government procurement."[106]

Our interviews with foreign multinationals in China confirm this assessment. Of particular importance are adjustments in the requirements governing the ownership of intellectual property in China. Notice 618, issued in November 2009, had limited indigenous innovation accreditation to products that were based solely on intellectual property developed and owned in China. In contrast, the April 10, 2010 notice appears to have been relaxed to allow indigenous innovation accreditation for products based on intellectual property that has been licensed for use in China from overseas. A product now qualifies as an indigenous innovation product when it covers one of the following three aspects: (i) originality of technology; (ii) integration: the product combines various technologies or technological building blocks; or (iii) incremental innovation based on existing imported technology.

Our interview sources emphasize that, due to R&D internationalization through global innovation networks, no company, not even a global technology leader like IBM, can claim full ownership of the IPR for a particular technology. There are always multiple contributors and patent holders. Hence, even if an artifact contains only one clearly identifiable, locally generated patent, it is likely to be considered an indigenous innovation product by the revised April 10, 2010 notice.

In addition, the April 2010 notice no longer requires that, as stated in the November 2009 notice, "a product must possess highly advanced technology that reaches or surpasses international standards to be considered eligible for indigenous innovation accreditation." Instead, the April 2010 draft circular proposes a much more pragmatic definition: "a product must possess technologies that have proven effective in conserving energy, reducing pollution, and/or raising energy efficiency, or 'substantially' improve on an original product's

106. "Foreign Investment," editorial, *China Business Review* 37 (3): 8.

structure, quality, material, craftsmanship, or performance, to be eligible for independent innovation accreditation."

As of September 2010, the implementation rules still appear to be a proposal. MoST, NDRC, and MoF are in the process of reviewing feedback and comments. Interview sources emphasize that the above documents on indigenous innovation products need to be seen together with various communication between MoST and U.S. and EU authorities regarding possible negative trade impacts. The Chinese government keeps emphasizing that "there is no trade-averse component in this policy and that foreign companies are admitted to the system if their China affiliate effectively holds the rights on the respective IP."[107]

Revision of Government Procurement Regulations[108]

China's public procurement market is huge and rapidly growing, reflecting the prominent role played by the government and SOEs in the Chinese economy. According to official figures for 2008, China's purchases through the public procurement process totaled roughly $88 billion, more than triple the amount in 2003. But, according to the *China Business Review,* "…[t]he actual size of China's government procurement market might be significantly larger than official figures indicate because of difficulties in determining which entities are state-run and which are private" (Matechak and Gerson 2010: 1).

This large market obviously is attractive to foreign firms, who complain that China's government has resisted significant openings. According to Deputy USTR Demetrios Marantis, China's policy to use its vast government procurement (GP) programs to spur domestic innovation is "… one of our greatest challenges with China today."[109]

The Chinese leadership considers the GP market to be an important policy tool to foster indigenous innovation. When China entered the WTO in 2001, the government committed to join WTO's Agreement on Government Procurement (WTO-GPA), but the terms of its membership are still under negotiation.

China's initial GP regulations were quite drastic. The key legal document, China's Government Procurement Law, first issued in 2002, required that "government agencies and entities must purchase domestic goods, works, and services" and provided very limited exceptions. This was followed by a raft of regulations that defined a fairly restrictive approach. The May 2007 "Measures for Administration of Government Procurement Budgets for Indigenous Innovation Products" warned government at all levels to develop specific indigenous innovation procurement plans or they would lose procurement funds.

107. According to an interview source who requests anonymity.

108. This section draws on interviews, and on Ahrens 2010; Matechak and Gerson 2010; and USITO 2010.

109. Deputy USTR Demetrios Marantis, quoted in "U.S., China Begin Talks on Innovation Trade Dispute," at http://www.reuters.com/assets/print?aid=USTRE66J6SO20100720, accessed October 6, 2010.

In the same month, the "Measures for Assessment of Government Procurement of Indigenous Innovation Products" lowered government procurement supplier qualification standards for companies doing indigenous innovation. And in December 2007, MoF issued "Measures for the Administration of Government Procurement of Imported Products," which directed that approval by a board of experts is necessary for government entities to purchase imported goods. It called for favoring foreign suppliers that provide the domestic industry with technology transfers and training services.

Are recent developments signaling a gradual shift towards greater pragmatism? On January 11, 2010, the State Council's Legislative Affairs Office released the long-awaited Draft Implementing Rules for the Government Procurement Law that outline the scope, responsibility, conditions, format, procedures, and requirements for government procurement in China. Notably, the draft defines domestic products, projects, and services in a way that appears to include foreign investment enterprises (FIEs). Specifically, Article 10 of the draft defines a "domestic product" as one "made within China's borders and for which domestic manufacturing costs exceed a certain percentage of the final price." This definition should allow FIE products that pass a local content threshold—which apparently will be equally applied to Chinese-owned companies—to qualify as domestic for the purpose of government procurement.

Article 10 also states that government procurement for projects and services will apply to Chinese nationals, Chinese legal persons, or other Chinese organizations. Because FIEs have legal-person status under existing PRC laws, this definition indicates that projects and services provided by these FIEs should be treated as "domestic" for government procurement. According to a December 2009 statement by MofCOM, China's indigenous innovation policies, including its GP regulations, are non-discriminatory, as they apply equally to domestic and foreign-invested companies.

Foreign observers acknowledge progress towards greater pragmatism, but argue that challenges remain. For instance, the U.S. Chamber 2010 report states that draft revisions to Circular 618, issued on April 10, 2010, "have softened some of the most controversial requirements. The draft removed references to 'indigenous brands' and the requirements that the trademarks and brands must first be registered in China and the IP owned by the local entity." The U.S. Chamber, however, considers these revisions to be insufficient and states that " … [f]oreign business associations … continue to push for elimination of the indigenous innovation product catalogues altogether" (McGregor 2010: 20).

Specialized U.S. lawyers argue that "… [t]hough the relaxed trademark and IP rules are welcome changes, the requirements remain onerous for many FIEs."(Matechak and Gerson 2010: 3). Somewhat surprisingly, these authors add that equal treatment for domestic and foreign-invested companies in China "is exactly the problem, because it eliminates too many opportunities for foreign companies."

This seems to confirm an argument presented by a Chinese lawyer that

> … [u]ntil recently, there was a tendency to treat foreigners better than Chinese firms, because foreigners had technology, knowledge, and capital. … [In Chinese ministries], foreign visitors could count on getting special attention and on meetings with top officials. Foreigners are missing this privileged treatment. As China has improved its economic situation, negotiations with foreigners are now more business-like. In my opinion, things are now getting more normal—that's all.[110]

Ambiguity enters the picture, however, as the same Draft Implementation Rules also stipulate that support and protection will be given to indigenous innovation products via priority or compulsory procurement. According to interview sources, several provinces and cities throughout China have drafted and released product catalogues to promote indigenous innovation. These catalogues differ from province to province, and it is unclear how these local lists will interact with a national product list. The product catalogues apparently discriminate against FIEs. According to a recent survey, "of the 523 products listed in Shanghai's catalogue of indigenous innovation products, only two are made by FIEs (both are from Chinese-foreign joint ventures with majority Chinese ownership)" (U.S.–China Business Council 2010: 2).

The latter example illustrates a fundamental dilemma faced by China. Ubiquitous globalization and rising complexity of technology imply that it is very time-consuming and cumbersome to construct and to manage reasonably systematic lists of products and technologies. As illustrated by the failure of the control list of embargoed "dual-purpose goods" prepared for the Coordinating Committee for Multilateral Export Controls (CoCom), such lists risk being quickly outdated and bypassed. Even more important for China's objective to foster independent innovation is that such control lists, by their very nature, focus on existing technologies, rather than on the future innovations that they are designed to promote.

Nathaniel Ahrens has recently made a strong and convincing argument for China to become a signatory to the WTO-GPA "in order to build a solid system that can legally incorporate certain mechanisms that stimulate indigenous innovation while keeping markets open" (Ahrens 2010: 2). It is difficult to disagree.

In fact, the WTO-GPA allows many exceptions, such as small and medium-sized enterprises and national security. Research on GPA documents indicates that if a country like the United States, United Kingdom, or Germany is sophisticated in how it uses the many loopholes, GPA membership provides an extraordinary amount of flexibility and fairly rich benefits. In the United States, the Small Business Innovation Research (SBIR) program makes effective use of GPA loopholes, and is one of the most effective tools in the U.S. government's

110. Interview with Chinese IP counsel at a foreign company who requested anonymity.

kit for stimulating innovation.[111] The United States also makes ample use of exceptions due to national security and homeland security concerns through DARPA and the Department of Homeland Security.[112] The irony is that debates about China's government procurement policy make no reference to this secret weapon of the U.S. innovation system. In fact, proponents of "open procurement" in China are disingenuous when they fail to acknowledge that the United States has made ample use of this highly sophisticated approach to government procurement.

In July 2010, China's government made a long-awaited revised offer to join the GPA. The initial response of the Deputy USTR was cautiously positive: "We are still analyzing (the offer), but we recognize that it includes significant improvements over its initial offer that was submitted at the end of 2007."[113] Negotiations are still continuing.

In our interviews, the following reasons were given to explain why China thus far has refrained from joining WTO-GPA:

- ***A lack of confidence in Chinese domestic companies' competitiveness:*** Once China joins, the procurement process will be transparent and foreign companies will have equal opportunities to compete with Chinese players. So far, with the exception of giant companies like Huawei, ZTE, and Haier, the innovation capabilities of Chinese industries are still weak. China, in this context, would prefer to postpone its entry into the GPA for a few years, buying more time for its domestic companies to grow.
- ***The size of China's GP market:*** Foreign companies would like to include the SOE sector into the GP definition, yet China's government is reluctant to extend GP to this huge market. China's current definition of GP is very broad and includes procurement using fiscal funds, covering government agencies at all levels, organizations, hospitals, and schools, including product, service, and projects.
- ***Problems with the legal framework:*** China has two laws governing the GP market, the Government Procurement Law and the China Bidding Law. The former deals with products and services while the latter focuses on projects. There are many conflicting clauses between these two regulations and it takes time to coordinate interests.

111. "SBIR is the world's largest seed capital program for science and technology businesses. As a source of early stage finance, SBIR is probably at least as important in value terms as venture capital. However, unlike most venture capital investments, SBIR awards are available from right at the start of a business's life" (Connell 2006: 1–3). For details on SBIR and related programs, see the official website at http://www.sbir.gov/about/index.htm. For an evaluation, see Wessner 2008.

112. For some of these programs, the United States does not allow Japanese and Korean suppliers.

113. Deputy USTR Demetrios Marantis, quoted in "U.S., China Begin Talks on Innovation Trade Dispute," at http://www.reuters.com/assets/print?aid=USTRE66J6SO20100720, accessed October 6, 2010.

- ***Implementation:*** China faces a shortage of experienced staff in the GP area and there is considerable overlap of responsibilities within the government on GP. It takes time for the Chinese government to train staff and adjust its structure for effective implementation.
- ***Lack of experience:*** Chinese government agencies just do not have the experience to run a government procurement system of this size. The government recognizes the need to adapt the Chinese GP law to WTO standards, but this a complicated process that was only begun in 2008. It needs time to build the system before the floodgates can be opened. This is not just a legal challenge. The primary challenge is administrative—getting the right structure and human resources in place is very time-consuming.
- ***Control:*** Both the local governments and SOEs are hard for Beijing to control. When international bodies exert pressure on China to join the WTO-GPA, this is really just emphasizing Beijing's lack of control. The government does not like to be held accountable in the WTO for SOEs. The government has emphasized that SOEs will be subject to commercial laws, not to the government. In addition, the Chinese government believes it was agreed upon its accession to the WTO that SOEs would not be included. As a result, the Chinese government feels it is unfair that the United States keep trying to force this into the GPA negotiations.

These interview findings support Scott Kennedy's argument that, on standards and innovation policy, China is going through a "… socialization process … [that] … is gradually encouraging more constructive behavior so that competition and cooperation occur within the context of a clearer set of boundaries" (Kennedy 2010: 20).

New Regulations for Patents Included in Standards

As demonstrated in Chapter Three, an important challenge for China's standardization strategy is that the role of essential patents in standards has dramatically increased. As a result, China is under considerable pressure to come up with effective regulations on this issue. On November 2, 2009, the SAC posted for public comment a draft of the Provisional Rules Regarding Administration of the Establishment and Revision of National Standards Involving Patents (the "Draft Rules").

These draft rules represent a much more aggressive approach than an earlier 2004 draft. SAC signals that it intends "using its powers to impose lower royalty rates on patent owners and encouraging the future use of compulsory licensing under the patent law to avoid perceived windfalls to patent owners—particularly foreign ones."[114] The Draft Rules set out in detail the possible consequences in cases where a patent owner involved in the standards development process

114. J. Simone and Jing He, "Standards in China: Intellectual Property," Baker & McKenzie Client Alert, Hong Kong, November 2009, 1.

fails to disclose relevant information regarding its patents or pending patent applications.

Article 9 of the Draft Rules foresees in the case of inclusion of IPRs in standards "royalties significantly lower than a normal royalty." In the case of non-compliance with the obligation of disclosure of patents during the standardization process, the IPR owner may face the entire loss of his property rights. In addition, the Draft Rules include policies that could constrain the transferability of licensing commitments during the process of adopting international standards as Chinese standards.

This has raised substantial opposition in the international business community and complaints that the requirements of the Draft Rules are incompatible with the IPR policy of international standards bodies such as ISO, IEC, and ITU. However, initial fears about negative impacts on market entry for foreign companies may need to be reconsidered. It seems that, in response to complaints by both Chinese and foreign organizations, Chinese authorities have toned down and softened some of the initially harsh requirements.

According to our interview sources, SAC apparently has decided to delete the most controversial parts of the Draft. This includes the requirement in Article 9 of "a significantly lower than the customary royalty." The new formulation—"a commitment to license on a RAND basis"—would be in line with international practice.[115] Informed foreign interview sources also expect that other initial requirements, such as the royalty-free penalty for not disclosing patents on time, will be watered down.

If that assessment is correct, what explains the retreat? It seems foreign complaints have played a role. According to one foreign interview source, "We heard that SAC received over 2,000 pages of comments and are not expected to issue a revised draft for some time, possibly to let things cool down." And according to Scott Kennedy, "… foreign industry and governments are an integral part of the Chinese policy-making process, and their involvement, along with that of pro-liberal Chinese firms and experts are a standard, routine part of the process which helps determine what policies are adopted."[116]

It may well be that Article 9 of SAC's 2009 Draft Rules was too much focused on reducing the cost of technology licensing. That may no longer be the primary concern of large and increasingly global Chinese companies (like Huawei) that have growing IPR portfolios and hence can negotiate patent swaps.

Recent developments seem to support this assessment. For instance, the CNIS Disposal Rules for the Inclusion of Patents in National Standards, issued by SAC on January 21, 2010, no longer require that a holder of an essential patent commits to royalties that are considerably lower than normal royalty rates. In the Disposal Rules, third parties are simply encouraged to disclose potentially essential patents on a voluntary basis.

115. RAND = Reasonable and non-discriminatory patent licensing terms.
116. Scott Kennedy, email to author, November 1, 2010.

