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The Challenge of Rising Complexity for Innovation Policy – China's Standardization Strategy in the ICT Industry

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Introduction

Since China's opening-up to the international economy, fundamental changes have occurred in the country's innovation system. The speed of learning and institutional adjustments has been impressive. Not only has China substantially improved its capacity to develop and implement incremental innovations in a broad array of industrial manufacturing technologies. There has also been substantial progress in architectural and radical innovations in technologies related to mobile communications, clean energy and climate change, as well in materials technology, especially nano-technology[1].

At the same time, China's innovation system continues to display important weaknesses. For instance, while Chinese companies have increased their patent applications with SIPO (the Chinese Patent office), most of these applications are for so-called "utility patents' many of which have very low or even no technical innovation[2]. In essence, the utility model patents may give the Chinese companies a way to cut and paste to file patent applications, rather than investing in real R&D to harvest innovation. For some companies (like the ubiquitous vendors of illegal "Shanzhai" phone handsets) this provides a quick way to scale up quantity rather than quality. For China's innovation system, however, the unintended negative consequence is that patent quality has suffered, and abuse of patent rights (by patent trolls) has been encouraged.

The fundamental root cause of such problems is that a huge gap exists between the speed of China's resurgence as an economic power and the country's capacity to develop appropriate policies and institutions. One way to close this gap is to promote innovation to enhance productivity and international competitiveness in the dramatically altered post-crisis environment. Industrial upgrading through 'indigenous' or home-grown innovation is seen as the necessary catalyst for a sustainable recovery of China's economy that will last well beyond the short-term stimulus packages.

To achieve this objective, a well-functioning standards system is needed that facilitates knowledge diffusion, investment and trade, and that allows for a fair distribution of costs and benefits of innovation. In fact, innovation requires a diversified and robust set of interoperability standards, security protocols, product specifications, and the formats and protocols that govern data transfer and interpretation[3]. These strategic standards are as important for a country's innovative capacity as are R&D investment,

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[1] See, for instance, Ernst, D. and B. Naughton,2008, China's Emerging Industrial Economy -- Insights from the IT Industry (pp. 39-59), in: C. McNally, ed., *China's Emergent Political Economy – Capitalism in the Dragon's Lair*, London and New York: Routledge; Atkinson, R., et al, , 2009, *Rising Tigers, Sleeping Giant. Asian Nations Set to Dominate The Clean Energy Race by Out-investing the United States*, The Information Technology and Information Foundation, Washington, D.C.; BAI Chunli and WANG Chen, 2007, "Nanotechnology research in China", in: Jakobson, L., ed., *Innovation with Chinese Characteristics. High-Tech Research in China*, Palgrave MacMillan, Basingstoke.

[2] Key features of "utility patents" are low patenting costs and a fast examination and granting process, as there is no search or substantive examination. In addition, once utility patents are granted, it is very difficult to invalidate them because of the low inventiveness criteria. Most problematic arguably is that, if infringements are established by the court, the patentees of a utility patent enjoy the same level of remedy and damage recovery as the owner of an invention patent.

[3] Tassey, G, 2007, *The Technology Imperative*, Edward Elgar, Cheltenham.

intellectual property rights, human capital, venture capital and IT infrastructure. In this sense, standards are the lifeblood of innovation in the global knowledge economy.

The paper examines how one key building-block of China's innovation policy, its evolving standardization strategy, is affected by and responding to the challenge of rising complexity in technology, business organization, market structure and laws and regulations. A defining objective of China's standardization strategy is to use standardization as an enabling platform for the development of indigenous innovation.

Much of this effort has focused on the information and communications technology (ICT) industry which serves as a testing ground for developing China's standardization strategy. The generic nature of information and communications technology 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 however for our purposes is that the ICT industry is particularly exposed to the challenge of rising complexity.

Rising complexity will be analyzed on four levels:

- *technology* (modular design enables large complex systems; accelerated pace of technical change reduces product life cycles; smaller, faster, lighter, more energy-efficient devices; convergence of infrastructures culminates in ubiquitous networks);
- *business organization* (multi-layered global corporate networks extend production and innovation across boundaries of firms, countries and sectors);
- *market structure* (new players challenge existing rules, increasing diversity of stakeholders and strategies; economic power is shifting beyond the established Trilateral powers); and
- *laws and regulations* (inability of legal and regulatory systems to rapidly adapt to changes in technology, business organization and market structure; and the pendulum swings back to more active regulation).

I argue that rising complexity creates new opportunities for learning and institutional innovations. But it also increases the cost of standards development and its risks, and it drastically reduces the time available for standards development and implementation. In addition, rising complexity makes it very difficult to predict possible outcomes of any particular policy measure. And it is next to impossible to predict the full consequence of interactions among an increasingly diverse population of standardization agents.

To cope with rising complexity requires a diverse set of highly sophisticated capabilities in both industry and government. 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. This implies that the Chinese standards system needs to adjust. A defining characteristic of that system is that the government bears the primary responsibility for standardization as a tool to support China's industrial development. Rising complexity implies that new approaches need to be developed that combine a stronger focus on market-led standardization with a government-led coordination of standards, innovation and competition policies.

I argue that for China the development dimension 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. However, as rising complexity and uncertainty is reshaping the international standardization landscape, China's government-centered standardization strategy is facing limitations and needs to be combined with elements of market-led standardization.

To study the evolution of standards systems and related policies in China, I have conducted extensive interviews with corporate executives, government officials and scholars, as well as case studies of Chinese standards projects in the ICT industry. Key concepts and tentative research findings have been discussed in two international workshops in Beijing, organized as part of the EWC-NBR standards project, in conference calls with standards experts from the US, China and the EU, as well as in seminars and lectures in American, Chinese and European universities.[4] In addition, I draw on over 30 years of research on innovation policies and national innovation systems in emerging economies in Asia and Latin America, and on the role that these economies play in global corporate of production and innovation.

It is important however to emphasize the exploratory nature of this paper. Its main purpose is to use preliminary (mostly qualitative) findings to suggest the direction for further, more in-depth empirical research.

Part 1 draws on complexity theory to examine indicators of rising complexity in technology, business organization, market structure, and laws and regulations. Part 2 highlights challenges and opportunities for China's still largely top-down, government-led standards system.

Part 3 discusses recent policy initiatives to reform and upgrade the Chinese standards system. The analysis focuses on attempts to establish standardization as a platform for indigenous development, and examines the following hot- button policy issues: the registration of products that contribute to indigenous innovation; the revision of government procurement regulations; the Draft Telecommunications Law; and new regulations for patents included in standards[5].

The conclusions spell out challenges ahead, generic policy suggestions and implications for future research.

[4] See, for instance proceedings of the NBR/EWC October 14, 2009 Beijing conference "Standards and Innovation Policy in the Global Knowledge Economy – Core Issues for China and the US" : http://cdn.nbr.org/announcements/Email/NBR_200910_ChinaStand.papers.html

[5] In a related paper, I use illustrative examples of China's major standards projects in the ICT industry to examine whether there are signs of a greater flexibility and pragmatism, and whether there are examples of flexible adaptation and timely correction of unintended side effects of earlier policy decisions. Examples include institutional innovations introduced by AVS, CESI and IGRS to cope with the rising complexity requirements. The paper also takes a fresh look at achievements and opportunity costs of the TD-SCDMA project, and ask whether the WAPI alliance has learnt from earlier mistakes and whether it has shifted to a more pragmatic approach. (Ernst, D., forthcoming, "Institutional Innovations? Recent Developments in China's ICT standards projects", East-West Center)

1. Indicators of rising complexity

1.1. Complexity theory

Complexity theory defines "complex systems" by the number and characteristics of populations of agents[6]. But complexity is more than "many moving parts." I will use the definition proposed by Murray Gell-Mann, the Nobel Laureate in Physics, who argues that a system should be called complex when it is hard to predict, not because it is random but rather because the regularities it does have cannot be briefly described. For Gell-Mann "complexity is the length of a concise description of the regularities of a system… the number of possible regularities keeps increasing with time, and so does the possible complexity." [7]

What matters for our purposes is the subjective and context-specific nature of complexity. Perceptions of different actors or observers matter. Gell-Mann emphasizes that "…[t]he length of the description will vary with the language used, and also with the knowledge and understanding of the world that the correspondents ..[Gell-Mann's term for actor or observers] …share….[Hence]…, [a]ny definition of complexity is necessarily context-dependent, even subjective*."* (Gell-Mann, 1994: page 33)

"Complex systems" are now at the frontier of debates in innovation theory[8]. Innovation is highly unpredictable as it results from interactions of multiple and very diverse stakeholders through geographically dispersed innovation networks. 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, p. 11)

I use this theoretical framework to highlight indicators of rising complexity and to examine how this affects China's evolving standardization strategy.

1.2. The new world of international economics

Rising complexity and increasing uncertainty are two defining characteristics of the new world of international economics. 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 told the House Committee on Oversight and Government Reform that he had put too much faith in the self-correcting power of free markets. Basic

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[6] Axelrod, R. and Michael D. Cohen, 1999, *Harnessing Complexity. Organizational Implications of a Scientific Frontier*, The Free Press, New York etc

[7] Gell-Mann, M. 1995, *The Quark and the Jaguar: Adventures in the Simple and the Complex*, W.H. Freeman and Company, New York, pages 228 and 229.