But again, there remains a fair amount of ambiguity. For instance, the Disposal Rules provide no definition of essential patents. It is unclear whether ambiguity in this case reflects unresolved inter-agency rivalries or whether ambiguity is intended to provide greater flexibility to handle unexpected negotiation challenges that might result from rising complexity. However, one well-informed foreign interview source doubts whether the Disposal Rules indicate a softening of China's policy: "On the contrary, this strengthens the implementation of the new policy by having a clear process in place." And another interview source adds:

> Although not nearly as controversial as the SAC proposed policy, many comments were received, and supposedly CNIS is preparing a revised draft, or possibly just a final version, without another round of draft review. Some international organizations … are attempting to arrange meetings with CNIS to discuss the main issues, in anticipation of not having another opportunity to comment in writing before a final policy is issued.

Finally, recent revisions in China's Patent Law promulgated on October 1, 2009, may also indicate a partial relaxation of earlier more stringent requirements.[117] The law seeks to strengthen China's legislative and implementation framework for the protection of IPR, while at the same time promoting China as a research and development center for multinationals. Before the revision, China's Patent Law required that, for inventions made in China, patent applications had to be made first in China before filing for a patent in a foreign country. The rationale proposed for this requirement was to ensure that patents are exploited within China.

The revised version of the Patent Law partially relaxes this requirement. The new Article 20 no longer requires a first filing in China. For inventions made in China, an applicant—Chinese or foreign—"could either file first in China, and then secure foreign filing permission from SIPO for foreign filing, or not file in China but directly requesting a security check for foreign filing permission."[118]

The stated goal of the security check is to protect China's national defense interests or other vital national interests (Clark et al. 2010, 31). Specifically, the implementation regulations of the new Patent Law require that, to file a patent application abroad, the applicant must submit a security check request form and a detailed explanation of the invention's technical solutions in Chinese.

It remains to be seen whether this "security check" will work as a de facto restriction against foreign firms. A possible concern is the length of the waiting period. In fact, the Patent Law's Examination Guidelines state that "… [i]f the applicant does not receive the first notice within four months or the second no-

117. For details, see EU–China IPR2 2009. This document has been jointly sponsored by the European Patent Office and the Chinese Ministry of Commerce.

118 Email from Zhang Yan, senior counsel, intellectual property law, IBM China, August 8, 2010.

tice within six months of submitting the request, the applicant may file abroad" (ibid.). In the fast-moving ICT industry, where product life cycles can be six months or less, such long waiting periods may well constitute a fundamental entry barrier.

However, some of our interview sources argue that these concerns may be exaggerated. For instance, one Chinese interview source who requests anonymity emphasized:

> My company is currently applying for both foreign patents and Chinese patents (different patent applications of course). I don't recall Chinese patent office ever rejecting our application based on that rules. Even if it was enforced, I can think of many ways to get around that in real practice.

Key Findings

This chapter has documented a gradual progress toward greater openness, transparency and flexibility. This reflects genuine efforts to learn from mistakes.[119] But there are also countervailing forces that seek to slow down these adjustments.

For all three of the above recent policy initiatives, we find a fairly consistent pattern of China's response to foreign complaints. In Round One, PRC government regulations start out with quite demanding requirements that exceed established international norms. This typically gives rise to a wave of criticism from foreign enterprises and business organizations, but also from Chinese companies that have established a significant position in the international market and that have begun to accumulate a reasonably broad IPR portfolio. In response to this criticism, Round Two then leads to some adjustments in PRC government regulations that combine a selective relaxation of contested requirements with persistent ambiguity.

This, of course, raises two questions: What will happen in Round Three and further rounds of negotiation? And, more importantly, is it realistic to expect substantial changes away from China's fundamental objective of using standards as a platform for fostering indigenous innovation?

On the first question, most of our foreign interview partners assume that Chinese authorities use the first round to gauge the international response, and tend to backtrack in response to foreign complaints, in particular if these complaints are well coordinated among the United States, the European Union, and Japan. Here are two examples of this perception:[120]

119. According to An Baisheng, "China has learned not to make low-level mistakes such as failing to fulfill the WTO notification obligations. China has also learned … to better prepare for disputes in order to avoid unnecessary ones" (An 2009: 195).

120. Both the quotes from foreign and Chinese observers are from interviews conducted by email between August and November 2010, but the interview sources have requested anonymity.

> In fact China … [has] … issued revisions recently that mitigated some of the more egregious requirements, such as that IP and trademarks had to be filed in China first. However, even as revised they will continue to be controversial.
>
> SAC received so much push back from the international community that they may simply drop this issue, at least for a time, rather than releasing an updated IPR policy proposal. … They are also using the proposed CNIS policy as a bit of a test case, to at least gauge the international response to what amounts to a subset of the SAC proposal.

These interview assessments are in line with an interesting observation by Scott Kennedy: "We'd need to see … [particular formulations] … repeatedly in multiple documents to know if this is an oversight or a sign of something new. .... The real measure will be in actual contracts."[121] On the second question, foreign interview partners typically acknowledge that China needs to strengthen its homemade innovative capacity, but they are concerned that current implementation will have trade-distorting effects. For instance, one foreign interview partner argues that

> … not the basic policy is controversial but the impact on trade and market access. We would wish that China is more sensitive regarding this link and chooses to a) better communicate its policies; b) better coordinate between ministries; c) allow foreign companies and governments feedback; d) carefully measure trade impact. China emphasizes time and again that this policy is not against anybody—it's a development tool for its own benefit.

As for Chinese interview partners, most agree that on the first question, there is ample scope for "modifications and improvements in technical terms." On the second, however, Chinese observers believe that the answer is likely to be negative. Here are three illustrative quotes:

> I do not think there will be fundamental change in China's indigenous innovation policy. China will continue with its innovation support policies more or less in the same way as the European Union and United States are doing.
>
> One thing is sure that … [China's] … indigenous innovation policy will not have a big change, only it will open the public procurement to the TNC affiliates in China.
>
> China's indigenous innovation policy certainly has been a controversial issue recently with some big name foreign companies crying over un-

121. Scott Kennedy, email October 29, 2010.

fair competition. But I am not sure if there will be any big changes soon because the old policy was in place to specifically encourage Chinese domestic companies to innovate and also to protect its market. This policy serves that interest well. So what's the incentive to trigger a change?

Overall, this study finds sufficient evidence that pragmatism is on the rise. Of particular interest is a recent policy document, Decisions of the State Council on Accelerating the Cultivation and Development of Emerging Strategic Industries [G.F. No. 32 (2010)], issued on October 29, 2010.[122] This document contains guidelines for implementing the strategy of indigenous innovation to accelerate the development of seven technology industries (energy, biomedical, ICT, high-end manufacturing, new energy, new materials, and new energy autos).

It is important to emphasize that public procurement is not mentioned once in this document. Instead the document emphasizes international cooperation, particularly in joint R&D and co-development of standards in China for the international market. In fact, Section VI contains an intriguing formulation. "Encourage Chinese enterprises and R&D institutes to participate in the setting of international standards, and encourage foreign-funded enterprises to participate in China's pilot projects, and form international standards." This formulation is in line with what interview partners from the Chinese government told us. In addition, the document also notes that China will further open the market to foreign venture capital in these strategic industries.

Of course, the jury is still out on whether the above policy document constitutes an important shift in China's innovation strategy. However, it at least indicates that there are important stakeholders in China who push for greater openness and pragmatism in the Chinese innovation and standardization strategy.

122. For the Chinese document, see http://www.gov.cn/zwgk/2010-10/18/content_1724848.htm, accessed October 30, 2010.

CHAPTER FIVE
Institutional Innovations? Recent Developments in China's ICT Standards Projects

This chapter examines recent developments in three major Chinese standards projects in the ICT industry (TD-SCDMA, IGRS, and AVS) that started out with different business models, in terms of their reliance on the government and industry support. While earlier developments in these projects have been extensively researched (especially for TD-SCDMA), this study takes a fresh look and documents that current adjustments in their organization and management have produced institutional innovations and greater flexibility and pragmatism.[123]

Using the criteria for success developed in Chapter One, the following questions will be examined for each of the projects:

- What are the objectives of this project?
- Has there been a change in the role of the government?
- Who are the main stakeholders and how broad is the base of industry support?
- What can we say about the impact of this project on China's innovation capacity?

I conclude with a brief discussion of future prospects for each project.

TD-SCDMA[124]

China's TD-SCDMA mobile communications standard has received enormous attention in the media as well as in academic research. Some observers argue that the achievements of this standards project are limited and that they come at an extraordinarily high opportunity cost. For instance, Kennedy et al. (2008: 24) predict that the TD standard is bound to fail, because no amount of government support and regulatory protection from foreign competitors can compensate for "a relatively narrow coalition of industry backers, and the widespread dissemination of alternative standards," i.e. W-CDMA and CDMA-2000. And

123. Recent developments in China's WAPI standard are examined in Ernst and Martin 2010b.
124. This section draws on interviews, and on Liu 2007; Marukawa 2010; Stewart 2009; Whalley et al. 2009; Shen 2010; Chen and Wen 2010; Wu et al. 2010; Suttmeier et al. 2006; Gao 2009; Clark 2009; and Zhan and Tan 2010.

Duncan Clark argues that "it will be a struggle for TD-SCDMA…[which]… faces hurdles of handset supply…, a need for increased subsidies, and insufficient support from vendors" (Clark 2009).

But there are also more positive assessments. Gao Xudong (2010: 2) from Tsinghua University's Center for Technology Innovation argues that "TD-SCDMA has become a successful example of indigenous innovation," but acknowledges that this standard needs to cope with big challenges, such as latecomer disadvantages, ambiguous government policies, and conflicting stakeholder interests. A study funded by the Center for International Governance Innovation in Canada, and the German Leibniz Foundation, argues that, while the TD standard "thus far is unproven commercially, … the lessons learned will benefit future related efforts in follow-on technologies"(Whalley et al. 2009: 2). And a policy brief prepared by the China-EU Information Technology Standards Research Partnership concludes that "TD is considered a major Chinese success story, and it is now being spoken of as a standard for export, particularly to developing economies. This success … [has] increased China's confidence and participation in 3GPP, ITU, and other telecommunications SDOs."[125]

Objectives

China's TD-SCDMA standard is not exclusively a national standard. It was jointly developed by the China Academy of Telecommunications Technology (CATT) and Siemens. A fundamental objective was to establish an international third-generation mobile telecommunications standard against the two dominant international standards, W-CDMA and CDMA-2000. Given the global nature of the telecom industry (and the broader information and communications industry), it was clear that a Chinese 3G mobile standard had to have international recognition.[126]

An important objective is to reduce China's dependence on foreign technology in a sector that is critical not only for economic development but also for national security. An immediate operational goal is to improve China's bargaining position in licensing negotiations. Specifically, it is expected that the TD project will contribute to the development of homegrown innovative capabilities and produce a critical mass of essential patents that Chinese firms can use to negotiate cross-licensing agreements. This is in line with an important 2007 study by Liu Xielin, who has played an important role in advising the government on its Medium- and Long-term National Plan for Science and Technol-

125. China EU Information Technology Standards Research Partnership, European Policy Brief, March 2010, 8, 9. Available at http://www.china-eu-standards.org/index.htm, accessed July 28, 2010.

126. China's TD-SCDMA standard is one of the five IMT-2000 standards for 3G mobile telecommunications accepted by the ITU in 1999, along with the EU's W-CDMA and the U.S. standard CDMA-2000. In March 2001, the standard was adopted by the Third Generation Partnering Project (3GPP), making it an international standard.

ogy Development (2006–2020). Liu argues that, "as Chinese companies have been locked out of existing second-generation GSM network … [development, this placed enormous pressure on the government] … to leapfrog the next generation technology so that Chinese companies can have more competence in the future."(Liu 2007: 18, 19). According to Liu, this implies that the Chinese government should play " a very important role in the catching-up process in the earlier stage of the process and … [that] … it is more important in leapfrogging than in path-following catching-up." (ibid.: 23).

At the same time, Liu emphasizes the importance of collaboration and alliances with leading foreign companies to gain access to the latest technology. Liu argues that, without such international cooperation, "catching-up is almost impossible" (ibid). In fact, the TD standard contains a substantial share of foreign essential patents for major building blocks of this technology that are owned, inter alia, by Nokia, Ericsson, Siemens, Qualcomm, Motorola and Alcatel-Lucent. Widely quoted estimates put the share of these six global companies of essential patents for the TD-SCDMA technology at between 36 and 66 percent.[127] As indicated later in this chapter, such patent data are problematic. Nevertheless, it is safe to assume that most of the essential patents that define the basic technological building blocks of the TD-SCDMA standard are owned by foreign companies. The promoters of the TD standard were realistic enough to acknowledge that China's share of essential TD patents will remain limited for quite some time, and that the only way to establish credibility was to choose the international standardization approach through ITU and the international consortium 3GPP.

A second important objective has largely been neglected in the literature. Many of China's top decision makers are trained as engineers. For them, it was attractive to have a standard to call their own in a strategic industry. As engineers, they were also fascinated by the promise of substantial benefits and cost savings that are inherent to the TD-SCDMA design. According to Siemens, the German company that initially played an important role in this project, the TD-SCDMA standard was designed to provide the following benefits:[128]

- Lower investment costs than other 3G systems.[129]

127. The source for the 36 percent share is Telecomasia.net, November 14, 2008, at http://www.telecomasia.net/. The Chinese journal *IT Time Weekly* (June 5, 2005, 23) is the source of the 66 percent share, as quoted in Stewart 2009.
128. Siemens 2004. Siemens contributed patents of its own TDD standard, which had earlier failed to win acceptance within ETSI.
129. "In conventional 2G and 3G CDMA based systems, due to intra-cell interference, cell area is reduced when data rates or numbers of user grow. As a result, when traffic increases, an operator has to introduce a higher number of base stations in order to guarantee an adequate coverage. On the contrary, in TD-SCDMA systems the traffic load can be increased without reducing coverage. This leads to a considerable reduction of infrastructure costs" (Siemens 2004: 3).

- Design is better suited for asymmetric 3G applications, like the mobile Internet, which is expected to become a major growth market in China.
- Allows for a better utilization of scarce frequency bands than radio technologies, which require separate bands for uplink and downlink portions of the spectrum (such as GSM, EDGE, W-CDMA or CDMA-2000). Efficient use of the available spectrum is of critical importance for China's densely populated urban areas (99 of its cities have more than 1 million inhabitants!).
- TD-SCDMA's carrier bandwidth of 1.6 MHz provides high flexibility in spectrum usage and network design.
- Beam Steering Smart Antennas direct power to active mobile terminals only, enabling low power emission.
- Reduced costs of transmission thanks to joint detection, smart antennas, and an accurate terminal synchronization.

Of course, this description of TD-SCDMA benefits needs to be taken with a grain of salt. There will always be tradeoffs between different technologies, and it is common practice for the proponents of a particular standard to highlight the benefits of their standard without comparing them with the benefits of other standards.

Additional objectives of the TD-SCDMA project reflect China's latecomer status in leading-edge digital mobile communications technology. Our interviews show that the key decision makers of the TD standard project are very conscious that they still have quite some way to go to catch up with the dominant international standards. Major gaps that will need to be filled over the next few years include an extension of network coverage and substantial improvements in the performance and design of handsets and in services content.