[8] Arthur, W.B, 2009, *The Nature of Technology. What it is and how it evolves*, Free Press, New York etc; Antonelli, C., 2011, "The systemic dynamic of technological change: an introductory frame", in: Antonelli, C., ed, *Elgar Handbook on the System Dynamics of Technological Change,*Edward Elgar Publishing*;* Lester, R.K. and M. J. Piore, 2004, *Innovation – the Missing Dimension*, Harvard University Press, Cambridge/Mass etc.; and Hildrum, J., D. Ernst and J. Fagerberg, 2011, "The complex interaction between Global Production Networks, Digital Information Systems and International Knowledge Transfers", in: Antonelli, C., ed, *Elgar Handbook on the System Dynamics of Technological Change*, ,Edward Elgar Publishing.

assumptions of economic theory are being revisited, and market regulation is now again becoming an accepted policy tool to contain the risks of unfettered markets and excessive innovation.

But more fundamental forces are at work. As globalization has been extended beyond markets for goods and finance into markets for business services, technology, intellectual property rights and knowledge workers, the organizational and geographical mobility of knowledge has increased. However, the new geography of knowledge is not a flatter world where technical change and liberalization rapidly spread the benefits of globalization[9]. Instead, a handful of new – yet very diverse and intensely competing – manufacturing and R&D hubs are emerging in Asia. 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."[10] 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."[11]

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 legalese 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.

But while the importance of standards has increased, new challenges have emerged for standards and innovation policies. Peter Cowhey talks of an "inflection point" that requires a reconsideration of strategy and organization[12]. 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, market structure , and laws and regulations.

1.3. Technology

Anyone involved in the ICT industry knows how difficult it is to meet 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 more multi-functional and less power-consuming. To cope with these demanding performance requirements, engineers

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[9] Ernst, D., 2009, *A New Geography of Knowledge in the Electronics Industry? Asia's Role in Global Innovation Networks*, in Policy Studies #54, August 2009East-West Center, Honolulu, USA

[10] Ernst, D., 2002, "The Economics of Electronics Industry: Competitive Dynamics and Industrial Organization", in: Lazonick, William, ed., *The International Encyclopedia of Business and Management (IEBM), Handbook of Economics.* London: International Thomson Business Press.

[11] Alic, J., 2009, *Energy Innovation from the Bottom Up. Project Background Paper*, prepared for the joint project of the Consortium fro Science, Policy, and Outcomes (CSPO), Arizona State University, and the Clean Air Task Force (CATF), March : p.3

[12] Cowhey, P., J. Aronson and D. Abelson, 2009, *Transforming Global Information and Communication Markets: the Political Economy of Innovation*, MIT Press, Cambridge: Mass.

have pushed modular design and system integration, with the result that major building-blocks of a mobile handset are now integrated on a chip[13].

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 are rapidly shrinking to a few months. Hence time-compression is essential for competitive success – 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 less cost than its competitors[14].

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', IOT). 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[15]. This has important implications for innovation and standards policy. 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 so-called patent thickets[16].

The resulting complexity is mind-boggling, even for the current generation of the internet[17]. Consider the multiple layers of internet standards that consist of the Transmission Control Protocol (TCP) and the Internet Protocol (IP) which are grouped into four functional layers: the link layer (e.g. Ethernet or Synchronous Network); the internet layer (e.g., IPv4, IPv6, and the Internet protocol security IPsec); the transport layer (e.g. TCP); and the application layer (e.g.HTTP). In addition, the Internet we know needs multiple embedded complementary standards such as MP3 for audio files, JPEG for image files, MPEG for video, as well as various protocols for Voice over Internet Protocol (VoIP).

The implications for standards development are mind-boggling. The growing complexity of information and communication technology requires *interoperability*

[13] For a economic analysis of the impact of these new chip design methodologies, see Ernst, D., 2005, "Complexity and Internationalization of Innovation: Why is Chip Design Moving to Asia?", *International Journal of Innovation Management*, 2005, 9(1), March: pages 47-73

[14] Kogut, B. and U. Zander, 1993, "Knowledge of the firms and the evolutionary theory of the multinational corporation", *Journal of International Business Studies*, 24 (4)

[15] Oracle acquired Sun Microsystems's server and microprocessor business, HP acquired networking equipment vendor 3Com and IT services company EDS, while Cisco has moved into computer servers.

[16] 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: *Scenarios for the Future, Munich,* page 17)

[17] See, for instance, DeNardis, L., 2009, *Protocol Politics*, MIT Press, Cambridge, Mass.

standards that specify properties that a product or process must have in order to work with complementary products and processes.

Take the unprecedented standardization challenge faced by the Smart Grid Interoperability project in the US[18]. 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 US, 3,100 utilities are involved in the electric power system grid, and more than 15 standard development organizations. And to top it all, the project needs to establish effective cooperation within a very short time frame between two industries (utility industry and the providers of information hardware and software for integrating the grid) whose business models and strategies could hardly be more different[19]. 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."[20]

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[21]:

> " *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] s*tandards 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 increasing

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[18] Ernst, D., 2010, *The American Standards System – a 'Best Practice' Model for Other Countries*?, manuscript, East-West Center, pages 48 -55.

[19] 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.

[20] Bob Gohn, senior analyst at Pike Research, quoted In Harbert,T., 2010,"The not-so-smart-grid" *EDN,* May 25, http://www.edn.com/article/print/509094-The_not_so_smart_grid.php pages 1 and 2, accessed June 1st, 2010.

[21] NIST, 2010, *Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0* , Office of the National Coordinator for Smart Grid Interoperability, NIST Special Publication 1108, National Institute of Standards and Technology, US Department of Commerce, Washington, D.C., January, pages 19 and 20

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, Duysters and Verspagen, 2002) [22].

For the current 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[23]. 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 etc. 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 (confidential interview with smart phone company).

1.4. Business organization

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[24]. 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 organization. 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"[25]

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[26].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

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[22] An 'essential' patent is 'necessary to produce any product that meets the relevant interfaces defined in the standard. It can cover either general system architecture or specific details." (Bekkers, 2001: p.226). A fundamental criterion of essentiality is that it is not possible to comply with a given standard without infringing that particular IPR.

[23] Davey, Paul, 2006, "Patents and Standards", paper presented at WIPO seminar, downloaded March 21, 2008 from http://www.wipo.int/export/sites/www/meetings/en/2006/patent_colloquia/11/pdf/davey_presentation.pdf

[24] Grove, A.S., 1996, *Only the Paranoid Survive. How to Exploit the Crisis Points that Challenge Every Company and Career*, Harper Collins Business, New York and London

[25] Penrose, 1959/1995, Foreword, 3d edition, *The Theory of the Growth of the Firm*, Oxford University Press, Oxford, pages XVI and XVII.

[26] Ernst, D., 2003, Digital Information Systems and Global Flagship Networks: How Mobile is Knowledge in the Global Network Economy?", in: J.F. Christensen (ed.), *The Industrial Dynamics of the New Digital Economy*, dedicated to the memory of Keith Pavitt, Edward Elgar, Cheltenham

$80 billion are shifted around the world in the process of creating some 1 billion types of finished products."[27]

While the proliferation of global production networks goes back to the late 1970s, a more recent development is the rapid expansion of global innovation networks (GINs), driven by the relentless slicing and dicing of engineering, product development and research[28]. 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, 2009). The flagship companies that control key resources and core technologies, and hence shape these networks, are still overwhelmingly from the US, the EU 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 table 1).

Table 1 – Global Innovation Networks: Huawei

Kista/Stockholm, Sweden
- base station architecture and system design; analog-mixed signal design (RF); algorithms; 3GPP (standards)

Moscow, Russia
- algorithms; analog-mixed signal design (RF)

Bangalore, India
- embedded SW and platforms

Plano/Texas (Dallas telecom corridor)
- total solutions for CDMA; 3G UMTS; 4G LTE; CDMA Mobile Intelligent Networks; mobile data service; optical; VoIP

Joint R&D labs with
- Vodafone, British Telecom, Telecom Italia, France Telecom, Telefonica, Deutsche Telekom

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The complexity of global corporate networks of production and innovation however gives rise to increasing uncertainty and risk: "The inherent fragility of a far-

[27] Marsh, P., 2010, "Marvel of the World brings both benefit and risk", FT, June 11. page 7. For a detailed case study of the multi-layered global production networks in Asia's ICT industry, see Ernst, D., 2004, Global Production Networks in East Asia's Electronics Industry and Upgrading Perspectives in Malaysia", in Shahid Yusuf, M. Anjum Altaf and Kaoru Nabeshima (eds.), *Global Production Networking and Technological Change in East Asia*, The World Bank and Oxford University Press

[28] Ernst, D., 2007, "Innovation Offshoring-Root Causes of Asia's Rise and Policy Implications", Chapter 3 in: Palacio, Juan J.(Ed.), , *Multinational Corporations and The Emerging Network Economy in the Pacific Rim,* Co-published with the Pacific Trade and Development Conference (PAFTAD), London: Routledge; Ernst, D., 2005, "The New Mobility of Knowledge: Digital Information Systems and Global Flagship Networks", in: Latham, R. and S. Sassen (eds.), *Digital Formations: IT and New Architectures in the Global Realm*, Princeton University Press; Henderson, J., Dicken, P., Hess, M., Coe, N. and Yeung, H. W.. (2002), "Global production networks and the analysis of economic development", *Review of International Political Economy* 9: 4436-464.

flung system with millions of interactions can lead quickly to negative repercussions for the companies whose futures are bound up with it." (Marsh, 2010) [29]

For standardization, the proliferation of global corporate networks of production and innovation poses daunting challenges. A defining characteristic of global networks of production and innovation 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[30].