A particularly serious challenge is that China's wireless spectrum, especially the high-quality part, is extremely limited. Most high-quality spectrum parts are the preserve of the military and state broadcasters, not telecom operators. As a result, the unchecked promotion of bandwidth-hungry smart phones, netbooks, and data cards by Chinese operators will degrade the quality of China's mobile networks. This creates a dilemma for the development of the TD standard, which needs to expand its customer base especially for the more profitable, bandwidth-hungry applications.

Furthermore, the TD project needs to find ways to compensate for the huge opportunity costs caused by the delayed introduction of 3G licenses in China, and its negative impact on the speed of innovation in 3G-related services and their early diffusion within the Chinese market.[130] In addition, the delay of MIIT's decision on 3G licenses enabled a myriad of illegal producers of Shanzhai handsets to enter the market. Rather than investing in R&D, these com-

130. See details in Clark 2009.

panies use ready-made chipsets designed by Taiwan's MediaTek as a quick and low-cost way to gain market share.[131]

On a more fundamental level, the TD project seeks to avoid mistakes made earlier in Japan and Korea. In both countries, the local market was so competitive and the operators so demanding that local manufacturers exhausted their development capacities to serve a low-margin, cut-throat market. Promoters of China's TD standard claim that they have studied why Japan has not been able to become a global market leader in 3G, despite its pioneering role as a lead customer market, and despite the presence of strong and highly innovative companies (NEC, Panasonic, Toshiba, Sharp, and others).

China's TD project also seeks to learn from Korea's experience. That country's strategy was to leapfrog into the most advanced type of CDMA instead of licensing the initially dominant GSM standard. As GSM and the less-advanced W-CDMA technologies cover 80 percent of the world, Korea's overly ambitious strategy backfired and has slowed down, at least initially, exports for Samsung and LG.

In short, the strategic objectives of the TD standard project are broad and multi-faceted, reflecting China's latecomer status in this industry. Hence, while commercial indicators like market share, ROI, and rents from innovation are important, they are insufficient to assess the broader impact on China's economic development. There is a growing consensus in China that the ultimate litmus test of success or failure of the TD project is whether it will enable China to become a co-shaper of next-generation mobile telecom standards such as TD-LTE.

Business Model and the Role of Government

China's TD standard project started out with a business model that is typical of the traditional Chinese standards system: A top-down, government-centered approach focuses on technology development, uses research institutes and state-owned enterprises (SOEs) as primary carriers, and neglects market development and standards implementation. The interesting question, of course, is whether globalization and rising complexity has forced the government to adjust its support policies, giving rise to changes in the TD standards business model.

Right from the beginning, the government has played a very active role, both in the R&D and in the commercialization of TD-SCDMA.[132] As argued by Shen Xiaobai (2010), this is in line with earlier developments in other countries, when these countries were still in the process of constructing their telecommunications infrastructure. In addition, the telecommunications sector

131. In 2009, Shanzhai handsets were estimated to have at least a 40 percent share of the Chinese handset market (Chen and Wen 2010: 4, quoting data from DigiTimes, June 2009).
132. See the excellent discussion of the much-neglected early history of TD-SCDMA and the deep involvement of the government in Marukawa 2010.

lends itself most easily to deep government involvement, due to the critical importance of frequency allocation, which is government controlled.

Backed by a fund of RMB 700 million, MIIT asked Datang (an offspring CATT established as an SOE) to establish the TD-SCDMA Industry Alliance (TDIA) with seven Chinese manufacturers as founding members, including Huawei, ZTE, Potevio, and Lenovo. The fund was used to pay licensing fees to CATT for related patents.

In addition to creating an SOE (Datang) as project leader and providing funds, the government has shaped the development of the TD standard with three important policy instruments:

- The government provided preferred access to the frequency spectrum for the TD standard.
- It delayed the licensing of 3G technology in China until the TD standard had sorted out its main teething problems.
- And the government charged China Mobile, the dominant mobile operator, with the development of the TD network, despite the fact that China Mobile would have preferred to use the W-CDMA standard.[133]

China's government initially used a coalition of CATT and SOEs as main carriers of its policy. However, as Gao Xudong (2010) emphasizes, the implementation of this policy was substantially constrained by ambiguity that resulted from inter-agency rivalries within the government, which reflected the conflicting interests of major stakeholders.

Our interviews show that this policy ambiguity results from the unresolved tension between the objectives of China's telecommunications, industrial, and media policies, and China's national security requirements. For example, while China's industrial policy is primarily interested in developing a strong domestic industry base for the TD technology, telecommunications policy and telecom operators are primarily interested in a fast and cost-effective expansion of the network and the quality of its services. A younger generation of telecom technocrats in China has been exposed to the international telecom market and is eager to unleash the huge innovation potential of the mobile market.

In addition, telecommunications policy is primarily interested in open and easy-to-manage networks with low overall life-cycle operating costs. In contrast, both China's media policy and its security apparatus support more restrictive policies.This raises an important question: How has the role of the government in the TD project been adjusted to cope with these conflicting interests?

Potential catalysts for changing the role of the government are four important recent developments: i) the delayed licensing of 3G technology as part of

133. The transition to W-CDMA would have been much easier from China Mobile's existing 2G GSM standard. It also would have been faster and more profitable, and might well have created more innovative, market-leading, and customer-friendly services.

a restructuring of the Chinese telecom sector; ii) the Beijing 2008 Olympics; iii) the anti-crisis stimulus package in the spring of 2009; and iv) the 2010 Shanghai World Expo. In all of these cases, implementation remained decisively top-down, but there are signs that the content of policies is shifting gradually towards signaling opportunities, reducing risks, and engaging in R&D and related support activities.

The restructuring of China's telecom industry received a big push in September 2008 when SASAC (China's State-owned Assets Supervision and Administration Commission) ordered China Mobile to transfer US $7.3 billion to China Unicom. The main objective, apparently, was to break China Mobile's de facto monopoly position—an objective that thus far has remained elusive.[134]

In December 2008, MIIT announced that it would issue 3G licenses in early 2009, expecting that this would generate RMB 200 billion (US $29.1 billion) in investments by the three operators. Specifically, China Mobile has received the TD-SCDMA license; China Unicom has merged with China Netcom and concentrates on W-CDMA (the European standard); and China Telecom received the CDMA-2000 license and is ordered to take over the mobile operations from Unicom that use the U.S. standard CDMA. Underlying this decision is the expectation that Unicom and Telecom will fiercely compete to catch up with China Mobile. In addition, all three operators are required to reach an agreement on infrastructure sharing before the licenses can be awarded.

MIIT's decision to grant 3G licenses both to the dominant global standards and to the TD standard indicates greater pragmatism. It is debatable, however, as to whether this was a conscious decision motivated by a concern for healthy innovation policies. Accepting the leading global standards has perhaps more to do with the slow development of the TD-SCDMA industrial value chain, the lack of attractive TD handsets, and the resultant reluctance of China's telecom service providers to use the TD standard.

Pragmatism, however, goes hand in hand with persistent attempts to shape competition. In January 2009, MIIT announced a significant increase of funding for the development of the TD standard. According to Li Jinlang from MIIT's Commission of Electronics, Science, and Technology, RMB 100 billion were to be allocated to TD development, as part of the economic stimulus package.[135]

MIIT's announcement is quite explicit that it expects Chinese companies, and especially Huawei and ZTE, to benefit the most, while the share of non-Chinese equipment vendors is expected to decline. To achieve this goal, MIIT

134. In December 2009, China Mobile reported a 71.3 percent share in China's subscriber market share, way ahead of China Telecom and China Unicom. See China Mobile 2010 Annual Report at http://www.chinamobileltd.com/ir.php?menu=3, accessed July 30, 2010.
135. This compares to a total of RMB 170 billion that were assigned for investment in the construction of 3G mobile communications infrastructure as part of China's RMB 4 trillion stimulus package. See Ernst 2009b.

has expanded its arsenal of promotional policy tools for the TD standard, to include the following measures:

- Companies that are involved in TD development can access existing government funds for the electronics industry.
- Government procurement will be used to foster TD applications in e-government, wireless city, rural informatization, and e-business projects.
- The approval process for TD projects will be streamlined and accelerated.
- Support for TD network construction will be made more effective by ensuring good location and power supplies for base stations.
- Government procurement of TD handsets and data cards will be expanded.
- TD will receive special frequency spectrum allocations to cover rural areas.
- MIIT will provide specialists and consulting services to support TD handset manufacturers.
- Owners of networks that refuse to share infrastructure with the TD network where it is deemed necessary will face punishment.

In addition, MIIT announced policies to prohibit TD users from migrating to other networks, as well as an unspecified proposal to "limit the import of foreign technologies."[136] This indicates that old habits die hard. While the overall thrust of MIIT's approach is moving toward promotional policies, the legacy of market regulation remains alive.

An important new development is that there is now an intensive debate in China about inherent disadvantages of policies that place too much emphasis on market regulation. For instance, Cheng Dejie, an influential telecommunications policy blogger, argues that

> as long as China Mobile will not be fully exposed to competition with W-CDMA and CDMA-2000, it will have little incentive to improve the TD standard and its services. … Support for the TD standard is necessary, but it should come through tax rebates and other incentives rather than through the government procurement market, which tends to create over-priced white elephant systems.[137]

Most importantly, the focus of China's policy debate has shifted beyond the 3G standard to the question what policies are conducive for China to become

136. *Interfax TMT China Weekly*, January 17, 2009, 9.
137. Quoted in *Interfax TMT China Weekly,* January 10, 2009, 21, 22. Cheng Dejie, a graduate of the University of Electronic Science and Technology of China, is a senior analyst in Sichuan Communication Research Planning & Designing Co. Ltd. His blog is available at http://blog.sina.com.cn/teletech, accessed July 30, 2010.

a co-shaper of next-generation mobile telecom standards, such as TD-LTE.[138] The 2010 Shanghai World Expo helped to accelerate the transition. Today, leading telecom equipment vendors from China as well as foreign companies are competing as suppliers of TD-LTE test networks. Chinese firms, in particular Huawei and ZTE, have already made substantial investments in the development of TD-LTE.[139]

Competition is very intense, and managing this increasingly complex industry value chain is no longer possible through the traditional, top-down approach with a focus on market regulation. More subtle and sophisticated forms of government support are required to coordinate the transition to TD-LTE. An additional complicating factor is that the TD-LTE standard has to compete with UBM (ultra mobile broadband) and WiMAX (Worldwide Interoperability for Microwave Access), two alternative approaches to next-generation mobile communications technology.[140]

There is much at stake for China's government, and failure to build on the huge investments for TD-SCDMA to co-shape the TD-LTE standard is really no longer an option. If the transition to TD-LTE would fail, some of our interview partners emphasize that

- "Chinese people may lose their faith in future domestic technological innovation";
- the belief of Chinese customers that "foreign technology is always superior to Chinese technology" would be reinforced;
- the Chinese government would hesitate to support further domestic innovation and standards;
- and investors (both domestic and foreign) would be less willing to provide risk capital for domestic innovations.

138. TD-LTE builds on China's TD-SCDMA standard, and has the full backing of the 3GPP as part of its overall Long Term Evolution (LTE) standards project for next-generation mobile network technology. The main advantages of LTE are high throughput, low latency, flexibility through combining FDD and TDD in the same platform, an improved end-user experience, and a simple architecture resulting in low operating costs.

139. In November 2009, Huawei announced the deployment of the world's first TD-LTE trial network with an actual download speed of up to 29Mb/s for China Mobile. Huawei's trial network was inaugurated on April 15, 2010 by China Mobile (Digtimes, April 16, 2010). Motorola, however, was faster. The company announced on February 24, 2010, that it had successfully deployed a TD-LTE network for the Shanghai 2010 World Expo. Motorola's announcement states that "… these advancements demonstrate another milestone of collaborative industry efforts on TD-LTE commercialization, reaffirming Motorola's commitment to address the future needs of TDD spectrum operators in China and around the world." See http://www.prnewswire.com/news-releases/motorola-deploys-worlds-first-td-lte-showcase-network-at-shanghai-expo-85269367.html, accessed July 30, 2010.

140. LTE is derived from the 3G technologies W-CDMA and TD-SCDMA. UBM is based on Qualcomm's 3.5G technologies EV-DO, which in turn are developed from the 3G standard CDMA-2000. WiMAX is promoted by a global alliance whose core members include Cisco, Intel, Motorola, Nokia, and Samsung, as well as Huawei and ZTE from China.

In fact, a failure of TD-SCDMA might well have broader and potentially serious negative implications for China's foreign policy and economic diplomacy, especially in developing countries (African countries, Iran, and others),[141] which serve as test beds for Chinese technology. Given their resource constraints, these countries are willing to use cheaper, unproven Chinese technology, but they still view Chinese technology as inferior to Western technology (even though that may not be the case). Were TD-SCDMA to fail, it would be a big strike against China's image as an emerging global technology supplier. This might well impair China's efforts to capture overseas markets for green technology, bio-technology, railway infrastructure, and defense equipment.

What matters for the evolution of China's standardization strategy is that a successful transition to TD-LTE technology requires substantially improved inter-agency cooperation. This is necessary to cope with the complex requirements of harmonizing standards and patent sharing for a diverse portfolio of information and communication technologies. It will be interesting to watch how effective the Chinese government is in bringing about this change over the next few years.

Organization: Stakeholders and Industry Support

Initially, China's TD-SCDMA standard could only count on a narrow industry support base, consisting primarily of a handful of Chinese SOEs and public research institutes. There are now signs of a significant broadening of that base, and leading foreign companies are beginning to be seriously involved. Possible explanations are the pull effect of China's massive investments in telecom infrastructure and the significant profit opportunities inherent in the transition to TD-LTE.

To understand what is happening, let us look at the evolving organization of the TD standards project. Two organizations have been created around the TD standard, the TD-SCDMA Industry Alliance (TDIA) and the TD Forum. Unfortunately, only limited information is available in the public domain on the precise tasks of both organizations and their division of labor.[142] There is also no information available on either organization's English or Chinese website on the types of membership arrangements, the rights and obligations of members, or bylaws and policies on IPR.

Given these data constraints, the following observations need to be taken with a grain of salt. It seems that TDIA is the more important institution. TDIA has close links to the powerful Hi-Tech Industry Department of NDRC, and has the mandate to define strategy and execute policies to develop and

141. I am grateful to Nathaniel Ahrens for raising this issue.

142. An October 2009 interview with TDIA Secretary General Yang Hua and Assistant Secretary General Zhao Sen brought insights into the origins and evolution of the TD-SCDMA project. However, specific questions on the organization and procedures of the TDIA were not addressed.

implement the TD-SCDMA standard and products. TDIA requires its members to share IPR, and therefore, most of its members are Chinese companies.

The TD Forum, on the other hand, seeks to commercialize and internationalize the TD standard. It also seeks to broaden the involvement of international firms.[143]

The TD-SCDMA Industry Alliance (TDIA)

TDIA's mission is to "promote industry and market growth for the TD-SCDMA technology."[144] Specifically, TDIA is responsible for the following eight tasks:

1. foster the development of an integrated industry chain, by promoting related investments;
2. continuous improvement of TD-SCDMA and TD-LTE technology standards;
3. lobby the government "to implement favorable industry policies";
4. organize experiments and tests;
5. global marketing;
6. conduct R&D to disseminate technologies and standards;
7. develop a plan for the sharing of intellectual property rights;145
8. and develop a platform for cooperation among TDIA members.

This mission is reflected in the organizational structure of TDIA, which consists of the General Assembly, the Council, and the Secretariat, under which there are four Working Teams: the TD-SCDMA IPR Management Team, the Industry Projects Management Team, the Administration Team, and the Propaganda Team.[146]

Yang Hua, TDIA's secretary general, is a former Datang senior engineer with strong links to the Chinese Air Force. He was head of R&D on TD-SCDMA at CATT from 1999 to 2002. Before joining CATT, Yang was engaged in missile technology R&D at the headquarters of the Air Force. He also was a member of the Experimentation Engineering Committee on Unmanned Aircraft of the China Space Navigation Association. Yang received his bachelors degree from

143. The TD Forum website shows that 47 out of the 324 members are foreign companies, around 15 percent. Two membership categories exist. Board members "have the right to manage the Forum … and the strategy…. Senior members don't have these privileges." Of the 13 board members, 7 are foreign companies (53 percent), and Nokia-Siemens Networks' Manager of Standardization Work in China is the TD Forum vice president. Of the 40 senior members, 22 are foreign companies (55 percent).

144. Yang Hua, "Industrial Chain of TDD & Development of TD-LTE Industry," slide 7. I am grateful to Zhao Sen for sharing this powerpoint presentation in an email dated July 30, 2010.

145. Presumably this refers to the use of a patent pool. Unfortunately, there is no information available on this important issue.

146. http://www.tdscdma-alliance.org/english/asp/tdia2.html, accessed August 1, 2010.

the Air Force Engineering University in Xi'an in 1982.

According to the TDIA website, "TDIA members are committed to conduct and promote research, development, production, manufacture and service of the TD-SCDMA standard and products."[147] Out of a total of 37 TDIA members, two are FIEs (Alcatel Shanghai Bell; and UTStarcom), and two are Chinese research institutes (CATT and Wuhan Research Institute of Post and Telecommunications). Of the 33 Chinese member companies, one company, Commit, has gone out of business, so this list may be dated. What matters is that no foreign company is part of the seven core members.

It is safe to assume that decision power is largely shaped by NDRC and MIIT, together with China Mobile and a small group of SOEs (such as Datang and Potevio). This indicates that TDIA is still a relatively closed organization, with limited influence from outsiders, and especially from foreign companies.

However, the real question is to what degree the transition to the much more demanding TD-LTE standard will lead to a gradual opening up of the TDIA governance structure. Foreign companies now play an important role in R&D for TD-LTE technologies and standards in four out of the five major building blocks. The question is whether this will be reflected in changes in the TDIA organization.

For instance, four foreign companies (Ericsson, Nokia-Siemens, Alcatel-Lucent, and Motorola[148]) participate in TD-LTE system design, together with Datang, Potevio, Huawei, and ZTE.[149] For chip sets (which integrate much of the system's key functions), the foreign lead players are Qualcomm, NEC, Taiwan's MediaTek,[150] and Freescale, competing against five Chinese companies (Leadcore, T3G, Spreadtrum, Innofidei, and Huawei's chip design affiliate Hisilicon). For testing, Agilent and Rhode & Schwartz will play a leading role,[151] and for handsets and other terminal equipment, Nokia, LG and Motorola are in leading positions relative to Lenovo and Hisense. Note, however, that three Chinese companies (Haitian, Mobi, and Tongyu) are the only participants in smart antenna development, which is a critical building block for TD-LTE.[152]

147. Unfortunately, the website does not provide information on the rights and obligations of TDIA members, membership fees, or TDIA's policy on IPR.

148. Note, however, that in July 2010, Nokia-Siemens bought Motorola's mobile network infrastructure unit, beating Huawei, which had also placed a bid ("U.S. Government Divided on how to Tackle Huawei," *Financial Times*, July 30, 2010, 13).

149. Following a request by SASAC, Datang and Potevio are scheduled to merge in early 2011 to become China's third-largest telecom equipment vendor ("Datang, Potevio to Merge," telecomasia.net, July 16, 2010). Both are struggling for growth and profitability as the big investment push from China's stimulus package comes to a close.

150. Thanks to its booming China business, Taiwan's MediaTek is now seen by analysts as a global tier-1 semiconductor company, ranked ahead of traditional industry leaders like Texas Instruments and Infineon. See EETimes Asia, July 21, 2010.

151. According to its website, Rohde & Schwarz offers integrated test solutions for TD-SCDMA and TD-LTE from R&D up to production. See http://www2.rohde-schwarz.com/en/technologies/cellular_standards/td-scdma/information/, accessed August 1, 2010.

152. See further details in the next section.

Greater openness to foreign participation

There are signs that the TD-SCDMA standards project is opening up to foreign participation. One possible reason is that foreign companies are needed to overcome key bottlenecks that China is facing in the transition to 4G TD-LTE technologies. And foreign firms, partly in response to the global economic crisis, also have much stronger incentives to engage with China's TD-SCDMA and TD-LTE projects.[153] Judging from market presence, it seems that Samsung and LG have been the keenest among foreign firms to be a part of the TD project. Nokia, which has long resisted participation, has now become an active contributor.[154]

But equally important are links with Taiwanese firms. For instance, since January 2009, the China Telecommunication Technology Lab (CTTL) and MediaTek are cooperating on handset testing and standardization for the TD-SCDMA standard.[155] CTTL's expectation is that MediaTek will be more effective in attracting global handset leaders like Nokia than Spreadtrum and other Chinese chip designers who had previously been given lead responsibility. Mediatek is now the only viable TD chip maker who can play this role, as Commit has collapsed, Spreadtrum has accumulated heavy losses, and T3G has been taken over by the former IC division of Philips, following its sale by Datang. For MediaTek, a big attraction of participating in China's TD standard projects is that this enables the company to shake off its bad reputation as a provider of chips for illegal Shanzhai handsets.

China's TD projects are now a major attraction for Taiwan to increase its economic cooperation with China. In February 2009, for instance, CCSA and CESI announced at the 5th Cross-Taiwan Straits Information Industry Technology and Standard Forum that Taiwan's laptop and netbook producers, such as Asus and Acer, have started or plan to start producing netbooks and laptops containing TD-SCDMA WLAN cards.[156] In addition, HTC, one of Taiwan's most innovative ICT companies, signed a cooperation agreement with China

153. For example, Dell is integrating TD-SCDMA data cards in its computers sold in China, while Microsoft cooperates with Datang on the joint development of data card drivers; applications based on the Windows 7 operating system; TD-SCDMA solutions and applications based on the Windows Mobile operating system; and value-added services (*Interfax TMT China Weekly*, July 26, 2008, 4).

154. For lack of other market opportunities, Nokia seems to have decided to look more seriously at China's TD market. Much is at stake—in 2008, China (plus Taiwan and Hong Kong) accounted for more than 16 percent of Nokia's unit sales and 14 percent of its total revenue. In October 2008, Nokia-Siemens Networks (NS) expanded its TD-SCDMA service team to 1,200 as part of its cooperation with China Mobile in the construction of Shenzhen TD network. One month later, Nokia signed a deal with China Mobile to develop dual-mode TD/GSM handsets based on its Symbian S60 operating system. And in February 2009, Nokia announced that its China Nokia affiliate would not be affected by the drastic cost-cutting program that hit all other parts of Nokia.

155. *Interfax TMT China Weekly*, January 10, 2009, 6, 7.

156. Ibid., February 21, 2009, 5.

Mobile in August 2009 to design and produce TD smart phones based on China Mobile's handset operating system OMS (Open Mobile System).[157] China Mobile is reported have paid HTC $ 6.88 million for R&D on TD handsets and 4G handsets. In turn, China Mobile expects that HTC will be able to deliver high-quality smart phones at a lower price than global industry leaders.

This Cross-Taiwan Strait cooperation on TD and other ICT industry standards is bound to receive a significant boost by the Economic Cooperation Framework Agreement (ECFA) signed by China and Taiwan on June 29, 2010.[158] Leading Taiwanese ICT companies, from silicon foundries TSMC and UMC, to chip design companies and equipment producers, will now face fewer restrictions on joint engineering and R&D projects in China. In this context, the substantial market and investment opportunities of China's transition to TD-LTE technology will exercise a powerful pull effect.

In short, there is now sufficient evidence to argue that the support for China's TD-SCDMA and TD-LTE standards projects is serious and broad enough to sustain and expand those standards, at least within the China market.

The big unanswered question, of course, is whether and when both standards will be able to compete in foreign markets. MIIT announced in May 2009 that it wants the TD standard to gain a 20 percent share of the international 3G market by 2020, with a focus on penetrating emerging markets in Asia, Africa, and Latin America.[159] But by then, next generation mobile communication technology will offer significantly better performance and much lower operating costs than 3G technology.

The TDIA website mentions TD trial networks in Korea and Taiwan, established in cooperation with Korea Telecom and Taiwan's Industrial Technology Research Institute (ITRI). But according to one interview source, who requests anonymity, the sole purpose of these trial networks is to test equipment and terminals made by Korean and Taiwanese manufacturers who want to sell their products to operators and equipment manufacturers in China.

Impact on China's Innovation Capacity

Serious data problems make it difficult to assess how China's innovation capacity has been affected by the TD standards project.[160] Useful proxy indicators are changes in R&D activities by Chinese firms that are participating in the TD projects.

157. Ibid., August 22, 2009, 11.

158. The purpose of this agreement is to "strengthen economic trade and investment cooperation between China and Taiwan by … progressively reducing and eliminating restrictive measures to trade in services … [and by] … improving the simplification of investments and industrial interaction and cooperation" (Baker & McKenzie, "Client Alert: ECFA Signed Between China and Taiwan," July 2010).

159. *Interfax TMT China Weekly,* May 23, 2009, 9.

160. A detailed analysis of China's evolving innovation capabilities will be conducted in a joint EWC-IGCC project as part of SITC program.

R&D trends

The analysis focuses on handset makers (which are essential for overcoming the TD standard's handset bottleneck); chip design companies (which provide chipsets with key functions for the TD handsets): and Datang, an equipment producer which, as a spin-off from CATT, was at the center of creating the TD standards.

Chinese mobile phone vendors over the last few years have lost their erstwhile strong market position to global market leaders like Nokia, Samsung, Motorola, and LG. The Chinese companies lost because they lack their own intellectual property for key technologies, making them dependent on foreign technology for items like base band and radio frequency chips, multi-layer printed circuit boards, and camera modules. As the Chinese companies have to pay high licensing fees, their profit margins remain wafer-thin, with little room for R&D investment.

Many of China's mobile handset vendors see the TD standards as a lifeline for their survival. They hire engineers when China Mobile announces subsidies for handset R&D or a new round of handset tenders. But these firms also fire these engineers at short notice when they are not among the winners of those tenders or when those tenders are reduced in volume. Hence, it is almost impossible for these Chinese handset firms to develop a critical mass of R&D personnel to internalize learning effects from TD-related projects.

In addition, legal Chinese handset producers are under attack from a growing number of illegal producers of Shanzhai handsets which, as mentioned earlier, in 2009 had at least a 40 percent share of the Chinese handset market. As too many Chinese vendors have entered China's handset market, this has generated intense price wars and increased even further the barriers to R&D investment.

The combination of persistently weak innovation capabilities of the legal Chinese handset producers plus the availability of cheap handsets explains why China Mobile is still struggling to increase significantly the number of its TD-SCDMA handset subscribers. To note the difference, in April 2010, the increment of second-generation GSM service subscribers of China Mobile was more than six times larger than its increment of TD-SCDMA subscribers (Marukawa 2010: 9).

A more positive picture is emerging for Chinese chip design companies, thanks largely to the support of dedicated quasi-government agencies. While one company (Commit) went out of business, it seems that a major reorganization initiated by the government has been successful. There is now an explicit division of labor between three Chinese chip design companies: Spreadtrum focuses on TD chips for smartphones; Leadcore on TD chips for netbooks; and CYIT on next-generation TD chips.[161] Spreadtrum, which was originally funded by U.S. venture capital firms, is now closely linked to and supported

161. *Interfax TMT China Weekly*, April 4, 2009, 9.

by the China Communications Technology Labs (CTTL) to expand its TD-related R&D.[162]

Finally, Datang, a founding member of the TDIA, is constantly struggling with financial problems that constrain its capacity to fund R&D. In 2009, Datang had a total TD-related R&D budget of RMB 1.2 billion (US $176 million), of which TD data cards received RMB 96.01 million (US $14.04 million), TD data fusion technology RMB 191.72 million (US $28 million), and bank cards RMB 172.02 million (US $25.16 million).[163] Datang seeks to fund its R&D through private share placement. The company's major challenge is a heavy debt burden, primarily through bank loans. This matters, as Datang is China Mobile's third most-important TD equipment supplier, after ZTE and Huawei, and ahead of Nokia-Siemens and Potevio. To consolidate Datang's finances, SASAC requested on July 26, 2010, that Datang and Potevio merge in early 2011.

Overall, these examples paint a mixed picture, where substantial support from the government and quasi-government institutions is needed to back up and sustain TD-related R&D activities. But as this support is focused on incentives and the provision of public goods, its contribution to China's innovation capacity may be more sustainable than earlier forms of top-down market regulation.

Patent data

Another proxy indicator are patent applications at SIPO related to TD-SCDMA and TD-LTE.

The analysis of patent data faces serious methodological problems that are widely discussed in the literature. This is especially the case for essential patents. To start with, there are no shared definitions of what constitutes "essential patents."[164] An even greater problem is a lack of reliable information in the public domain on the distribution of essential patents for the TD-SCDMA standard.

Data from a study by Wang Xiaoxing and Cheng Lili show that, by October 2006, 214 TD-SCDMA–related patents had been filed at SIPO, of which 148

162. Light Reading email newsletter, May 18, 2009, available at http://www.lightreading.com. CTTL is a quasi-government agency under MIIT and is administrated by the China Academy of Telecommunication Research (CATR).

163. These data are courtesy of an informed industry expert who has requested anonymity.

164. According to Ted Dean, president of BDA (China), a telecommunications consultancy, "different companies have their own interest in promoting their share of the standard, so it is very hard to get a consensus view on this. Even companies that believe they have key IPR in the standard have to make a political decision about whether they want to press that claim in China and risk damaging their business in other technologies or give China a pass on a standard they may believe will not ultimately be successful in the market and focus instead on making their money from W-CDMA products, for example, instead of TD royalties" (email to author, December 13, 2009).

covered TDD and 66 SCDMA.[165] Of the 148 TDD–related patents, Chinese firms owned 29.7 percent, while Siemens had 22 percent and Qualcomm 6.1 percent. For the 66 SCDMA-related patents, Chinese firms claim ownership for 51.5 percent of those patents, while Siemens, the originator of that technology, claims a 21.2 percent share. Unfortunately, this source does not distinguish between invention patents and utility patents, many of which have very low or even no technical innovation.