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.

1.5. Market structure

At the same time, globalization is shifting economic power from west to east[31]. China's resurgence creates new opportunities and poses new challenges, and the US, like the EU and Japan, are 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 US has, not just in the economy, but in leadership, intellectual and otherwise."[32]

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 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."[33]

Until recently, the international standardization system was shaped by competition between three alternative approaches to standardization - the US, the EU and

[29] For case studies of risk in complex global networks, see Schneider, R.J., 2008, "Supply Chain Risk Management. Risk in the evolving supply chain process", *Industry Week*, Oct. 27.
[30] The resultant challenges for standardization in chip design are analyzed in Ernst, D., 2005, "Limits to Modularity - Reflections on Recent Developments in Chip Design", *Industry and Innovation*, 2005, 12(3): 303-35.
[31] As emphasized by Peter J. Katzenstein, 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" (Katzenstein, P.J., 2005, *A World of Regions*, Cornell University Press, Ithaca and London, p.13)
[32] Interview with Paul Volcker, *Financial Times*, November 12, 2009, p.7
[33] Roach, S., 2010, "The new lesson for resilient Asia", *FT*, June 9, p. 9

the Japanese approaches. Conflicts about standardization had to be resolved among these three major trilateral players.

China's entry has added a new level of complexity – the international standardization system is now moving decisively beyond a trilateral towards a multi-polar architecture. The US may have less influence to determine international standards development as *interdependence* defines its economic relations with China, as well as with India, Brazil and 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 the usual suspects like 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."[34] And Huawei emphasizes "customer-centric innovation" where the service delivery platforms requested by the telecom operators define Huawei's choice of technology and standards[35].

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[36]. The classic case is DVD players, where Chinese producers in 2004 had to pay US$ 15 to 20 in patent royalties for each player with a retail value as low as US$ 60[37]. At 25% to 33% of retail value, this share is much higher than the 15% share of retail value that makers of PCs and fax machines had to pay for licensing fees when these technologies were still new.[38]

Another prominent example are the licensing fees 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$ 4.0 for each device[39].

The resultant increasing diversity of stakeholders in standardization and of standards strategies adds yet another level of rising 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

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[34] Joseph Hsu, chairman of MSI, quoted in *FT*, June 7, 2010, page 7

[35] Huawei Corporate presentation, May 5, 2010, courtesy of Huawei.

[36] As we will see in part three, breaking-out of this "patent licensing fee trap" has been an important motivation for China's standardization strategy.

[37] Deloitte, "Technology Firms Risk Losing Advantages as China's Influence on global Standards reaches Critical Levels", August 2004, quoted in Updegrove, A., 2005, "The Ying and Yang of China's Trade Strategy", *Standards Today*, April, at http://www.consortiuminfo.org/bulletins/pdf/apr05/feature.pdf, accessed June 10, 2010

[38] Data are courtesy of *Fairfield Resources International*, a US firm, based in Darien (Conn.) that helps clients like Nokia and TI evaluate and license patents.

[39] For recent developments, see case study on China's AVS standard in Ernst, forthcoming

would need to reconcile 'efficiency' with fairness, equity and sensitivity to differences in economic development, institutions and capabilities.

1.6. Laws and regulations

In particular, innovation and standards policies need robust laws and regulations

- to improve the speed and acceptance of standards;
- to resolve tensions over the role of patents in standardization (disclosure of essential patents; licensing conditions; operation of patent pools);
- to accelerate the definition of technical specifications;
- to improve the effectiveness of testing and compliance processes;
- to govern the role of public procurement and infrastructure policies; and
- to reduce potential trade-disrupting effects when standards are used as Technical Barriers to Trade(TBTs).

This brings us to an additional challenge to standards and innovation policy, i.e. the inability of legal and regulatory systems to rapidly adapt to rising complexity[40]. Take again the Smart Grid Interoperability project that needs to cope with an extraordinarily complex regulatory environment - in addition to the federal government, there are 51 jurisdictions (50 states plus DC).

The Internet provides even more telling examples. Take attempts by national regulators to reign in the abuse of privacy data by Facebook, or Google's battles with regulators around the world about rogue data collected by Google' Street View service cars[41].

With rising complexity in technology, business organization and market structure, there are clear limits to government activity in driving standardization. As a result, informal standardization processes, through consortia, fora, patent pools and alliances, have gained in importance relative to formal standardization processes[42]. Despite considerable achievements, in terms of the speed and market acceptance of standardization, standards consortia face substantial problems especially related to their IPR policies. In the real world of standardization, courts have often been brought in to address limitations that standards consortia face in their policies on licensing conditions of essential patents. As a result, legal *ex post* remedies to balance interests of patent licensors and licensees have gained in importance.

But, as highlighted by Downes (2009) and Heller (2008), such legal *ex post* remedies are often slow, and may well delay the implementation of standards on time. In addition, these legal remedies come at a significant cost. According to one expert, patent litigation typically costs "each side three to five million dollars, although it is not rare for cases to take more than five years and cost each side twenty to thirty million dollars… …

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[40] Downes, L., 2009, *The Laws of Disruption*, Basic Books, New York; Heller, M., 2008, *The Gridlock Economy*, Basic Books, New York

[41] "Google to give regulators rogue data as it admits WiFi privacy blunder", *FT*, June 4, 2010, page 1; and Vijayan, Jaikumar , 2008-04-18). "Blockbuster sued over Facebook Beacon information sharing". *Computerworld*. April 18.

[42] Blind, K. and Gauch, S. 2005. *Trends in ICT Standards in European Standardisation Bodies and Standards Consortia*, *IEEE SIIT2005 Proceedings* pp. 29-39.

[D]amage awards in patent cases frequently reach into the hundreds of millions and sometimes billions of dollars."[43]

While leading global firms can well live with this, smaller firms and companies from emerging economies may simply lack the financial resources that are necessary to cope with such high costs of litigation[44].

2. The Challenge for China's standards system

2.1. What precisely is the challenge?

Rising complexity creates important new challenges for national innovation and standards policies. For instance, we obviously need to rethink some basic assumptions of such policies when global corporate networks integrate national production and innovation systems across sector and geographic boundaries. Specifically, how do we 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? Recent research show that patent grant analysis faces serious methodology problems with the localization of patent data, as research projects are dispersed among multiple locations and research teams are deeply integrated into formal and informal global innovation networks[45].

Another fundamental challenge is to identify what is the appropriate role for national public policies. As globalization becomes ubiquitous, what are inherent limitations of such policies? How do we define the interests of a country? Are interests of the country and of its corporations aligned, or are there fundamental conflicts?[46] 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? Or is it national security, as emphasized in China's *National Information Assurance Policy Framework* and its *Multi-Level Protection Scheme* (MLPS) that seeks to protect China-based information systems against perceived threats. [47]

In short, rising complexity reminds us that standardization, like innovation, is a complex interactive process that needs to align the often divergent interests of multiple stakeholders across different locations with rapid changes in technology, business

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[43] Kieff, F.S., 2007, "Removing Property from Intellectual Property and (Intended?) Pernicious Impacts on Innovation and Competition", *Discussion Draft*, Washington University (St. Louis), December, page 5

[44] See Tapia, C.G. and D. Ernst, forthcoming, "Intellectual Property Rights and Standards – Challenges for Chinese Exporters", East-West Center, Honolulu.

[45] See, in particular Lin, Xin-Wu, 2005. *An Analysis of Taiwan's Technological Innovation – on the Basis of USPTO Patent Data Analysis*, slide presentation, Taiwan Institute of Economic Research, Taipei, 27 July; and Wong, P.K., 2008. "The Role of Global MNCs vs. Indigenous Firms in the Rapid Growth of East Asian Innovation: Evidence from US Patent Data", in:China's Quest for Independent Innovation (Marguerite Gong Hancock, Henry S.Rowen, and Willliam F. Miller, editors), Shorenstein Asia Pacific Research Center and Brookings Institutions Press.

[46] See, for instance, the testimony of Ralph E. Gomory (a former IBM Senior Vice President of Science and Technology and President Emeritus, Alfred P. Sloan Foundation) to the *U.S.-China Economic and Security Review Commission*, March 24, 2009, who argues that the growing divide in the US labor market indicates that "the interests of many of our global corporations and the interests of the nation have diverged."

[47] Ernst, 2009, *China's National Information Assurance Policy Framework – Objectives, Players and Possible Impacts*, manuscript, East-West Center, Honolulu.

organization, market structure and regulations[48]. This implies that standardization strategy has to cover more than standards development, i.e. the development of the underlying technology, the development of negotiated specifications, and the development of supporting infrastructure for testing and conformity assessment. Equally important are policies and strategies for standards implementation.

But even more important is that standardization needs to become an integral part of innovation policy. At the same time, competition policy needs to be integrated with both standards and innovation policy.

2.2. Complexity and cost of standardization

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

2.2.1. 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.

(a) Standardization tasks

Based on interviews with leading standards experts in the US, the EU and China[49], I suggest a *taxonomy* of standardization that involves, but is not restricted to, the following tasks (table 2)[50]:

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

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Typically, tasks 1, 3 and 4 are the most costly standardization tasks, but in case of litigation, legal costs in the US can easily run into the hundreds of millions of US dollars

[48] For an excellent analysis, see Garcia, D.L., B.L. Leickly, and S. Willey, 2005, "Public and Private Interests in Standard Setting: Conflict or Convergence, in: *The Standards Edge: Future Generations*, The Bolin Group, Ann Arbor/Michigan

[49] See List of Interviews.

[50] Ernst, D., 2010 a, "The American Standards System – a 'Best Practice' Model for Other Countries?", chapter two in Ernst, D., *Standards and Innovation Policies in the Global Knowledge Economy – Core Issues for China and the US*, book manuscript, East-West Center, Honolulu: p.9.

(Kief, 2007). However in China, while costs of patent litigation are rising, they still remain significantly lower than in the US. Top judgments (or settlements) range from RMB 30 million to RMB 157 million RMB, top cases include domestic firms against foreign firms, only one top case of foreign firm against domestic (using a design patent)[51].

(b) 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 intellectual property rights (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 intellectual property rights. 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.

(c) Standardization strategies

In principle, countries and companies can choose one of the following standardization strategies described in table 3 (or a combination of them)[52]:

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

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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.

2.2.2. Analysis

Using this framework in our interviews, 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 across standardization tasks, capabilities and standardization strategies.

For *free riders*, like Shenzhen's assemblers of illegal "Shanzhai" handsets, rising complexity has opened up vast new opportunities as they can use ready-made chipsets

[51] Interview with Zhang Yan, IBM Senior Counsel IP Law, 04 08 2010.
[52] Ernst, D., 2010 b, "China's Response – Integrating Standards and Innovation Policy", manuscript, East-West Center, Honolulu: p.28.

from specialized chip design companies like Taiwan's MediaTek to churn out low-cost smart phone copy-cats of the iPhone and Google's Android.

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 for licensing fees. According to Ministry of Science & Technology (MoST) research, Chinese firms typically pay foreign patent holders 20 to 40 % of the price for each cell phone made in China; 30% for each PC; and 20 to 40% for each CNC machine tool[53]. This results in low domestic value-added. According to Arthur Kroeber, "…[t]he Chinese value share is generally estimated at 10-15% - and the majority of the value is captured by the Asian subcontractors of multinational firms, not by domestic companies."[54]

In addition, membership fees and travel cost are also likely to increase, as rising complexity implies that *fast followers* now need to participate more often in a greater number of consortia and standards development organizations. And 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.

However, the main challenge for China is that remaining a *fast follower* is an increasingly unattractive option in a world of rising complexity. 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. It is at this stage, that Chinese companies may be particularly vulnerable to the impact of rising complexity.

As co-shapers of international standards, Chinese firms need to substantially increase and upgrade their participation in both formal SDOs and informal private standards consortia. But 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 is trying to do, but 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[55]. 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,like the ITU, IETF, 3GPP, the WiMAX Forum, OMA, IEEE, ATIS, ETSI. In addition, Huawei is a Board member in OMA, IEEE, ATIS, IETF, and WiMAX Forum[56].

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

[53] MoST data quoted in *China Daily*, May 15, 2006

[54] Kroeber, A., 2007, "China's Push to Innovate in Information Technology", in: L. Jakobson, ed., *Inoovation with Chinese Characteristics. High-Tech Research in China*, Palgrave MacMillan, London: pages 37, 38. One interview source estimates that, for a laptop exported from China, the Chinese assembler typically does not earn more than 2.5 to 5.0% of the average export price.

[55] Information provided by Huawei by email, May 4, 2010. For more discussion on Huawei's participation and influence in international standards development organizations, see Ernst, 2010 b

[56] See Appendix for List of Abbreviations

Force (IETF) which develops and promotes Internet standards, cooperating closely with the W3C and the ISO/IEC standards bodies[57]. From a complete outsider position only a few years ago, Huawei now holds 21 leadership positions in IETF, occupying for instance two powerful Area Director[58] positions for transport and routing, four chairs and 6 co-chairs of IETF working groups, and acting as a member of the Internet Architecture Board that oversees the technical and engineering development of the Internet.

As Internet extension to IPv6 and beyond is one of Huawei's main strategic standards objectives, the company has invested a lot of effort to develop these leadership positions. The key to success was Huawei's recruitment of three well-respected international standards experts, Adrian Farrel (who is now IETF's area director for routing) , David Harrington (who is now IETF's Transport are director), and Spencer Dawkins (who is now a member of IETF's Board).

While selective recruitment of experienced and well-respected experts is important, Chinese companies now also need to expand substantially their portfolio of essential patents. Take again Huawei. With an accumulated total of 42,623 patent applications (most of them submitted over the last few years), Huawei is now number two on WIPO's list of PCT patent applications[59]. In addition, Huawei has developed a portfolio of essential patents that is large enough to become an established player in important technologies, such as fourth-generation LTE mobile communications, Internet extension, and convergence of fixed and mobile networks.

2.3. Defining characteristics of China's Standards System

2.3.1. Can China cope with the complexity challenge?

China's capacity to cope with rising complexity is facing substantial constraints, both from outside and from within its own standards system. It is important to first lay out these external and internal constraints in order to assess how much China's innovation policy has achieved and what next steps precisely are required to upgrade China's standards system.

External constraints are aplenty for China like 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

[57] 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 Electrotechnical Commission (IEC) is a non-profit, non-governmental international standards organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

[58] 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 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, P. , 2009, *The Tao of IETF: A Novice's Guide to the Internet Engineering Task Force*, November 30, at http://tools.ietf.org/rfcmarkup?doc=fyi17, accessed May 8, 2010, page 4).

[59] The Patent Cooperation Treaty (PCT) is an international patent law treaty, managed by the World Intellectual Property Organization (WIPO), and provides a unified procedure for filing patent applications to protect inventions in each of its contracting states.

companies and business organizations from the US, the EU and Japan[60]. 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[61]. Attempts to adjust the existing rules and procedures are costly, conflict-ridden and time-consuming and face resistance of 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 on *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."[62] As complexity and uncertainty rise and the speed of change accelerates, attempts to "pick winners" and to promote national champions may easily fail or be by-passed. In addition, 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.

It is important to emphasize however that China's standardization strategy reflects the enormity of China's economic development task. It also reflects China's latecomer status in standardization. China's overriding concern is to develop this vast quasi-continental country as rapidly as possible, and to catch up with the US, the EU and Japan.

For Western standards experts, the focus of China's standardization strategy on the "developmental state" may seem odd and out of place in an international standardization system that has seen the government retreat from its earlier dominant role[63]. But China's strategy needs to be placed in a historical context. 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 the fact remains that 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

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[60] See, for instance, Drahos, P. with J. Braithwaite, 2002, *Information Feudalism. Who Owns the Knowledge Economy?*, New Press, New York; Yu, P.K., 2009, "The Global Intellectual Property Order and its Undetermined Future", *The WIPO Journal*, No.1: pages 1 -15; Karachalios, K., 2010, "The Challenge of Patent Governance in ICT Standards, Seen from a Patent Authority's Perspective", *East-West Center Working Papers, Economics Series*, No. 110, February; and LI Xuan and AN Baisheng, 2009, "IPR Misuse: Core Issues in Standards and Patents", South Centre Research Papers No. 21, April.

[61] Ernst, D. and D. Hart, 2008, Governing the Global Knowledge Economy: Mind the Gap!, EWC Working Paper #93, January

[62] Cargill, C.F., 1989, *Information Technology Standardization. Theory, Process, And Organizations*, Digital Press, Digital Equipment Corporation, Bedford Mass., page 18. It is worthwhile emphasizing that this highly respected standards expert has always emphasized the external constraints that China is facing in its attempts to develop and upgrade its standards system. In his former position as Director of Standards, at Sun Microsystems, he has advised the Chinese government on its standardization strategy.

[63] A "developmental state" is characterized by having strong state intervention, as well as extensive regulation and planning. The concept was introduced by Chalmers Johnson who wrote in his book *MITI and the Japanese Miracle*: "In states that were late to industrialize, the state itself led the industrialization drive, that is, it took on developmental functions." (Johnson, C. 1982. *MITI and the Japanese Miracle. The Growth of Industrial Policy, 1925-1975,* Stanford, CA: Stanford University Press. page 19.)

considering very carefully 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 particular serious challenge. As a latecomer, China needs simple strategic objectives that are relatively easy to implement. 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. While such solutions would have worked well in the 1970s, the challenge today is much more complex, which requires more sophisticated approaches. To develop such more sophisticated approaches requires ample time for careful consideration and social dialogue. But China feels that it does not have that much time.

However, China's latecomer status in standardization might also have a positive side. In fact, a fundamental insight of development economics is that latecomers tend to be less burdened with legacy institutions and behavioral patterns, and hence may be able to leapfrog in the development of new institutions and policies[64]. Most importantly, latecomers have also the great advantage that they can learn from achievements and weaknesses of strategies and institutions that global leaders have used at an earlier stage.

To assess China's capacity to cope with the challenge of rising complexity, it is necessary to review the objectives of its evolving standardization strategy, as well as its strengths and weaknesses.