Of particular interest are recent SIPO patent data for digital smart antennas (the so-called beam steering smart antennas) which are an important core technology of the TD-SCDMA standard (Wang and Dai 2008). Initially filed by Beijing Xin Wei Telecom Technology in 1997, domestic filings have been surpassing foreign filings since 2003, with foreign filings declining since 2004. Of the 632 patent filings for smart antennas until the end of November 2007, 355 were domestic filings (56 percent). 301 of the domestic filings are for invention patents (85 percent), with 77 granted. This indicates a fairly successful track record of Chinese innovation in digital smart antennas. Another sign that this is one of China's strengths is that six of these 355 domestic filings have been submitted to WIPO as PCT patent filings, of which one patent has been granted until the end of November 2007.

Other SIPO data indicate that Chinese firms now concentrate on the commercialization of TD-SCDMA technology (Wang and Dai 2009: 24–25). A focus of patent filings on end user applications and service innovation is indeed of great importance for the development of the TD standards. This emphasis on end-user-related application patents also could help to strengthen China's bargaining power in price and licensing fee negotiations.

As for next-generation mobile technology, by February 2009 a total of 170 Long Term Evolution (LTE) patents had been filed with SIPO, mainly for architectural and application patents. Chinese companies are reported to have filed more LTE patents than foreign companies. A major challenge for China is that the cost of LTE technology will be heavily influenced by the price of IPR licensing for the critical OFDM technology.[166] In fact, a number of international consortia, like Sisvel, Via Licensing, and MPEG LA, are working to

165. Wang Xiaoxing and Lili Cheng, "TD-SCDMA *zhuanli yiyun* [Doubts about the TD-SCDMA patents]," *Nanfang xinwen wang*, October 24, 2006, quoted in Marukawa (2010: 7).

166. OFDM stands for Orthogonal Frequency Division Multiplexing, a modulation technique for transmitting large amounts of digital data over a radio wave, and is a fundamental building block for next-generation communication technologies. OFDM is conceptually simple, but its implementation relies on complex, very-high-speed digital signal processing, and this has only in the last few years become available at a price that makes OFDM a competitive technology in the marketplace. OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, wireless networking, and broadband Internet access.

create patent pools designed to bring more predictable costs to the LTE world. Hence, progress in China's TD-LTE standards project would seem to depend on whether and how China is able to participate in and co-shape the policies of these OFDM-related patent pools.

Of particular interest is that Chinese companies (Huawei, ZTE, the chip design company Innofidei, and Datang) and leading Chinese universities (Tsinghua University, Beijing University of Post and Telecommunication, Shanghai Jiao Tong University, Xi Dian University, and Xi'an Jiao Tong University) have all filed patent applications for OFDM, which is an important base technology for next-generation LTE technologies.

In short, the above findings on patent data related to TD-SCDMA and TD-LTE technologies provide room for cautious optimism. These data show clearly that filing activity by Chinese organizations for TD-related patents has substantially increased. This in itself is a positive development. Much more important is a qualitative aspect. The above patent data clearly indicate much more focused efforts to improve the quality of the domestically generated patent portfolios, and to be more selective and realistic in the choice of priorities.

Future Prospects

This study suggests two alternative scenarios concerning the future prospects of China's TD-SCDMA and TD-LTE standards projects.

In a negative scenario, the government retains control over the telecom sector and continues to impose from the top restructuring by fiat. Techno-nationalism plus security interests dominate strategic and tactical decisions, preventing a flexible and pragmatic response to changes in technology and markets.

In this negative scenario, inter-agency rivalries will continue and prevent China from reaping the benefits of technology convergence between communication, computing, consumer electrics, and information security technologies. In such a policy environment, the TDIA would remain relatively closed and it would make little progress in improving transparency. Finally, state-owned enterprises, under the guidance of MIIT, would continue to play key role in the development of China's TD standards. Specifically, the government might place its bets on the forthcoming merger of Potevio and Datang.

The evidence presented on recent changes in the TD project makes it quite unlikely that such a negative scenario will materialize. However, given the messy and unpredictable nature of standardization processes and the lack of transparency in Chinese policy-making, it cannot be excluded that bits and pieces of the negative scenario may continue to accompany China's TD standards project.

Our analysis, however, gives greater credence to a positive scenario where the main catalyst is a successful transition to the next-generation TD-LTE standard. In this scenario, the government will reduce over time its control of China's telecom sector, moving toward more indirect forms of coordination.

In this positive scenario, lobbying by global Chinese firms (like Huawei and ZTE) and some foreign "China friends" with a long China presence (like Microsoft and Motorola) would help to contain the influence of techno-nationalism, opening up new space for a flexible and pragmatic response to changes in technology and markets. There would be a conscious effort to reduce interagency rivalries in order to enable China to reap the benefits of technology convergence.

Another important component of the positive scenario are adjustments in the organization and governance of the TD standards process. Specifically, the TDIA would continue to open up to a greater diversity of stakeholders, including foreign companies. In addition, greater emphasis would be placed on improving the transparency of corporate governance of SOEs like Potevio and Datang. Finally, new government policies would seek to generate new applications for TD standards through linkages with other Chinese standards like CMMB.[167] And serious efforts would be made to rein in the Shanzhai sector and to support the upgrading of a handful of the more successful Shanzhai companies, beyond the current success case of Tianyu Lantong.[168]

This positive scenario would be strengthened if the TD project would learn from the experience of the following two Chinese standards projects, IGRS and AVS. Those two projects are providing best-practice benchmarks for developing more sophisticated standardization procedures and IP policies for the TD standards projects.

IGRS: A Pragmatic, Industry-led Approach with Chinese Characteristics

The Intelligent Grouping and Resource Sharing (IGRS) standards project provides an interesting example of how much China's standardization landscape has changed over the last few years. IGRS represents a pragmatic, industry-led approach to the development of interoperability standards that enable the integration of digital computing, consumer and communications devices. The IGRS Alliance actively participates in international standardization and pursues a policy of "gradually increasing the role of foreign companies."[169] However, the IGRS institutional set-up comes with Chinese characteristics, where a coalition of leading Chinese companies co-exists with strong government support.

167. China Multimedia Mobile Broadcasting (CMMB) is a mobile television and multimedia standard developed and specified in China by the State Administration of Radio, Film, and Television (SARFT). It is based on the Satellite and Terrestrial Interactive Multiservice Infrastructure (STiMi), developed by TiMiTech, a company formed by the Chinese Academy of Broadcasting Science. Announced in October 2006, it has been described as being similar to Europe's DVB-SH standard for digital video broadcast from both satellites and terrestrial repeaters to handheld devices. See Karamchedu 2009.

168. For case studies of the upgrading of Tianyu Lantong, see Chen and Wen 2010 and Marukawa 2010.

169. Interview with Michael Ding, director of international cooperation and vice director general of the secretariat of the IGRS Information Industry Alliance, March 25, 2010.

Objectives and the IGRS Business Model

Established on July 17, 2003 by Lenovo and four co-founders (TCL, Hisense, Konka, and China Great Wall Computer Shenzhen Co., Ltd.), the IGRS Alliance brings together some of China's leading electronics manufacturers of computer, consumer, and mobile communications devices. The common interest of these five founding companies is to move beyond price competition and razor-thin profit margins for stand-alone "commodities" like TV sets, PCs, white goods, and mobile handsets. The IGRS standards project offers these companies a way out of this "commodity price trap."[170]

A primary objective is to capture value from product differentiation by developing application-level software that ensures easy compatibility among the above devices as part of integrated information systems for the digital home, the digital office, or for mobile networks.

The underlying assumption is that digitization, combined with the Internet, is bound to increase convergence among the so-called 3C technologies, i.e. between computing, consumer, and communications devices. In essence, the IGRS approach is to develop a protocol for advanced message, data-based exchange, and network management that defines connections between and among computing, consumer, and communications devices. IGRS reports that by late 2007, it had released more than 20 compliant products (primarily PCs, TV sets, and mobile phones), with a combined 5 million in unit sales.[171]

The potential for 3C convergence has been debated for quite some time. Until now persistent market barriers have constrained the growth of demand.[172] Yet expectations are running high. A recent report projects that the global 3C convergence market for the digital home will be worth EUR 149 billion in 2013.[173] Hence, it is hardly surprising that IGRS is not alone in its attempt to create interoperability standards for complex integrated information and communication systems. A similar vision is pursued by the Digital Living Network Alliance (DLNA), a global standards consortium that seeks to create interoperability among disparate devices in the "digital home."

Within China, IGRS faces competition from the Home Network Standard Industrialization Alliance (Itophome) project which, like IGRS, traces its origins to government initiatives in 1999 to develop Chinese home networking standards (Kennedy 2006). But Itophome differs in two important respects from IGRS. Unlike IGRS, Itophome addresses exclusively the digital home

170. For an analysis of the "commodity price trap" in the ICT industry, see Ernst 2007b.
171. Email from Michael Ding, July 18, 2010. But, as Kennedy et al. (2008: 25) observe, the significance of such figures is debatable, as "it is unclear what features were the key selling point of the products."
172. Main barriers to the growth of the digital home market include the "lack of truly "easy-to-use and affordable devices … ; lack of home networking integrators…" and lack of unified interoperability standards (In-Stat, 2006, "The Digital Home in China. Next Step: Be Networked to Entertain," at www.instat.com).
173. IDATE, 2010, "Connected TV: Digital Home Booster," at http://www.idate.org/en/Research-store/Digital-Home_471.html.

market, focusing on low data rate connections. Second, Itophome's strategy and policy decisions are dominated by Hai'er, China's leading consumer electronics company, which apparently has made it difficult to attract other influential companies, both from China and from other countries.[174]

In June 2005, six home network standards were approved by the Ministry of Information Industry as industry standards. In 2006, Itophome apparently signed a cooperation agreement with the WAPI Association, but there is no more recent information available (Feng and Wu 2009: 3). More recently, Itophome has submitted proposals to IEC committees TC 100 and TC 59 for Home Multimedia Gateways and Requirements for Networked House Appliances in the Home Network.[175]

The Global Standard: The Digital Living Network Alliance (DLNA)

Established one month earlier than IGRS, DLNA was founded in June 2003 by leading companies from the computer, consumer electronics, and communications industries, including Sony, Philips, Hewlett-Packard, Matsushita, Microsoft, Intel, and Nokia.[176] DLNA published its first set of Interoperability Guidelines in June 2004 and the first set of DLNA Certified products began appearing in the market soon thereafter. The latest version of the DLNA Interoperability Guidelines, version 1.5, was published in March 2006, and then expanded in October 2006. These guidelines enlarge the capabilities of a DLNA-defined network to include more home and mobile devices. They also include specifications to allow secure transmission of copyright-protected commercial digital content. A critical component of the DNLA business model is its certification program: To become certified, device manufacturers need to submit their products for extensive testing.

Microsoft's support for DLNA in its Windows 7 program is expected to spark significant growth in DLNA-enabled devices—sales are projected to surpass a billion units by 2014, up from a few hundred million in 2009. However, it may take several years before large numbers of consumers use the technology, as "… [t]he number of consumers who realize it has this functionality and understand its implications continues to be very low."[177]

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174. The member list on the itophome website shows a total of 14 companies, of which two are foreign companies (Daewoo and Freescale). It is unclear whether this information is current. There is no information available on different types of membership arrangements and bylaws and policies, for example on intellectual property rights in patents. http://www.itophome.org.cn/allianceen.aspx?flag=5&total=16&page=2, accessed July 20, 2010.

175. I am grateful to Zhou Lin from Hai'er's Intellectual Property and Standards Department for sharing these documents. IEC/TC100 is IEC's technical committee for audio, video, and multimedia systems and equipment. IEC/TC 59 is the IEC Technical Committee for the performance of household and similar electrical appliances.

176. See "About Digital Living Network Alliance," http://www.dlna.org/about_us/about/, accessed July 18, 2010.

177. In-Stat, "DLNA and UPnP Kick-Start In-Home Media Networking with Windows 7

Looking at the DLNA membership list of more than 245 companies, one finds a "Who's Who" of leading players in the emerging digital home industry.[178] DLNA members include consumer electronics, computer, and mobile device manufacturers, as well as component and software developers. Major Asian and Chinese companies play an important role. For instance, Huawei, LG, and Samsung are promoter members, and contributor members include six Chinese companies (among them leading IGRS members Lenovo, Hisense, Neusoft, and ZTE), and 17 companies from East Asia (exclusive of Japan), mostly from Taiwan.

This indicates that the competitive dynamics in the 3C industry has significantly changed. While Kennedy et al. (2008: 25) argue that "there is little in the way of entrenched technology for IGRS … to overcome," this is clearly no longer the case. In fact, Michael Ding, the director for international cooperation of the IGRS Information Industry Association, emphasizes that there is "resistance and hostility from others, especially from the European Union, because major corporate interests ... didn't want too many standards."[179] For instance, Philips, with its proprietary Nexperia platform standard, is one of the incumbent industry leaders that would have much to lose from new competing standards.[180]

For IGRS, DLNA is both a competitor and a partner. Both groups compete fiercely in China's digital home market.[181] But IGRS also sees substantial opportunities for cooperation. This is because IGRS covers a broad array of markets outside the digital home, including the digital office, integration of mobile devices, and possible applications for China's smart grid program. As a result, "…[w]e are also collaborators in terms of interoperable technologies as the underlining connectivity technology used in DLNA (which is UPnP) can interoperate with IGRS provided both sides improve their specifications."[182]

Release," IN1004647RC, Scottsdale, Arizona, July 2010, 3. According to In-Stat, handsets, PCs, and digital televisions will account for 74 percent of the DLNA market.

178. http://www.dlna.org/industry/join/roster, accessed July 16, 2010.

179. Interview with Michael Ding, March 25, 2010.

180. See interview with Charles Wang, the senior director and technical support manager of Philips for greater China, at http://www.eetasia.com/ART_8800427746_499488_NT_b481877d.HTM. Accessed July 21, 2010.

181. There is no information available in the public domain on the relative shares of DLNA and IGRS, and iTop-Home in the Chinese market.

182. Email message from Michael Ding, July 16, 2010. Universal Plug and Play (UPnP) is a set of networking protocols promulgated by the UPnP Forum. The goals of UPnP are to allow devices to connect and to simplify the implementation of networks in the home (data sharing, communications, and entertainment) and in corporate environments. UPnP achieves this by defining and publishing UPnP device control protocols (DCP) built on open, Internet-based communication standards. UPnP devices are "plug-and-play" in that when connected to a network they automatically announce their network address and supported device and services types, enabling clients that recognize those types to immediately begin using the device. UPnP Forum, "UPnP Specifications Named International Standard for Device Interoperability for IP-based Network Devices," 2009-02-05. Accessed July 19, 2010.

This broader specialization of IGRS beyond the digital home seems to go back to a request of MII (the forerunner of today's MIIT).[183] IGRS thus provides an interesting example of positive effects of government policies. Today's projections of 3C convergence markets are placing greater emphasis on the huge demand potential for applications outside the digital home, such as the smart grid, smart medicine, and smart environmental protection systems.[184]

Main Stakeholders

Government

China's attempts to establish 3C convergence standards go back quite some way and were driven by Chinese industry. But, as described by Kennedy (2006: 57ff), the government has played an important role right from the beginning.