2.3.2 Objectives – **China's evolving standardization strategy**

China's standards system still carries the legacy of the planned economy. But since the country's opening-up to the international economy, substantial changes have occurred in China's standardization strategy, and its institutions and management practices. In a very short time, China has substantially 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."[65]

As we will see below, there have also been substantial qualitative improvements. Nevertheless, China still has a long way to go to establish a fully developed standards system that can cope with the challenge of rising complexity. A good proxy indicator is that China has still 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 that result from the fundamental transformations that have occurred since then in China's economy. Most importantly, the existing *Standardization Law* simply does not provide the legal tools and regulations that would enable China to better cope with the challenge of rising complexity.

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[64] Gerschenkron, A., 1962, *Economic backwardness in historical perspective, a book of essays*, Cambridge, Massachusetts: Belknap Press of Harvard University Press.

[65] Ziegler, K., 2010, Foreword to *Talk Standards Online Forum "Standards policy in China"*, June 24, page 1

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 that were under its jurisdiction. National and ministerial standards were compulsory standards that were enforced by the government.

That system came under pressure, once Deng Xiaoping's economic reforms gathered momentum, culminating in China's application to enter into the 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, as 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 EWC-NBR 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." [66]

In anticipation of the resulting new challenges, MOST allocated RMB 200 million to promote two major studies – MOST's 2002 Study *on the Strategy of Technical Standards Development*, 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 gave rise to a *unified* strategy with an explicit focus on the following priority objectives:

- First, 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.
- Second, standardization should help to reduce the cost of licensing essential patents for both Chinese manufacturers and consumers. Access of foreign companies to Chinese standard development organizations should face a *quid pro quo* condition – 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.

[66] WANG Ping, WANG Yiyi, John Hill, 2010, Standardization Strategy of China – Achievements and Challenges, East-West Center Working Paper – Economics Series #107, January, : p.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).

- Third, a defining characteristic of China's standardization strategy is to use standardization as a platform for indigenous innovation[67].
- Fourth, "enterprises" are encouraged to be the "main players in formulating standards" (Wang et al, page 8). This leaves open the question 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.[68]
- Fifth, standardization should focus on priority sectors and should reflect sector-specific requirements[69].
- Sixth, 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 MIIT's NAL [Network Access License], and the NAI [Network Access Identifier] regulations for telecommunications. These *conformity assessment* regulations are essential for controlling access to the Chinese market.
- Seventh, standardization should take a decentralized approach, in order to reduce the urban-rural gap and to encourage dispersed local industrial development.
- Eighth, 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.
- Ninth, 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 etal, 2010: p.5)
- Tenth, outward Chinese foreign direct investment should be facilitated through the promotion of Chinese standards practices and processes in overseas markets.
- Finally, China's role in international and regional standard development organizations and consortia should substantially increase, enabling Chinese enterprises and research institutes to move from being *standards-takers* to *standards-co-shapers* and ultimately to *standards-setters*.

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 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

[67] For a precise definition of "indigenous innovation", see section 3 of this paper.
[68] Ziegler, K., 2009, 'The European Standardization System - Prospects for EU-China Cooperation", *China-EU IT Standards Research Partnership* Beijing Policy Workshop, 8 December, http://www.china-eu-standards.org/press/ziegler.pdf, accessed June 12, 2010.
[69] Note however that the list of the so-called "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.

substantial challenges. In addition, China's standardization strategy keeps evolving in order to cope with rising complexity. Over the last few years, new objectives have been added. This includes for instance 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 now 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: p.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."

In the US, there is a widespread expectation that further reforms of China's standards ystem will "naturally" converge to (almost) full compliance with a US-style market-led standardization system. Yet, a careful analysis of 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.

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: pages 14,15), this implies that "…[v]oluntary national standards should still be managed and coordinated by the Standard Administration of China (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."

2.3.3. Strengths and Weaknesses

In fact, standardization in China today is a *hybrid* system where the government remains in charge as the main driver and as the final arbiter of China's standardization strategy. According to Wang *et al* (2010: p.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 rivalries among central and local government agencies. Industry and especially private firms and final users continue to play a very 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"[70], standard-making bodies, industry associations, research institutes and consumer organizations remain dependent on the government. Instead, it falls on local governments to act as pace-setters for a more decentralized approach, establishing local standards as a constituent building block of the Chinese standards system[71]. 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[72].

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

For modern complexity theory, 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."[73] In addition, the vision of local self-government finds ample support in the "collective action" governance theory, developed by Elinor Ostrom, the 2009 Nobel laureate in economic sciences. In her path-breaking study *Governing the Commons. The evolution of institutions for collective action*, Ostrom argues that "… all organizational arrangements are subject to stress, weakness and failure. "[74] However, external regulatory agencies are even more subject to stress, weakness and failure: "A regulatory agency … always needs to hire its own monitors. The regulatory agency then faces the principal-agent problem of how to ensure that the monitors do their own job….It is difficult for a central authority to have sufficient time-and-place information to

[70] Based on concepts developed by18th-century Scottish social philosophers (such as Adam Smith and David Hume), "civil society" is the arena of un-coerced collective action around shared interests, purposes and values. In theory, its institutional forms are distinct from those of the state, family and market, though in practice, the boundaries between state, civil society, family and market are often complex, blurred and negotiated. Civil societies 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. (What is civil society?. Centre for Civil Society, London School of Economics (2004-03-01). http://www.lse.ac.uk/collections/CCS/what_is_civil_society.htm. Retrieved on 2010-4-15.

[71] This is in line with the role regional governments played in innovation policy, as described for instance in Segal, A., 2003, *Digital Dragon. High-Technology Enterprises in China*, Ithaca and London, Cornell University Press

[72] 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） 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, http://www.34law.com/lawfg/law/1797/3122/law_258909093846.shtml

[73] Axelrod, R. and Michael D. Cohen, 1999, "Harnessing Complexity. Organizational Implications of a Scientific Frontier", The Free Press, page 22

[74] Ostrom, E., 1990, *Governing the Commons. The evolution of institutions for collective action*, Cambrige University Press, page 25

estimate accurately both the carrying capacity of a … [public good, like standards]… and the appropriate … [incentives and fines] … to induce cooperative behavior." (Ostrom, 1990: p.17)

There is however also 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. In fact, even China's definition of "standards" deviates from the definition used in the US and the EU which focuses on voluntary consensus standards[75].

For instance, China's *Mandatory National Standard Management (Trial) – Exposure Draft*, issued by the Standard Administration of China (SAC) for public comments on May 15, 2010, seeks to establish "Compulsory National Standards" firmly as "a separate 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"[76]. 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 4 highlights the fragmented nature of the Chinese Standards System.

Table 4 - 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 (CCC) 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

- Ca 25,000 standards, owned by SAC
- Covers all areas of standardization, including products, processes, 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

[75] 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 U.S., 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), http://www.whitehouse.gov/omb/rewrite/circulars/a119/a119.html, accessed June 18, 2010.

[76] Email exchange on June 21st, 2010 with industry expert who has requested anonymity.

III. Sector/Industry/Ministerial

- For market participants (especially in the ICT industry), these standards are equally important as National Standards.
- Estimates range from 40,000 to 100,000 standards. Probably only 20% 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% 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 hundreds

V. Provincial

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

Sources: Interviews, and Ziegler, K., 2009, *Chinese Standardization System Update*, presentation at China-EU Internet platform workshop, Brussels, October 16, http://www.sustainableda.org/media/docs/platform_launch/2China-EU%20Standards%20Cooperation%20-%20Chinese%20perspective%20presented%20by%20Mr%20Klaus%20Ziegler.pdf, accessed June 12, 2010

Another equally important source of fragmentation are inter-agency rivalries that reflect turf battles among different ministries and their respective stakeholders. These rivalries reflect the conflicting interests of major Chinese stakeholders in innovation and standardization. Inter-agency rivalries are arguably an important root cause for an apparent trend towards a more "heavy-handed government approach to regulation and interventionist methods to encourage ...[domestic].. industry"[77]

Earlier research has focused on the threat of "Chinese techno-nationalism"[78]. But this analysis provides at best a partial picture of the dynamics of change in China's innovation system. Furthermore, Chinese interview partners have argued that the distinction between *techno-nationalism* and *techno-globalism* needs to be used also to study diverse stakeholders in the US standardization system. In fact, this is in line with the argument of the two authors who created this distinction, Richard R. Nelson and Sylvia Ostry. In their pioneering study *Techno-Nationalism and Techno-Globalism – Conflict and Cooperation* Nelson and Ostry emphasize that *techno-nationalism* not only played an important role in the rise of American technological leadership but that it

[77] As argued in USITO's *Written Comments to the US Government Interagency Trade Policy Staff Committee regarding China's Compliance with its Accession Commitments to the World Trade Organization (WTO)*, http://www.tiaonline.org/gov_affairs/fcc_filings/documents/P-USITO_Submission_on_China_WTO_Compliance_2009.pdf.

[78] See, for instance, Kennedy, S., R. P. Suttmeier, and Jun Su, 2008, *Standards, Stakeholders, And Innovation: China's Evolving Role in the Global Knowledge Economy.* Seattle. National Bureau of Asian Research, NBR Special Report #15, September.

continues to coexist with *techno-globalism* that is promoted by US multinational corporations[79].

Thus, we need to broaden our analysis in order to understand precisely what challenges and opportunities China is facing in its standards and innovation policy. And it is necessary to fine-tune the analysis by taking on board insights from innovation economics and evolutionary theories of industrial dynamics and economic development.

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 exporting industry is a strong supporter of attempts to close gaps to international standardization and to comply with WTO commitments. This position reflects China's deep integration into global corporate networks of production and innovation. Support for greater compliance with international standards also comes from leading Chinese ICT firms which have accumulated a critical mass of intellectual property rights, like Huawei in telecom equipment. As we have seen, these firms are now playing a more active role in technical committees and on executive boards of international standard-setting organizations and standards 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 hi-tech industry with limited export exposure, as well as in the military, the CCP, and large parts of the general public. This coalition of domestic stakeholders are 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 Standard Administration of China (SAC) in November 2009 [80].

Third, China's security and military establishment plus 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, June 2007; and CNCA's Information Security Testing and Certification Regulations) are driven by three objectives that are unlikely to change in the foreseeable future: a) A modernization of security and safety infrastructure, i.e. making Chinese infrastructure more robust against any type of security threat (which is in line with established practice in other countries); b) Fostering domestic innovative capabilities, specifically for information security software; and c) Developing a domestic industry for such products[81]. A key assumption underlying these policies is that dominance of domestic products in this market will strengthen overall information security in China. A related assumption is that full (or at least very substantial) control over standards and related industry value chains is necessary to develop key innovation infrastructure and information security.

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[79] Nelson, R.R. and S.Ostry, 1995, *Techno-Nationalism and Techno-Globalism – Conflict and Cooperation*, The Brookings Institution, Washington, D.C.

[80] For details, see part three of the paper.

[81] Ziegler, K., 2009, "Update on Infosec (Information Security System)", *SESEC-2 First Quarterly Report*, 30 September, pages 5 and 6.

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

But the bottom line is that China wants to be recognized as a major player in international standardization, including the export of Chinese standardization products. Our research clearly shows that China's government is very serious in its aspiration to move from being a *standards-taker* to a *standards-co-shaper,* and ultimately to become a *standards-setter*. On a global scale, this process is still at the very beginning.

There is little doubt however 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, including TRIPS etc. 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, etc.) are exposed to strong scrutiny and where the status quo may no longer be sustainable.

This implies that research on China's standardization strategy needs to move beyond an exclusive focus on assessing China's compliance with existing rules and regulations. Much more important is the question whether China will succeed in pursuing a 'two-track' approach that consists of two building-blocks[82]. 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. The expectation is that including Chinese technology into global standards will serve effectively as a bargaining tool for China and reduce its exposure to high royalty fees. At the same time, however, China will seek to use its increasing geopolitical influence in order to promote new sets of rules for international standardization, and hence to transform the international standards system.

3. China's Response - Standardization as a platform for indigenous innovation

3.1. Significant progress towards an integrated approach

An important finding of our research is that China is moving rapidly towards a more coordinated and integrated approach to standards and innovation policy. From general statements by ministries such as 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 indigenous innovation.

Our research indicates that, while there are still many problems, China's recent policy initiatives on standardization are now better aligned with the general government focus on indigenous innovation, and the related revision of patent law and the public procurement legislation.

The long expected official announcement of China's revised *Standardization Law* is still pending. Yet, there is no doubt that China now has a *de facto* Standardization Strategy. Main objectives of that strategy include:

- promoting the development of domestic intellectual property;
- reducing dependence on foreign patented technology;

[82] For details, see Ernst, 2010b

- Chinese standards should rely as much as possible on non-patented technology;
- If Chinese standards have to rely on patented technology, this technology should be made available at prices lower than those prevailing in international markets.

China's *de facto* Standardization Strategy draws on a set of key legal documents (described in table 5) that have been developed since the State Council issued *the Medium and Long-term National Plan for Science and Technology Development* in 2006.

Table 5 China's *de facto* 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 1st, 2008
- *Action Plan on IPR Protection 2009*, issued in April 2009 by the State Intellectual Property Office (SIPO)
- *Revision of Patent Law*, effective October 1st, 2009
- *Draft Telecommunications Law*, issued by MIIT for public review and comment, October 2009
- *Draft rules on Standards and Patents,* November 2nd, 2009, issued by the Standards Administration of China (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,* 11 January 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 Standardization Administration of China
- *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

The length of the list indicates the intensity of China's effort to establish an integrated approach to standards and innovation policy. But the flurry of recent policy initiatives also shows how much remains to be done.

3.2. The catalytic effect of the Medium and Long-term Plan for Science and Technology Development (MLP) [83]

[83] This section draws on interviews, and on Schwaag Serger,S. and M. Breidne, 2007, "China's Fifteen-year Plan for Science and Technology: An Assessment". *Asia Policy*, No.4, July, pages 135-164: Cao, C., R.P. Suttmeier and D.F. Simon, 2006, "China's 15-year Science and Technology Plan", *Physics Today*, December, pages 38-43; Stevenson-Yang, A. and K. DeWoskin, 2005, "China destroys the IP paradigm", *Far Eastern Economic Review*, 168 (3): pages 9-18; GU Shulin and B.A. Lundvall, 2006, "China's Innovation System and the Move Toward Harmonious Growth and Endogenous Innovation", *DRUID Working Paper No.06-7*, Danish Research Unit for Industrial Dynamics, at http://www3.druid.dk/wp/20060007.pdf , accessed October 7, 2007; and OECD, 2008, *China. OECD Reviews of Innovation Policy*, OECD, Paris.

It is important to emphasize the catalytic effect that the Medium and Long-term Plan for Science and Technology Development (MLP) had on China's standardization strategy. It is probably not an exaggeration to state that, without the MLP there would be no unified standardization strategy.

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, environment protection, and public health. The plan also calls for 'leapfrogging' to research frontiers in key scientific disciplines, such biotechnology and nanotechnology.

The Plan's defining characteristic is a focus on "independent innovation" to redress China's weak record of innovation in commercial technologies (i.e. weak firm-level innovative capabilities). The MLP's strategic rationale can be summarized in two propositions:

- China now needs to make a concerted effort to strengthen its domestic innovative capabilities to ensure the country's long-term competitiveness in the face of the rapid and dramatic changes in the global production and innovation system.
- Strong domestic innovative capabilities are also critical to upgrade 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."[84]

Some observers claim that a focus on "independent innovation" signals a return to techno-nationalist notions of self-reliance. It seems to me however that such a negative interpretation misreads what is happening. The concept of "independent innovation" simply indicates that policy-makers are searching for ways to reduce China's dependence on foreign companies' intellectual property. Establishing a proper balance between domestic innovation and the use of imported technology is seen as a prerequisite for sustained economic growth.

The MLP uses a broad definition of "independent 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, although current debates on the 'broken' US patent system indicate that this is not as straightforward as it may

[84] Wen Jiabao, "Speech at the National Science and Technology Conference", Beijing, January 9, 2006, quoted in Cao, Suttmeier and Simon, 2006: page 78.

sound[85]. "Integrated innovation" comes very close to the concept of "technology diversification"[86]. 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[87]. 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 that are 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 the implementation of the MLP will help to achieve these objectives.

Like for any plan, the litmus test for the MLP is whether institutional innovations have been developed which 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 social elite dialogue has been used to tamper 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.

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".

In the same vein, 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 'hi-tech bias' and neglects the development of complementary 'soft' entrepreneurial and management capabilities[88].

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

[85] e.g., Jaffe, A.B. and J. Lerner, 2004, *Innovation and Its Discontents: How Our Broken Patent System is Endangering Innovation and Progress, and What to Do About It*, Princeton University Press

[86] Ernst, D., 2007, "Beyond the 'Global Factory' model: innovative capabilities for upgrading China's IT Industry", *International Journal of Technology and Globalization,* Vol.3, No.4: p.437-460.

[87] Nelson, R. R., and S. G. Winter. 1982. *An Evolutionary Theory of Economic Change.* Cambridge, MA: The Belknap Press.

[88] For a conceptual framework of innovative capabilities, see chapter three in: Ernst, D., 2009, *A New Geography of Knowledge in the Electronics Industry? Asia's Role in Global Innovation Networks*, *Policy Studies* #54, East-West Center, Honolulu, USA, August.

and individualism, while at the same time an intense 'winner-takes-all' competition obstructs trust as a base for collaboration[89].

In short, China's 15-year Plan for Science and Technology Plan may lead to considerable improvements in China's innovative capabilities, but it leaves untouched major weaknesses. Nevertheless, there is reason for cautious optimism. The plan 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 and ideas into economic and social gains." (Schwaag and Breidne, 2007: 162).

Of particular importance for China's standardization strategy 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 the key principles that government agencies should follow when implementing indigenous innovation.

3.3. Persistent ambiguity

It is important however to emphasize that Chinese policy-makers are still searching through trial-and-error for ways how to best protect China's own interests while at the same time minimizing possible negative effects on its innovation capacity and on its integration into the global economy.

To some degree, this may explain why ambiguity remains widespread in the definition of key concepts of China's standardization strategy. Our interviews show that foreign observers (from the US, the EU as well as Japan) find it difficult to understand why attempts to improve key concepts and procedures almost never see the light in a transparent manner. Foreigners complain that, while one document provides clarification on one particular issue, it leaves open many questions on other equally important concepts. There is a suspicion that ambiguity is used as a competitive weapon against foreigners. That may certainly be the case in some instances.