Interviews with IGRS indicate a considerable diversity of approaches used by different government agencies. The China Electronics Standardization Institute (CESI) acts as the main liaison to the Chinese government and provides a space for dialogue.[185] This is in line with CESI's main task, which is to provide guidance on how to draft standards, and to offer "public service platforms" to diverse stakeholders in standardization within the government, companies, and other institutions like research institutes and universities.

Within the government, multiple agencies have played different roles in the development of the IGRS project, and different agencies have different expectations. This is in line with our analysis in Chapter Two. For instance, NDRC has provided seed funds for the IGRS National Engineering Laboratory in Shenzhen, established in February of 2009 as a non-profit organization.[186] These public funds are matched by private funds from the IGRS lab's sponsor companies to guarantee that "companies are serious about making the Lab a success."[187] In line with NDRC objectives, the lab's main objective is to provide the essential infrastructure necessary for the dissemination of the IGRS standard and for developing it into an ISO/IEC international standard.

Other government agencies involved in projects undertaken by the IGRS lab include MIIT, MoST, the Beijing Municipal Commission of Development

183. According to Kennedy (2006: 57), when Lenovo asked the Ministry to approve IGRS in 2003, MII requested that IGRS should also address 3C convergence applications in the digital office and business environment.
184. Email from Michael Ding, July 18, 2010.
185. CESI is a research institute like the CNIS, but it is linked to MIIT. Its main function is to provide suggestions to SDOs on how to select standards, organize industry stakeholders, and develop national and industry standards that support the objectives of MIIT, the industrial policymaker, and SAC, the standardization policymaker. Interview with Wu Zhigang, director of the International Standardization Department of CESI, March 26, 2010.
186. The main functions of the IGRS lab in Shenzhen are to develop reference designs and key building blocks of the IGRS standard platform and to develop marketable products.
187. Interview with Michael Ding, March 25, 2010.

and Reform, the State Intellectual Property Office of PRC, the Beijing Municipal Science and Technology Commission, The People's Government of Beijing Municipality, the Administrative Committee of Zhongguancun Science Park, the Beijing Municipal Bureau of Industrial Development, and the Beijing Bureau of Quality and Technical Supervision.

Industry support

The key to success for any standards project is to strengthen the role of industry, especially the private sector, and to monitor and to hold firms accountable for their use of incentives and subsidies. Once the initial catching-up phase is over, equal treatment should be provided to domestic and foreign firms.

IGRS still has some way to go before it can achieve this goal. A review of the most recent publicly available IGRS membership list helps to identify the main stakeholders. It also gives us a clue of the increasing, albeit still limited, role of foreign firms.

Significantly, IGRS has successfully expanded its membership roster from 59 in 2006 to a grand total of 142 in July 2010.[188] Of these 142 members, 89 are Chinese companies (63 percent), 32 are Chinese universities, research institutes, and technology service providers (22 percent), and 21 are foreign firms (15 percent).

The IGRS constitution clearly defines the rights and obligations of four different membership categories: core members, promoting members, ordinary members, and observers. It is interesting to note that IGRS has four such membership categories, while DLNA has only two, promoters and contributors. This possibly indicates that in China the task of balancing the diverse interests of different stakeholders may be quite demanding, as there are not yet well-established rules on how to sort out possible conflicts.

Core members shape the agenda of the IGRS project. Each core member pays an annual fee of RMB 100,000, and it has one vote on each matter that requires voting within the IGRS Alliance. The 14 core members of IGRS are

- the five founding companies (Lenovo, TCL, Konka, Hisense, and Great Wall Technology)
- six other leading Chinese companies (Changhong Electronics, Skyworth, CNC Broadband, Huawei, and Midea)
- and three Chinese institutes (CESI, the Hong Kong Applied Science and Technology Research Institute (ASTRI) and the IGRS lab)

There are no foreign companies among IGRS core members.

Promoting members have the right to draft specifications and submit proposals, but they have no voting rights. Each promoting member pays an annual fee of 50,000 RMB. Among the 41 promoting members, there are seven for-

188. This and the following data are based on email from Michael Ding, July 20, 2010.

eign companies (17 percent), of which three are from East Asia. Of particular importance are Korea's LG and Europe's Philips. In addition, there are 10 Chinese research institutes (24 percent), with Chinese companies accounting for 59 percent of the promoting members.

Ordinary members pay a 20,000 RMB annual fee and can attend all IGRS Alliance committee and subcommittee meetings, but cannot draft specifications or submit proposals. Among the 48 ordinary members, there are eight foreign companies (17 percent), of which five are from East Asia (including the China R&D Center of Samsung Electronics). There are 18 Chinese institutes (38 percent), which include Peking University, Tsinghua University, the Institute of Computing Technology of the Chinese Academy of Sciences, the Beijing Post and Telecommunications University, and leading universities from other parts fo the country. This provides a powerful dissemination mechanism for IGRS reference design and platform standards.

Observers pay an annual fee of RMB 5,000, and can attend the IGRS Alliance conference and access relevant documents and published standards and related tools. Six of the 39 observers (15 percent) are foreign companies, of which two are from East Asia.

The overall picture that emerges is that IGRS has made quite some progress in terms of broadening the industrial support base beyond producers of final consumer, computing, and communications devices to include a wide range of specialized suppliers of components, subsystems, application and system software, and essential support services.

IGRS has made great strides in increasing its foreign membership, at least starting from the level of promoting members. To get there was not easy, as by 2004 there still was no foreign IGRS member. Initially, the government was quite reluctant, fearing that foreign participation would provide global industry leaders with a backdoor to raise licensing fees and/or to block domestically-developed international standards. Of critical importance was the active participation of IGRS members and staff at international standards development organizations, especially in ISO/IEC working groups. In addition, IGRS follows established international guidelines on licensing fees and disclosure, and has adopted innovative procedures, developed by CESI and as part of the AVS standards project, to minimize possible negative effects.

Conclusions: How IGRS Differs

The IGRS business model differs from the traditional Chinese standardization approach that is led by a research institute or a university in collaboration with a ministry. That traditional approach is focused on research and technology development, where success is measured by the construction of a prototype, but where industry support is typically lacking, and implementation, especially market promotion, remains weak.

The IGRS approach, however, is industry-led, where success means improvement of international competitiveness. According to Michael Ding, "this was something of a revolution."[189] In addition, IGRS has developed its business model through a conscious effort to "learn from other standards development organizations and from talking to people outside of China. Many of these foreign ideas are very good—we have participated in many standards groups, especially in ISO/IEC and learned from competition and participation."[190]

IGRS has fought hard to increase foreign participation in its technical working groups. The underlying rationale is, as Michael Ding puts it: "We can't shut out the best technology or procedural ideas from a group, and as long as they [the foreigners] don't become a blocking entity, it is better to have them inside and participating rather than outside."[191]

In short, it is time for the international standards community and for academic researchers to acknowledge that the Chinese standards system is no longer monolithic. Instead of an exclusive reliance on a top-down approach to standardization led by the government, China is now witnessing the emergence of diverse and often hybrid standardization projects that mix and match elements of industry-led and market-oriented approaches with the traditional reliance on government.

China today provides an experimentation field for new approaches to standardization that seek to combine the advantages of a bottom-up, market-led approach with a unified strategy designed and implemented in cooperation with the government. Policymakers and corporate executives in the United States, as well as in the European Union and Japan, would be well advised to study these Chinese institutional innovations and to learn from them.

AVS: A Public–Private Partnership for Developing Open Standards

China's AVS (audio and video coding standard) Working Group provides an interesting example of how China is developing institutional innovations to reduce constraints to standardization that result from widespread strategic practices of leading owners of essential patents. The AVS standard demonstrates a growing willingness of Chinese standards development organizations not only to learn from international best-practice processes, but also to involve leading foreign experts as sources of critical knowledge for institutional innovations.

A Pragmatic and Flexible "Business Model"

The AVS standard has its origins in the Institute of Computing Technology of the Chinese Academy of Sciences (ICT/CAS). Gao Wen, the chair of the AVS

189. Interview with Michael Ding, October 16, 2009.
190. Ibid.
191. Ibid.

Working Group,[192] was among the researchers from ICT/CAS and other institutes that discussed this idea at the March 2002 Xiangshan Science Conference on "Broadband Network and Security Stream Media Technology" in Beijing. This led to the establishment of the AVS Working Group in June 2002, and approval by the MII (the forerunner of today's MIIT) on December 9, 2002.

Officially approved as a "national standard" in March 2006,[193] AVS is an audio-video coding/decoding technique focused on the compression and decompression of video images and sound. AVS includes four main standards: system, video, audio, and digital rights management. In addition, AVS includes a support standard for conformance testing.

Initially, the primary motivation for developing the AVS standard was to reduce the high licensing costs for essential audio-video patents. In 2005, for instance, a Chinese producer of DVD players had to pay a licensing fee of $20 each for a device that in China is priced at $50 (40 percent of the ex-factory price). In Japan in the same year, the maximum licensing rate as a percentage of the ex-factory price of a DVD player was below 10 percent.[194]

Competing against a dominant standard

At the beginning, AVS faced a considerable challenge. It had to compete against a highly successful international standard, established by the Moving Picture Experts Group (MPEG), a working group of experts that was formed by ISO and IEC to set standards for audio and video compression and transmission.[195]

The H.264/AVC standard has every chance to repeat the success of MPEG2 in establishing a new global de facto standard to be used in digital media (Blu-Ray), telecommunications (video-conferencing), TV/SAT (DVB), and the Internet (YouTube, QuickTime Player, Media Player, and so on).[196]

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192. Gao Wen now directs the Institute of Digital Media Technology at Peking University. He is the head of the Chinese delegation to the ISO/IEC JTC1 SC/WG11(MPEG) and a member of the Chinese People's Political Consultative Conference (CPPCC). Of interest is his international exposure: In addition to a Ph.D. in computer science from Harbin Institute of Technology, Gao holds a Ph.D. in electronic engineering from Tokyo University and was a visiting scientist in the Robotics Institute of Carnegie Mellon University and at MIT's Artificial Intelligence Lab.

193. See China's definition of "national standards" (Chapter Two, this volume), which differs from the definitions used in the United States and European Union.

194. Wen Gao, presentation at ITU-T Workshop, July 22, 2005, slide 6, at http://www.itu.int/ITU-T/worksem/vica/docs/presentations/S3_P4_Gao.pdf, accessed July 9, 2010.

195. In 2006, the H.262/MPEG2-Video and H.264/AVC standards were voted as the most influential area of the standardization work of the ITU-T (and its predecessor, the International Telegraph and Telephone Consultative Committee [CCITT]), in their 50-year history. "ITU Corporate Strategy Newslog: Video Coding Work Voted Most Influential," at http://www.itu.int/osg/spu/newslog/Video+Coding+Work+Voted+Most+Influential.aspx, accessed July 10, 2010.

196. MPEG-2 covers digital TV set top boxes and DVD. MPEG-4 is the standard for multimedia for the fixed and mobile web. H.264/AVC is integrated into three mobile TV standards: T-DMB (South Korea), DVB-H (EU), and MediaFLO (Qualcomm). And for

Today, MPEG LA provides licenses to several hundred patents owned by 26 global industry leaders and research institutes, claimed to be essential to H.264/AVC implementations.[197] As a result, companies around the world can create products that will interoperate with one another, provided they are willing to pay the required licensing fees.

Under pressure from industry, the licensing fees for the MPEG4 have been substantially reduced, and MPEG LA is now charging substantially lower licensing fees for H.264/AVC than for MPEG-2 for each device. But a new kind of licensing fee on service operators has stirred up vehement debate.

An "under-dog" strategy

Given the overwhelming dominance of the MPEG standards, AVS has decided that a direct attack against the H.264/AVC standard would be unrealistic.[198] Instead, China's AVS standard seeks to exploit existing weaknesses and loopholes of the leader. This "under-dog" strategy of avoiding a direct attack on the dominant players had the advantage that the incumbents initially paid little attention to the emergence of this new competitor. This provided a window of opportunity for AVS, a latecomer with little prior expertise in standardization.

Specifically, the AVS strategy is focused on the following objectives. First, develop an audio-video coding standard with almost the same performance as H.264/AVC. AVS differs from H.264/AVC in terms of technical performance and in its IPR licensing policy. In terms of technical performance, AVS is positioned between MPEG-2 and H.264/AVC. AVS offers data compression rates two or three times higher than MPEG-2. Compared to MPEG4/H.264, AVS is less complex while producing image quality nearly identical to HDTV images. However, AVS lags behind in terms of quality of service, support, and network externalities.

A second objective of AVS is to avoid paying licensing fees to foreign patent holders, or at least to reduce those fees. That objective has been achieved, as the royalties charged for both MPEG standards have been substantially reduced (although it is impossible to establish what role precisely the establishment of AVS has played). Broad industry rejection, especially from broadcasters and other global users of MPEG standards was arguably the main reason for the reduction in licensing fees (Huang, Gao, and Reader 2009: 4). However, the existence of AVS may well have been perceived by MPEG LA as "one of the

mobile communications, H.264 has been adopted by 3GPP, and it is about to be adopted by 3GPP2.

197. MPEG LA, LLC, is a Denver-based firm that licenses patent pools covering essential patents required for use of the MPEG-2, MPEG-4 Visual (Part 2), IEEE 1394, VC-1, ATSC, and H.264/AVC standards. The firm is also working towards pooled licensing of LTE patents pertaining to 4G cellular telephony. MPEG LA is not affiliated with MPEG, the Moving Picture Experts Group.

198. AVS thus takes a very different approach from WAPI, which initially had attempted a direct attack against the dominant WiFi standard.

threats … that figured in their… revision of MPEG4 license terms. …[But] … Microsoft's preemptive announcement of a 25-cent fee for the VC-1 standard … [was] … a major factor."[199]

In short, the AVS approach seeks to combine learning from best practices in order to accelerate capability development with a focus on the provision of lower-cost, viable alternatives.

Sources of Learning and Industry Support

A third objective of the AVS business model is to develop a broad, supportive industry coalition that includes major international stakeholders in AV technologies. AVS has placed particular emphasis on learning best-practice approaches from diverse sources of knowledge by opening up its IPR Working Group to experienced international experts. A case in point is the recruitment of Cliff Reader (who previously served as co-founder and chair of the MPEG4 subcommittee and as head of U.S. delegation), as chair of the AVS IPR subgroup.[200] That AVS subgroup brings together engineers, patent attorneys, contract attorneys, and experts with experience in setting up patent pools from Asia, Europe, and North America.

About 30 of the roughly 175 AVS Working Group members are foreign companies, including Broadcom, Cisco, Freescale, IBM, Intel, LG, Matsushita, Microsoft, Motorola, Nokia, NXP Semiconductors, Philips, Samsung, and Texas Instruments as full members, and Alcatel, Ericsson, France Telecom, Hitachi, Marvell Technology, MediaTek, NEC Electronics, Sony, STM Microelectronics, Toshiba, and Vimicro as observers.

Our interviews with AVS show that its leadership is very conscious of the need to broaden its industry support across the entire value chain of AV products and services, including suppliers of key components. Apart from learning effects, this is necessary to improve the chances of penetrating new markets for next-generation technologies, such as mobile multimedia broadcasting (CMMB), terrestrial broadcasting, IPTV (Internet broadcasting), and high-definition video disk technologies.