Ambiguity may actually provide some space for flexibility to handle complex international negotiation challenges. Trade negotiations at WTO provide an example. Take for instance China's answers to the questions raised by the EU delegation on the WTO 2010 Trade Policy Review on China[90]. A specific example is the EU question on the WTO's statement that "the notion of domestic products has not been defined yet" (WTO, 2010: page 40, para 65).

- The EU asks: *"Could China provide the most recent available data on the volume and the value of non domestic goods or services purchased by procuring entities?"*
- China answers: *"China has not yet issued any definition of domestic products. Therefore, no relevant statistics is available at present. ... China has not conducted statistics in this respect. Therefore, no relevant data is available. "*

[89] Woolcock defines 'social capital' as the willingness and likelihood to share knowledge and information, based on shared values, norms, trust. Woolcock, M., 1998: Social capital and economic development: Toward a theoretical synthesis and policy framework, *Theory and Society*, 27 (2), 151–207

[90] WTO, 2010, Trade Policy Review on China. Report by the Secretariat, WT/TPR/S/230, 26 April; and China Comments to EU Questions, at http://www.wto.org/english/tratop_e/tpr_e/tp330_e.htm.

But a more important cause for ambiguity is, what Elise Owen, the director of the China Program of the American National Standards Institute (ANSI), calls "aspirational rule-making" [91]. In order to catch up quickly, there is a tendency in Chinese government agencies to mandate rules and regulations without prior careful impact analysis, risk assessment and due process. Often the intention on the Chinese side is to proceed in a trial-and-error fashion – "We put this out first and then see what happens!" The rationale for this "aspirational rule-making" is that Chinese policy-makers feel they cannot waste precious time needed to catch up with the leaders as quickly as possible. Another reason is that basic capabilities and institutions required for impact analysis may simply not yet be in place[92].

The result is, as Geoff Dyer (the *Financial Times* Beijing correspondent) puts it: "Ground-breaking policy shifts in China do not take place with one big, cathartic announcement or after a cliff-hanging vote. Instead, they evolve through a steady drip of leaks, hints, denials and oblique official statements"[93] This makes it difficult for foreign observers to understand what the real intentions of Chinese policy initiatives are.

3.4. Recent policy initiatives – key building blocks

To understand how China seeks to adjust its standardization strategy to cope with growing complexity, let us briefly review the following recent policy initiatives:

- The registration of products that contribute to indigenous innovation;
- The revision of Government procurement regulations;
- The Draft Telecommunications Law, issued by MIIT for public review and comment
- New regulations for patents included in standards;

3.4.1. 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 Ministry of Science and Technology (MOST), 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 for foreign companies to enter the China market. For instance, many comments on the above Notice 618 were concerned that an "indigenous innovation product" must be produced by a company that has full ownership of the intellectual property rights in China, and/or that 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

[91] Owen, E., 2010, "Standards in China: Behind the Headlines", *The China Business Review Online*, http://www.chinabusinessreview.com/public/1001/owen.html, accessed June 14, 2010

[92] According to one interview source who requests anonymity, another explanation for ambiguity is that Chinese officials seek to protect themselves and their agency from unexpected changes in policies handed down from the top of the political hierarchy. This reflects China's tradition of using ambiguity to "hide from the government".

[93] Dyer, G., 2010, "Property tax offers to pave way to China's social reform", *FT,* June 11, page 2.

requirements that products must satisfy to be eligible for national indigenous innovation product accreditation. Most importantly, it indicates that China's definition of 'indigenous innovation' appears to be quite pragmatic. According to an assessment by the US-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 US-China Business Council (USCBC)."[94]

Recent phone interviews with major US companies 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 IP 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 IP 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; or 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 modular design and increasing complexity, 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 10, 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 structure, quality, material, craftsmanship, or performance, to be eligible for indigenous innovation accreditation."

3.4.2. Revision of Government procurement regulations[95]

The State Council's Legislative Affairs Office released on January 11, 2010 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-invested enterprises (FIEs). Specifically, Article 10 of this draft defines a "domestic product" as one "made within China's borders and for which domestic manufacturing costs exceed a certain percentage

[94] The US-China Business Council, 2010, "Comments on the April 2010 Draft Notice on the Launch of the National Indigenous Innovation Product Accreditation Work", May 10

[95] This section draws on interviews and "Domestic Innovation and Procurement. Cover Story", *CBR*, March-April 2010; USITO, 2010, "Comment on the 'Implementation Rules of PRC Government Procurement Law", U.S. Information Technology Office, Beijing

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.

Ambiguity however enters the picture, 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. These product catalogues apparently discriminate against FIEs. According to a recent USCBC 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)" [96].

The latter example illustrates a fundamental dilemma faced by China's top-down approach to standards and innovation policy. Rising complexity of technology, markets and business organization implies 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 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 indigenous 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.

3.4.3. Draft Telecommunications Law

The draft of China's Telecommunications Law, issued by MIIT in October of 2009 for public review and comment, provides an important insight into the challenge faced by China's standardization strategy due to rising complexity.

Articles 2 and 3 of the Draft Law recognize the trend (described in the first part of this paper) toward *convergence* of different technologies and services offered by telecommunications, media and information services, based on the Internet. However, there is little effort to make the necessary adjustments in policies and institutional arrangements. The Draft Law simply applies the laws and regulations governing the traditional media and broadcasting sectors to rapidly growing variety of new convergent media services that are offered over telecommunication infrastructures, including the Internet.

This is problematic. According to comments provided by the U.S. Telecommunications Industry Association (TIA),

> *"...[m] any of these new services utilize drastically different technologies, delivery mechanisms, and, in some cases, with completely different business models*

[96] The US-China Business Council, 2010, "Comments on the April 2010 Draft Notice on the Launch of the National Indigenous Innovation Product Accreditation Work", May 10, page 2.

> *compared with the traditional services. As such, applying regulations that were designed prior to the advent of these new technologies and services risk stifling the innovation and new market creation brought forth by these new services. Applying laws and regulations from multiple regulatory authorities could also lead to overlapping and sometimes contradicting regulation over the same service, potentially creating market uncertainty and confusion that deter investment and market development."*[97]

It is difficult to disagree. But in light of China's very different economic system and institutions, it is unrealistic to argue that China should replicate the American approach that is based on a deeply entrenched tradition of decentralized public-private governance. China will seek to find its own institutional and legal approaches to cope with the challenge of rising complexity.

The second issue raised by the Draft Telecommunications Law is the nature of telecommunications standards. Article 68 states that

> *"Telecommunication standards include national standards and industry standards. National telecommunications standards are planned, drafted and approved by the State Council's department in charge of standardization in concert with the competent telecommunications authorities, and opinions shall be solicited from relevant departments under the State Council where network and information security is involved."*

This raises of course the question: What tradeoffs are involved in the selection of national standards when widely used and commercially successful international standards exist?

There is no doubt that mandating national standards through procedures that restrict foreign participation could have potentially disruptive effects on China's innovative capacity. That argument is made forcefully by TIA in its comments on the Draft Telecommunications Law:

> *"In order for China to continue to avail itself of the best technologies the world has to offer, we strongly encourage China to adopt international standards ... developed through privately managed, open, voluntary and consensus driven standards processes ... . This approach helps promote interoperability, reduces equipment costs, and helps accelerate innovation. Closed standards development procedures shuts out other important voices and can lead to creation of standards in a vacuum that are not compatible with internationally developed standards, and would not be relevant in a global market if those technologies were to be deployed outside Chinese jurisdiction. If China mandates national standards or technologies (as we have seen attempted in several areas), China is reducing its potential to be a global innovation leader."*
> (TIA, 2009: page 7)

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[97] The Telecommunications Industry Association (TIA), 2009, "Comments on China's Draft Telecom Law On Behalf of: The Telecommunications Industry Association (TIA), the U.S. Information Technology Office (USITO), & the Information Technology Industry Council (ITI) ,*Final Version, 11/3/2009,* http://www.tiaonline.org/gov_affairs/fcc_filings/documents/comments_on_china%20_telecom_law_final.pdf, accessed June 17, 2010, page 1

From China's perspective, however, simply adopting *existing* international standards as a *standards taker* is not considered to be a viable solution. To understand why, take the widely discussed case of TD-SCDMA[98]. A defining characteristic of the TD standard is that it is not a national standard, but an international third-generation mobile telecommunications standard established against two dominant *existing* international standards (WCDMA and CDMA-2000).

As the TD standard contains a substantial share of foreign essential patents (from Nokia, Ericsson, Siemens and Qualcomm), its promoters were realistic enough to choose the international standardization approach through the international consortium 3GPP. But progress in the implementation of TD-SCDMA has remained limited, as long as the government was reluctant to provide full support. This changed when the government finally decided to accept three competing standards in parallel, but at the same time forced China Mobile to aggressively develop a TD infrastructure and industry value chain.

Despite massive investments to extend TD coverage across China and to improve performance and develop attractive handsets, there is little doubt that TD still has quite some way to go to catch up with the dominant international standards. What matters however is that, through the TD standard, China was able to gain some ground in reducing patent licensing fees and in developing homegrown innovative capabilities. And while global industry leaders were initially reluctant to participate, they are now actively involved.