Take IPTV, which provides multimedia services delivered over IP-based networks at the required level of quality of service, security, interactivity, and reliability (as defined by ITU-T FG IPTV).[201] With MIIT acting as vice chairman, China actively participates in ITU-T FG IPTV. Out of six working groups, two are chaired by Chinese companies that are members of the AVS Working Group: WG3 (service security and content protection), and WG5 (terminal

199. Cliff Reader, email to the author, April 11, 2010.
200. http://www.reader.com/, accessed July 22, 2010.
201. The mission of FG IPTV is to coordinate and promote the development of global IPTV standards, taking into account the existing work of the ITU study groups as well as standards developing organizations, fora, and consortia.

systems and interoperability).[202] As the result of three years of efforts in ITU-T IPTV activities, AVS was approved as one of the four video standards (H.264, AVS, VC-1, and MPEG-2) for IPTV.[203]

AVS Policies on Intellectual Property and Patent Pool Management

AVS policies on intellectual property and on patent pool management are designed to provide incentives for all members so that they "agree to put their IP contributions into a pool … [in order to] … make money by product, not by patent."[204] An additional objective is to simplify licensing by creating a "one-stop shop for an entire suite of essential patents" at a low price.[205]

Attempts to establish open standards face multiple barriers. Technology-centered competition implies that "companies always try to establish proprietary standards" (Huang and Reader 2009). Proprietary standards generate higher profit margins, and hence are an essential tool for exercising market control. Proprietary standards also enable a company to shape future market direction and technology roadmaps. When open standards exist, leading companies with broad patent portfolios will try to control them through self-declared essential patents and the imposition of licensing fees through patent pools.

Unfortunately, existing "open standards" policies by SDOs and standards consortia are unable to cope with these barriers. In fact, the IPR policies of most standards bodies can bind members and new IP, but they do not cover non-members and legacy IP.

The obligation is limited to the disclosure of "known" related IP. Most importantly, the established principles to achieve results that are demonstrably fair and transparent—the so-called RAND or FRAND principles—leave undefined how precisely to measure "reasonable" and "fair" outcomes (Tapia 2009).

To cope with the challenge of elusive open standards, AVS has developed an impressive set of institutions and policies, some of which constitute institutional innovations in their own right. In practice, three principles are guiding AVS IPR policy.

The first AVS principle is the need to protect the IPR of patent holders. This is in line with established international practice. AVS acknowledges that this is a necessary condition for establishing a broad-based supportive industry coalition.

A second principle is an ex ante commitment "when signing the membership agreement to license on declared basic terms."[206] But this commitment

202. An important question for future research is what role AVS is playing in the IPTV standardization activities of ETSI and ATIS. And what role, if any, does AVS play in related standards, such as HD-DVD (CBHD), DTV (DTTB/DTTV), and CMMB?
203. http://www.itu.int/md/T09-SG16-090127-TD-PLEN-0063/en, accessed July 22, 2010.
204. Wen Gao, presentation at ITU-T Workshop, July 22, 2005, slide 7.
205. Ibid., slide 8.
206. Cliff Reader, email to author, April 10, 2010.

applies only to the specific subgroup in which the member participates. Subgroups include standards for audio, video, systems, and digital rights management, among others. Subgroup members must declare two default licensing obligations, choosing from two options:

1. royalty-free (RF) and participation in the AVS patent pool for implementations in China; and
2. royalty-free (RF), participation in the AVS patent pool, and RAND licensing conditions for implementations outside China.

A third AVS principle is the obligation to disclose "known related patents." The disclosure is based on actual, reasonable knowledge, not exhaustive search. This builds on disclosure and commitment principles developed in the VCEG group for H.264, but AVS has refined these concepts. According to Cliff Reader,

> … [a]ttorneys for organizations involved in standards have always insisted on this wording so far. Partly this is because attorneys are always paranoid. Partly it is from genuine fear that without rigorous infringement analysis on an organization's entire patent portfolio, even the patent holder itself doesn't know whether its patents are related. Partly it's because attorneys want to keep all options open.
>
> Until the explosion of activity in the last 10 plus years to monetize patent assets, this may have been reasonable. Now however, it is inconsistent to exert these assets for monetary gain, while arguing there is no accurate or complete inventory of the assets. Imagine if a landlord was coy about rental policy, and retained the flexibility to change the terms of rental from whole building to individual rooms…[207]

It is important to emphasize that AVS IPR policy adds precision to the established ISO/ITU policy. At AVS, members must select a default licensing obligation, choosing between RF, AVS pool, or RAND. Members also must disclose possible patents in their proposal.

Of particular interest is the approach AVS has chosen to manage its patent pool. The over-riding concern is to establish a process that is widely accepted by different stakeholders (both Chinese and international ones) as "demonstrably fair and transparent." Here is how Cliff Reader, the chair of the AVS IPR subgroup, describes the process that the AVS patent pool has developed to enable an independent evaluation (IE) of essential patents:

> Since this is China's first domestic patent pool, we wanted to assist Chinese organizations that would be submitting patents for evaluation for the first time. Naturally we wanted a process that was demonstrably fair and transparent.

207. Ibid.

> We formed a small committee to define the IE selection process. All AVS Patent Pool Management Committee Members were invited to join this group, but naturally only a few members did so. Fortunately this group included experienced licensors and licensees as well as newcomers (e.g., emerging Chinese companies) and was reasonably representative of the AVS membership.
>
> We were concerned that the IE process should not be compromised, and considered several approaches, such as multiple independent evaluators who would be selected in a blind choice for a given evaluation. But we also wanted consistency, so we designed a process with one principal independent evaluator, and an appeals process with a completely independent evaluator.
>
> We set prioritized criteria for selection of the evaluator—independent qualified patent attorney, experience in claim construction and infringement analysis, technical experience, dual-language skills.
>
> We designed a selection process—performed by PPA management …[i.e. AVS patent pool management] …, initial search for qualified candidates, interview of short-list candidates, proposals including financial terms, selection. We prepared Guidelines for Submitters. We held a seminar for Submitters.
>
> We allowed Chinese organizations to submit one patent for evaluation before an open call was made, and evaluated those patents first as a learning process. (It was arduous).
>
> … [It was only after all of these preparations that] … we made an open call for essential patents.[208]

Conclusions: How AVS Differs

The example of China's AVS project demonstrates in a nutshell the challenges faced by a latecomer to standardization like China when it seeks to establish policies and support institutions for standardization that reflect its unique requirements but at the same time guarantee a reasonable degree of fairness and transparency. This example may also help to counter arguments that Chinese standardization processes "always" lack fairness and transparency. While the learning process in China may be "arduous," there is a genuine commitment on the Chinese side to develop demonstrably fair and transparent processes.

The study finds that the AVS Working Group has pursued a pragmatic approach that avoids direct confrontation with global standards leaders and instead seeks to exploit their existing weaknesses. Implementing this pragmatic approach requires a capacity for flexible adjustments in cases where policies are producing unexpected negative results. Equally important has been a capacity to learn from best practices and weaknesses of international standards bodies.

208. Cliff Reader, email to author, July 8, 2010.

The AVS Working Group can draw on a broad supportive industry coalition that includes major international firms and research institutes across the industrial value chain of audio-video products and services.[209]

Finally, this study finds that the AVS Working Group has developed an intellectual property policy that seeks to establish open standards through a process that is demonstrably fair and transparent. To achieve this goal, the AVS project has introduced a sophisticated and flexible approach to implementing the AVS patent pool.

209. For evidence on current AVS applications in China and prospects for next-generation technology, see the detailed analysis in Fomin and Su 2009.

Conclusions: Main Findings, Policy Implications, and Future Research Priorities

Main Findings

This study documents the rapid pace of change in China's standards system, in its institutions and management practices, and in three important standardization projects (TD-SCDMA, IGRS, and AVS). In a very short time, China has substantially improved its capacity to develop and implement a broad set of interoperability standards, security protocols, and product specifications as an enabling platform for the development of indigenous innovation. Recent developments in the above standards projects indicate that both the government and industry are learning from mistakes and that there are attempts to shift to a more flexible and pragmatic approach.

Developments in China's TD-SCDMA project indicate a gradual shift toward greater openness and transparency. While the implementation remains decisively top down, there are signs that the contents of policies are shifting toward coordination and the provision of support services. MIIT's decision to grant 3G licenses both to the dominant global standards and to the TD standard signals that policy is moving away from regulating the market to promotional policies. But that move comes with a strong caveat: Chinese companies are expected to benefit the most. With the transition to next-generation mobile telecom standards, there is greater openness to foreign participation. R&D and patent data add to a picture of an overall positive impact of this project on China's innovation capacity.

In addition, the analysis of China's IGRS and AVS standards projects shows that both projects are providing best-practice benchmarks for developing sophisticated standardization procedures and IP policies that are demonstrably fair and transparent. While both projects had to go through an arduous learning process, they have succeeded in developing institutional innovations that have allowed them to overcome their latecomer disadvantage.

However, the study also highlights countervailing forces in China that seek to slow down these adjustments. This reflects the diversity of stakeholders and their conflicting views on the purpose of standardization. To capture the subtleties and nuances of the complex process of Chinese policy-making, it is necessary to study in depth the motivations of different Chinese stakeholders in innovation and standardization.

For China's standardization strategy, three main stakeholders are seeking to impose somewhat conflicting objectives:

- those who support compliance with the international standardization system (e.g., exporters and leading Chinese firms with a critical mass of IPRs);
- those who use standards as a tool to reduce technological dependence and to develop indigenous innovation capabilities (e.g., parts of the domestic high-tech industry, R&D labs, universities, large sections of general public)
- those whose main objective is to protect China-based information systems against perceived threats through robust information security and certification regulations (e.g., China's National Information Assurance Policy Framework Multi-Level Protection scheme, issued by the Ministry of Public Security in June 2007; and CNCA's Information Security Testing and Certification Regulations).

Debates on China's indigenous innovation policies need to take into account the fact that such policies differ across countries, reflecting the unique characteristics of a country's economic institutions, its stage of development, and its culture and history. For China, with its planned economy legacy, this means that the state will continue to play an important role as a creator of institutions (including a robust legal framework) as tools for strengthening China's indigenous innovation.

The study finds that China's standards system is defined by two fundamental characteristics that distinguish it from standards systems in the United States, the European Union, and Japan. It is important to keep these distinguishing features in mind when assessing recent developments in China's standardization strategy.

First, compared to the extended history of standardization in Europe, the United States, and Japan, China is a relative latecomer. The speed of learning and institutional adjustments has been impressive: In a very short time, major standards projects have been initiated in the strategically important ICT industry. Yet China still has a long way to go to develop a broad-based and sophisticated standards system. This reflects the huge gap between the speed of China's resurgence as an economic power and the country's capacity to develop appropriate institutions and policies.

China's latecomer status in standardization explains the second characteristic: a strong commitment by China's leadership to use standardization as an enabling platform for indigenous innovation. That commitment not only is "virtually unparalleled among developing countries" (Kennedy et al. 2008: 21), but its scope and depth certainly also goes much further than standardization strategies in the United States, Europe, and Japan.

The study shows that China's commitment to standardization as a tool for indigenous innovation is made credible by a standardization strategy that seeks to integrate policies on standards not only with conformity assessment and certification, but also with policies on innovation, IPR protection, industrial development, and competition.

China's standardization strategy needs to be viewed in the broader context of its development strategy. China's primary concern is to develop this vast quasi-continental country as rapidly as possible, and to catch up with the productivity and income levels of the United States, European Union, and Japan. Strengthening China's domestic innovative capacity is considered to be the key to a sustainable transformation of its economy beyond the export-oriented "global factory" model.

To achieve this goal, China's government is very serious in its aspiration to move from mere standard taker to a co-shaper, and in some areas, a lead shaper of international standards. The study shows that China seeks to develop a "two-track" approach. On the one hand, China is working within the international system with the long-term goal of creating patent-worthy technology essential to global standards. By including Chinese technology into global standards, China seeks to strengthen its bargaining power and to reduce its exposure to high royalty fees. At the same time, however, China seeks to use its increasing geopolitical influence to promote new sets of rules for international standardization, and hence to transform the international standards system itself.

On a global scale, this process is still at the very beginning. An important finding is that, in the medium term, China is going to change not only the international approach towards standardization but also the rules of broader frameworks that govern international trade and investment and other key areas of international diplomacy.

A central proposition of the study is that globalization and rising complexity make it necessary for China to combine a government-centered standardization strategy with elements of market-led standardization. China needs to increase the flexibility of policy tools and institutions in order to cope with sometimes disruptive effects of unexpected changes in technology, markets, and business strategies. In a world of rising complexity, it is always preferable to have built-in redundancy and freedom to choose among alternatives rather than seeking to impose from the top the "one best way" of doing things.

This is so for three reasons. First, rising complexity drastically reduces the time available for standards development and implementation, which makes it practically impossible to get solutions right the first time. There may have to be many policy iterations, based on trial and error, and an extended dialogue with all stakeholders to find out what works and what doesn't.

Second, rising complexity makes it difficult to predict possible outcomes of any particular policy measure, especially unexpected negative side effects, of which there is an almost endless variety. We have seen that rising complexity is systemic. Hence, a small change in one policy variable that describes a particular procedure for achieving compliance with a particular regulation can have far-reaching and often quite unexpected disruptive effects on many other policy variables and outcomes.

And, third, it is next to impossible to predict the full consequence of interactions among an increasingly diverse population of standardization stake-

holders. Given the diversity of China's competing stakeholders, the results of a particular standards policy depends much more on negotiations, gaming, and compromises than on the logical clarity and technical elegance of that policy.

The Chinese standards system is no longer monolithic. Instead of an exclusive reliance on a top-down approach to standardization led by the government, China is now witnessing the emergence of diverse and often hybrid standardization projects that mix and match elements of industry-led and market-oriented approaches with the traditional reliance on government.

China today provides an experimentation field for new approaches to standardization that seek to combine the advantages of a bottom-up, market-led approach with a unified strategy designed and implemented in cooperation with the government. Policy-makers and corporate executives in the United States, as well as in the European Union and Japan, would be well advised to study these Chinese institutional innovations and to learn from them.

The study highlights two important drawbacks of China's standards and innovation policy. First, elaborate lists of products and technologies that are constructed to assess compliance with China's standardization and certification requirements may have significant negative impacts. These lists risk being quickly outdated and bypassed. Even more important for China's objective to foster indigenous innovation is that such control lists focus on existing technologies, rather than on the future innovations that they are designed to promote.

Second, in its current form, China's Information Security Standards and Certification policy could create unintended disruptive side effects for the upgrading of China's standardization system. An extensive scope of regulation and a lack of coordination between Chinese security policies and trade policies could create potentially serious trade disputes.

The study argues that implementing a more integrated approach to innovation and standards policy poses daunting political and administrative challenges. On the one hand, some degree of stability must exist in policies and institutions: Without such stability, it is difficult to mobilize resources and to provide incentives for learning and innovation. On the other hand, rising complexity through globalization imposes disruptive changes on the very same institutions and policies.

In short, China's institutions for standardization and related policies that were successful during catching-up may well become barriers once the strategic focus shifts to an "upgrading through innovation" strategy. Any attempt to preserve the status quo ante of institutions and policies in the context of globalization and increasing complexity is likely to constrict learning and innovation, the two fundamental prerequisites for sustained industrial upgrading.