More to the point, it seems that developing the TD standard has facilitated China's capacity to co-shape the standards for future mobile broadband – particularly in 3GPP's Long Term Evolution program. This, together with the success of Huawei and ZTE, is strengthening China's position in 3GPP, ITU and other international standard development organizations.

In short, the case of the TD standard shows that the focus on national standards, as promoted in Article 68 of Draft Telecommunications Law, may be problematic. The TD standard certainly is an international standard. The real issue seems to be whether China's *Telecommunications Law* provides the legal tools and institutions that will strengthen China's capacity to *co-shape* relevant international standards and to improve the country's innovative capacity.

3.4.4. New Regulations for Patents included in Standards

As demonstrated in part one, an important aspect of rising complexity 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 Standardization Administration of China (SAC) posted for public

[98] See, for instance, SHEN Xiaobai; Stewart, J.: GAO Xudong, "Understanding key features of the TD-SCDMA adoption process in China", paper prepared for the EWC/NBR Beijing conference "Standards and Innovation Policy in the Global Knowledge Economy – Core Issues for China and the US" , October 14, 2009, http://cdn.nbr.org/downloads/CS09_GAO%20_paper_EN.pdf, accessed June 18, 2010. Clark, D. and T. Dean, Case Study of TD-SCDMA – What Lessons Can Be Drawn for China's Future Standards and Innovation Policy? EWC/NBR Beijing conference "Standards and Innovation Policy in the Global Knowledge Economy – Core Issues for China and the US" , October 14, 2009

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."[99]. The Draft Rules set out in detail the possible consequences in cases where a patent owner involved in the standards development process 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 an 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 the 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 in light of the fact that responses by Chinese authorities to complaints (by both Chinese and foreign organizations) have toned down and softened some of the initially harsh requirements.

It seems that SAC has decided to delete the most controversial parts of the Draft. This includes the controversial requirement in Art. 9 of "significantly lower than the customary royalty". The new formulation – "a commitment to license on a RAND basis" - would be in line with international practice[100]. It is also expected that other aggressive requirements, such as the royalty-free penalty for not disclosing patents on time, will be watered down. This raises the question: What explains the retreat? It seems that opposition of leading Chinese companies (especially operators) has played an important role. There may also have been inter-agency opposition. Less clear however is how much of an impact the opposition from foreign players has had.

It may well be that Article 9 of SAC's 2009 Draft Rules was too much focused on reducing the cost of technology licensing. Reflecting the impact of rising complexity, other motivations are now gaining in importance, among them the interests of Chinese companies (like Huawei) that have growing IPR portfolios and that have developed their own global corporate networks of production and innovation.

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, do 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.

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

[100] RAND = reasonable and non-discriminatory.

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.

Finally, recent revisions in China's *Patent Law* promulgated on October 1st, 2009 may also indicate a partial relaxation of earlier more stringent requirements. The Law seeks to strengthen China's legislative and implementation framework for the protection of intellectual property rights, while at the same time promoting China as a research and development centre 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, to ensure that patents are exploited within China.

The revised version of the *Patent Law* partially relaxes this requirement. It is now stipulated that, if the approval from the State Council is granted, then the patent can be filed first abroad. It remains to be seen however whether this change is more than cosmetic.

4. Conclusions

This paper documents substantial changes in China's standardization strategy, and in its institutions and management practices. 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. These strategic standards are considered to be as important for the country's innovative capacity as are R&D investment, intellectual property rights, human capital, venture capital and broadband infrastructure.

Much of this effort has focused on the information and communications technology (ICT) industry which serves as a testing ground for developing China's standardization strategy. However, as rising complexity in technology, business organization, market structure and laws and regulations is reshaping the international standardization landscape, China's government-centered standardization strategy is under pressure. The paper has explored how China's evolving standardization strategy is affected by and responding to this challenge.

We find that, while rising complexity creates new opportunities for learning and institutional innovations, it also increases the cost of standards development and its risks, especially for Chinese companies that seek to move beyond the status of *fast-followers* to become *co-shapers* of international standards.

An important finding of the paper is that China is making significant progress towards a more coordinated and integrated approach to standards and innovation policy. Using illustrative examples, I have shown that China's recent policy initiatives on standardization are now better aligned with the general government focus on indigenous innovation, and the related revision of patent law and the public procurement legislation. The paper demonstrates the catalytic effect of the Medium and Long-term Plan for Science and Technology Development (MLP) in developing a set of key legal documents that are now defining China's *de facto* Standardization Strategy. Focusing on Huawei, the paper discusses resourceful and creative efforts to strengthen China's position in international standard development organizations.

On the negative side, the paper has explored constraints that China's capacity to cope with rising complexity is facing from within its own standards system. Like other latecomer societies before, China's primary focus was on *quantitative* achievements, i.e. increasing the sheer number of patents granted and standards issued. 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. The paper emphasizes the role of *qualitative* parameters, such as the importance ('essentiality") of certain patents and the factors that shape the chances of successful implementation of a standard.

The paper also highlights a second drawback of China's top-down approach to standards and innovation policy. Important policy tools are elaborate lists of products and technologies that are constructed to assess compliance with China's standardization and certification requirements. This illustrates a fundamental dilemma of China's standards system. Rising complexity of technology, markets and business organization implies that it is very time-consuming and cumbersome to construct and to manage reasonably systematic lists of products and technologies. As a result, such lists risk being quickly outdated and bypassed. Even more important for China's objective to foster indigenous 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.

In addition, the paper finds that China's standards system remains overly complex and fragmented, and highlights the role of persistent ambiguity. Key concepts are loosely defined and often differ from the definition of these concepts in other countries. There is also a lack of clarity about the boundaries and the division of labor between mandatory and voluntary standards, and between competing national, industry, ministry and provincial standards. Specifically, the paper highlights that an important source of fragmentation are inter-agency rivalries that reflect turf battles among different ministries and their respective stakeholders, and their conflicting interests in innovation and standardization.

In the US, there is a widespread expectation that, in order to cope with rising complexity, further reforms of China's standardization system will "naturally" converge to an (almost) full compliance with a US-style market-led voluntary standards system. The paper however finds little evidence to suggest 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. In short, 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.

Challenges ahead

What then are the challenges ahead for efforts to upgrade China's standards system?

A central proposition of the paper is that for China the development dimension 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. However, it is necessary to combine China's government-centered standardization strategy with elements of market-led standardization. There is an urgent need 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 alternative options rather than seeking to impose from the top the "One Best Way" of doing things. This reflects Gell-Mann's insight that "any definition of complexity is necessarily context-dependent, even subjective." (Gell-Mann, 1994: page 33).

This is so for at least 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 in standardization to find out what works and what doesn't.

Second, rising complexity makes it very 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, one small change in one policy variable that describes for instance 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 stakeholders. Given the diversity of China's competing standardization 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.

For instance, inter-agency rivalries constrain China's policy to foster convergence between telecom, broadcasting & internet industries. The current division of labor between MIIT and SARFT is dysfunctional. MIIT is responsible for the development of indigenous innovation, ICT infrastructure, domestic industry, and creates the demand for ICT products, while SARFT fosters broadcasting media, cultural industry, content producers, and seeks to control content. If China wants to cope with rising complexity, that pattern is no longer sustainable. In fact, the MIIT-SARFT rivalry has hampered the development of China's mobile multimedia digital broadcasting standard, pitting MIIT's T-MMB standards against SARFT's CMMB standard[101].

Of critical importance are 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 standards. Additional reform tasks include the harmonization of standards and conformity assessment; attempts to rationalize the outsourcing of research and support services by ministries to specialized 'research institutes; efforts to strengthen cooperation between standardization system and SIPO; and, and integrating standards and innovation policy with China's still relatively new and untested Anti-Monopoly Law.

Finally, a sustainable upgrading of China's standards system critically depends on

[101] Note however that, since May 2009, China Mobile (which is part of the MIIT sphere of influence) uses SARFT's CMMB standard for its TD-SCDMA handsets. Further research is needed to assess whether this indicates a new model of inter-agency cooperation.

effective policies to strengthen the position of China's small-and medium-sized enterprises (SMEs). Our research finds that leading Chinese ICT companies (e.g. Huawei, ZTE) are actively involved in international standardization and have substantially improved their standardization capabilities. However, the situation is very different for smaller Chinese ICT companies. They simply lack the financial and human resources that would allow them to travel to Geneva and other foreign cities to participate in technical committees of ITU, ISO and private standards consortia like 3GGP. Chinese SMEs lack adequate standardization capabilities. Hence, for these companies, standards are a burden that generates very high costs. The same is true for other Chinese companies in other sectors outside the ICT industry, especially if these industries are primarily focused on the domestic market.

In short, a fundamental prerequisite for upgrading China's standards system is to reduce the huge gap in standardization capabilities that separates SMEs from the handful of dominant Chinese global players.

Finally, there are encouraging signs that the shock of the global economic crisis has worked as a powerful catalyst for new initiatives, such standards for environmental protection, resources, alternative energy, product safety and health standards, and consumer protection; standardization for high-performance DNA sequencing instruments; standards for the joint U.S.-China Electric Vehicles Initiative; and standards for the Chinese Smart Grid project.

Implications for future research (to follow)

- Create a new research agenda that helps to apply findings of complexity theory in a more operational manner to the formulation of standards and innovation policies (both in the US and China).

References
List of Abbreviations
List of interviews
(Word count: 20,432)