This has important implications for the future role of government in China's standardization strategy. While continuity matters, it needs to be combined with continuous adaptation in institutions and policies. It is obviously difficult to achieve the right balance. Change, however, should be constrained by the need to build on accumulated capabilities. "Big Bang" change, which discards

the latter, often involves prohibitively high opportunity costs; it may also destroy social consensus, the most fundamental prerequisite for economic development.

Finally, the study highlights the need for incremental reforms of China's standards system. As emphasized by Wang et al. (2010) and other Chinese reformers, it is time to give Chinese standards associations the right to make their own standards. A related proposition is to let the market develop voluntary standards, especially in strategic areas like inter-operability. Additional reform tasks include further progress in: the harmonization of standards and conformity assessment; efforts to strengthen cooperation between China's standardization system and SIPO; the integration of standards and innovation policy with China's still relatively new and untested anti-monopoly law; and policies to strengthen the standardization capabilities of China's small-and medium-sized enterprises.

Policy Implications

The international community should accept that significant differences exist across countries and industries in the organization and governance of standardization processes.

The international community should agree that technology-centered competition does not need to be a zero-sum game. From a global welfare perspective, one could argue that such competition could well have positive effects. When this process involves countries at different stages of development like China and the United States, there should also be agreement that market forces alone are insufficient. Supportive public policies are required to transform technology-centered competition between China and the United States into a positive-sum game.

The international community should acknowledge that the challenges faced by latecomers like China are significant and that one should not always apply the same criteria in judging performance of latecomers as one would to the advanced industrial economies. In light of China's very different political system and economic institutions, it is unrealistic to argue that China should converge to a U.S.–style, market-led system of voluntary standards. China will need to find its own institutional and legal approaches to develop a standards system that can both foster indigenous innovation and cope with the challenges of globalization and rising complexity.

The international community will want to monitor how Chinese policymakers are searching through trial and error for ways to reconcile the primary objective of strengthening the innovative capacity of Chinese firms and industries with the country's leading role in international trade and its deep integration into global corporate networks of production and innovation.

The international community should also acknowledge that perceptions differ on what constitute "international standards" and on the legitimacy of the existing international standards system. It is important to spell out explicitly

these different perceptions, given that compliance with international standards is the principal policy issue influencing the international discourse on China's standards policy. Hot-button policy issues include the role of patents in standards and the potential for market distortions; the role of government procurement as a tool for innovation policy; and attempts to restrict the free flow of information and knowledge across borders.

China, in turn, would benefit from studying inherent advantages in the deeply-rooted U.S. tradition of decentralized, market-led approaches to standardization. This may lead to new ways of blending elements of a U.S.–style voluntary system through independent standards development organizations and consortia with a government-led coordination of standards, innovation, and competition policies. A hybrid of the best elements of the U.S. and Chinese standards systems could help China to foster indigenous innovation while maintaining open markets.

China's role as a responsible stakeholder in the international system and its deep integration into the global economy imply that better coordination between Chinese security and trade policies should seek to reduce trade conflicts that could arise from China's current Information Security Standards and Certification policy. An important trust-building measure would be to improve access to and collection of data that allow for a better assessment of how information security standards and certification can be implemented without disrupting China's integration into the global economy.

The international community may want to reconsider initial fears about the possible trade-distorting impacts of recent policy initiatives on indigenous innovation products and the role of patents in standardization. This study shows that responses by Chinese authorities to complaints (by both Chinese and foreign organizations) have softened some of the initially harsh requirements.

Given the importance of the United States and China for the global economy, there will never be an escape from the day-to-day grind of the trade policy process. Obviously, the USTR, the Department of Commerce, and the ITC will respond to claims by U.S. companies that China is unfairly shutting them out through market barriers, once these claims are proven to be legitimate. The same is true for China's Ministry of Commerce and other relevant Chinese government agencies. But an effective U.S. response to China's innovation and standards policy should not be restricted to trade policy alone. This study suggests broadening the policy agenda to include a variety of cooperative elements. Ken Lieberthal's concept of result-oriented "focused engagement" clearly points in the right direction (Lieberthal 2007: 64).

Once both countries accept that their standards systems are different, then there is ample scope for selective cooperation where both the United States and China can draw on a plethora of cooperative links that exist as a result of China's deep integration into global networks of production, knowledge exchange, and innovation. From the Chinese side, An Baisheng highlights the rationale for such cooperation:

> … the United States and China … both … have an incentive to explore meaningful collaboration. … [S]ome issues will be difficult to overcome. …To achieve meaningful collaboration, both parties need to re-evaluate their strategies and relevant policy perceptions and adjust them in accordance with current global trends (An 2009: 199).

On that basis, it should then be possible to prioritize some areas for international cooperation, such as for interoperability standards for the smart grid, and standards for environmental protection, alternative energy, product safety and health standards, and consumer protection. An example is the joint U.S.–China Electric Vehicle Initiative.[210]

Specifically, this study suggests exposing Chinese government officials, academics, and corporate executives to new approaches to innovation policy in the United States, especially in the standardization of highly-complex technology systems. This is an area where the United States undoubtedly has significant "soft power." We have ideas to "sell" on how to combine the efforts of private industry and the government in ways that have not been tried before.

There is a great interest in China to learn from these debates and policy initiatives in the United States. Such exchange programs should be broadened beyond government officials, and include more Chinese company executives (especially junior engineering staff and managers). These practical steps can go a long way to reduce current tensions and to lay the groundwork for longer-term U.S.–China cooperation on innovation policy.

Finally, a concrete suggestion is to create a U.S.–China Institute of Standards and Innovation with two campuses: one in China (possibly linked to CNIS) and one in the United States (possibly linked to NIST). The charter of such an institute would be to train engineers, executives, technicians, government officials, and academics from both countries. The institute would also provide technical consulting services to enable both Chinese and U.S. companies to solve problems that arise from dealing with the differing standards systems in the two countries.

Future Research Priorities

Drawing on the findings of this study, the following priority topics are suggested for future research:

1. While this study has focused on the ICT industry, future research needs to examine how China's standardization policies differ in other industries such as cars, chemicals, food processing, energy, and clean technology.
2. A major research bottleneck is comparative research on different national standards and innovation systems. For example, a comparative study of the

210. "Launch of U.S.–China Electric Vehicles Initiative," at http://www.america.gov/st/texttrans-english/2009/November/20091117133641eaifas0.9047052.html#ixzz1IJCEH1y7.

origins and evolution of the Chinese and U.S. standards systems is necessary to improve policy debates on whether the systems are likely to converge or whether there will be persistent diversity.

3. Similar comparative studies should include Japan, South Korea, Taiwan, Singapore, Malaysia, and India. Furthermore, future research should include comparisons with the substantial recent adjustments in major standards systems in the European Union (in particular Germany, the United Kingdom, France, and small countries like the Netherlands and the Nordic countries).
4. Within China, comparative research is needed on the diverse approaches to standards projects that now co-exist and that create a potentially powerful force for a greater decentralization of policy-making. Specifically, research is needed that examines the role of local governments in China's standards system. Questions to be addressed might include: How does China handle the tension between a unified national strategy and non-standardized local implementations? Does this diversity of approaches strengthen China's standards system or does it add further to its fragmentation? In addition, comparative research should explore attempts in the United States and European Union to cope with the tension of reconciling decentralization through local governments with a unified strategy defined by the center that defines the overall strategic framework.
5. Drawing on the stylized model introduced in Chapter Three, we need detailed econometric research to nail down how the cost impacts of globalization and rising complexity differ across standardization tasks, capabilities, and strategies. Similar research is needed for a comparison of cost impacts across industries and product markets.
6. Political scientists need to deepen research on the role that key Chinese government agencies and organizations play in China's standards system: Who are the people involved, what are their backgrounds and networks? Who is actually making the relevant policies?
7. Finally, a comparative study of different national approaches to information security standards and certification is needed that highlights defining characteristics and impacts of such policies in China, the United States, Japan, and different European countries. In China, a systematic review of published Chinese sources (including military journals) could shed more light on Chinese views on information security standards and certification.

List of interviews

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List of Acronyms

3GPP: Third Generation Partnership Project to develop a globally applicable third-generation (3G) mobile phone system standard

ADs: Area Directors of IETF
AMD: Advanced Micro Devices, Sunnyvale, CA
AMS-China's Academy of Military Science
ANSI: American National Standards Institute
AQSIQ: General Administration of Quality Supervision, Inspection, and Quarantine
ASTRI: Hong Kong Applied Science and Technology Research Institute
ATIS: Alliance for Telecommunications Industry Solutions, a private U.S. standard organization
AVS: China's Audio and Video Coding Standard Consortium

BIS: Bank of International Settlements

CATR: China Academy of Telecommunications Research
CATT: China Academy of Telecommunications Technology
CCC: China National Certification and Accreditation Administration's Compulsory Certification
CDMA2000: A family of third-generation mobile technology standards
CESI: China Electronics Standardization Institute
CMMB: China Multimedia Mobile Broadcasting
CNC: Computer numerical control
CNCA: China National Certification and Accreditation Administration
CNIS: China National Institute of Standardization
CPU: Central processing unit
CTTL: China Telecommunication Technology Lab

DARPA: U.S. Defense Advanced Research Projects Agency
DCP: Device Control Protocols
DLNA: The Digital Living Network Alliance, an international standards consortium
DVB-SH: Europe's Multimedia Mobile Broadcasting standard

ECFA: Economic Cooperation Framework Agreement between China and Taiwan
EDGE: Enhanced Data Rates for GSM Evolution, a European telecommunications standard
EDS: Electronic Data Systems, Plano, TX
ETSI: European Telecommunications Standards Institute
EV-Do: Evolution-Data Optimized is designed as an evolution of the CDMA2000 standard
FDI: Foreign Direct Investment
FG IPTV: an Internet broadcasting standard organization that coordinates the work of ITU study groups
FIE: Foreign-invested enterprise
FLO TV: Forward Link Only TV, a proprietary standard developed by Qualcomm
FRAND: Fair and reasonable non-discriminatory patent licensing conditions

FTC: U.S. Federal Trade Commission

GIN: Global innovation networks
GP: Government procurement
GPN: Global production network
GPU: Graphic processing unit
GSM: Global System for Mobile Communications, a standard set developed by the European Telecommunications Standards Institute (ETSI) to describe technologies for second generation digital cellular networks

HTC: A Taiwanese mobile handset company

ICES: International Cooperation for Education About Standardization
ICT: Information and communications technology
ICT/CAS: Institute of Computing Technology of the Chinese Academy of Science
IEC: International Electro-Technical Commission of the ISO
IEEE: The Institute of Electrical and Electronics Engineers, an international non-profit professional association dedicated to advancing technological innovation
IESG: Internet Engineering Steering Group
IETF: Internet Engineering Task Force
IGRS: The Intelligent Grouping and Resource Sharing, a Chinese standards consortium
IPAC: Intellectual Property Affairs Center of China's Ministry of Science and Technology
IPR: Intellectual property rights
IPTV: Internet broadcasting
ISO: International Organization for Standardization
IT: Information technology
ITC: U.S. International Trade Commission
ITRI: Taiwan's Industrial Technology Research Institute
ITU: International Telecommunication Union

LED: Light-emitting diode, a semiconductor light source
LTE: Long Term Evolution, a set of fourth-generation digital mobile standards

MII: Ministry of Information Industry, the forerunner of MIIT
MIIT: Ministry of Industry and Information Technology
MLP: Medium- and Long-Term Plan for Science and Technology Development
MLPS: China's Multi-Level Protection Scheme for information security standards and certification
MofComm: China's Ministry of Commerce
MoF: China's Ministry of Finance
MoH: China's Ministry of Health
MoR: China's Ministry of Railways
MoST: China's Ministry of Science & Technology
MPEG: Moving Picture Experts Group, a private standards consortium
MPS: China's Ministry of Public Security
MSI: A Taiwanese computer company

NAI: China's Network Access Identifier regulations for telecommunications
NAL: China's Network Access License regulations for telecommunications
NCSC: China's National Computer Security Center
NDRC: China's National Development and Reform Commission
NEC: Japanese information technology company
NIST: U.S. National Institute of Standards and Technology

ODM: Original design manufacturer
OEM: Original equipment manufacturer
OECD: Organization for Economic Cooperation and Development, Paris
OFDM: Orthogonal Frequency Division Multiplexing, a modulation technique for transmitting large amounts of digital data over a radio wave
OMA: Open Mobile Alliance, a San Diego-based international mobile telecommunications standards consortium
OMB: U.S. Office of Management and Budget
OMS: Open Mobile System
OSCCA: China's Office of Security Commercial Code Administration

PC: Personal computer
PCT: International Patent Cooperation Treaty administered by WIPO
PDA: personal digital assistant
PRC: People's Republic of China
R&D: Research and development
RAND: Reasonable and non-discriminatory patent licensing conditions
RF: Royalty free

SAC: Standards Administration of China
SARFT: China's State Administration of Radio, Film and Television
SASAC: China's State-owned Asset Supervision and Administration Commission
SBIR: U.S. Small Business Innovation Research
SDO: Standard development organization
SEMC: Shanghai Environmental Monitoring Center
SILG: China State Information Leaders Group
SIPO: China's State Intellectual Property Office
SITC: Standard industrial trade classification
SMEs: Small and Medium-sized enterprises
SOE: State-owned enterprise
SPARC: Scalable Processor Architecture, a microprocessor design developed by Sun Microsystems
STiMi: A Chinese Satellite and Terrestrial Interactive Multiservice Infrastructure standard

TCL: A Chinese consumer electronics company
TCSEC: Trusted Computer System Evaluation Criteria
TD: A short hand for China's mobile telecommunications TD-SCDMA standard
TDIA: China's TD-SCDMA Industry Alliance
TD-LTE: China's fourth-generation digital mobile telecommunications standard

TD-SCDMA: Time Division Synchronous Code Division Multiple Access, China's third-generation digital mobile telecommunications standard
TNC: Transnational corporations
TRIPS: Agreement on Trade-Related Aspects of Intellectual Property Rights, administered by the WTO
TV/SAT (DVB): Europe's mobile TV standard

UBM: Ultra mobile broadband
UHF TV: ultra-high frequency television
UMC: A Taiwanese semiconductor company
UPnP: Universal Plug and Play standard
USB: Universal Serial Bus, a set of standards to establish communication between devices and a host controller
USITO: US Information Technology Office, Beijing
USTR: U.S. Trade Representative

VCEG: Video Coding Experts Group, a standard working group, administered by the ITU

W3C: World Wide Web Consortium
WAPI: WLAN Authentication and Privacy Infrastructure, a Chinese national standard for wireless local area networks
W-CDMA: Wideband Code Division Multiple Access, Europe's third-generation digital mobile telecommunication standard
WiFi: An interoperability standard for wireless local area network products
WiMAX Forum: A consortium for the interoperability standard for Microwave Access, a telecommunications protocol that provides fixed and mobile Internet access
WIPO: World Intellectual Property Organization, Geneva
WLAN: Wireless Local Area Network
WTO-GPA: WTO's Agreement on Government Procurement
WTO: World Trade Organization

ZTE: A Chinese telecommunications equipment company

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Figure 3. Huawei's Global Innovation Network

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