

## Standardized Confusion? The Political Logic of China's Technology Standards Policy

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### **Abstract:**

Studying technology standards in emerging economies provides a unique opportunity to examine the comparative political economy of science, technology, and innovation, as well as to analyze how economic institutions from mature capitalist countries fare when planted in different institutional settings. Of the emerging economies, the largest and arguably most important for the international economy is China. Looking from the national systemic level we find a puzzle in explaining the Chinese policy: Why do domestic standards continue to proliferate and be led and supported by government even when there is evidence that standards policies are counterproductive in terms of fostering innovation, their political and economic *raison d'etre*? We argue that this is the outcome of a two steps self-reinforcing sequence dynamic. In the first stage the state initiates standards development in the hope of fostering technological independence by offering status and economic incentives. As standard development starts, however, an unintended consequence is that more and more organizations, fearing a loss of competitive advantage, begin competing standard development efforts, creating an innovation arms race and explosive growth in the number of standards. This proliferation is counterproductive, leading to more uncertainty and less innovation. Nonetheless, since this dynamic has been creating vested interests, they ensure the continuation of the current policy.

### **Acknowledgements:**

The research for this paper was generously supported by the Sloan Foundation, the Kauffman Foundation, and the National Science Foundation under grant SES-0964907. Special thanks to Scott Kennedy, Pete Suttmeier, Amos Zehavi, Barry Naughton, Adam Segal, Tai-Ming Cheung, Andrew Schrank, Susan Shirk, John Zysman, Kenji Kushida, Peter Cowhey, Gerald McDermott, Jonathan Aronson, Robert Pepper, and Patrick Keating for their invaluable feedback during the research and drafting process which made this work possible. Earlier versions of this paper were presented at: the Academy of International Business (AIB)/CIBER Conference on Emerging Research Frontiers, Panel 3: *The Politics of Crisis and the New Institutions of Development*, the Georgia Tech Colloquium on National Security, the 2011 US-China Forum at Georgia Tech, and at the conference on Chinese Approaches to National Innovation at UC San Diego. We thank the participants for their many helpful comments and suggestions. All views expressed in this paper are solely the authors', as well as are all mistakes and omissions.

## **Introduction:**

Technology standards are becoming an important area of research in comparative political economy. Once thought to be of interest primarily to engineers and scientists, the economic implications of technology standards have raised the political stakes in their development and implementation (Mattli and Buthe, 2003). Indeed, recent interest in the impact of politics and institutions on the spread and development of technology should enhance interest in technology standards among political scientists (Breznitz, 2009a). The manner in which governments approach domestic and international technology standards greatly impacts their economic, technological and innovation performance.

Technology standards have become increasingly critical to the operation of globally modular industries and the loci of fierce political competition (Kennedy, Suttmeier, and Su, 2008; Lee and Oh, 2008; Mattli and Buthe, 2003; Suttmeier and Yao, 2004; Suttmeier, Yao, and Tan, 2006). In a world where production is fragmented across multiple regions both within and among companies, the ability of firms to produce compatible components and services is critical. However, many standards incorporate proprietary technology, which accrues to their owners significant profits should their particular standard become widely used. Consequently, there are major imbalances in the financial gains of producers at different positions in global production networks. Emerging economies' governments are increasingly aware of the relative distribution of benefits from adopting international standards and have begun to develop their own standards (Lee and Oh, 2008).

Studying technology standards policies in emerging economies provides a critical venue with which to study the comparative political economy of science, technology, and innovation, as well as to analyze how economic institutions developed in mature capitalist countries fare

when introduced into very different institutional settings. Of the emerging economies, the largest and arguably most important for the international economy is China – a country which is also the current paragon of indigenous technology standard development efforts (Suttmeier and Yao, 2004; Suttmeier, et al., 2006). As China remains the world’s fastest growing economy and an emerging technological power, the implications for how and why China develops standards have great implications for the rest of the world.

Interestingly, in contrast to popular belief that China practices a mercantilistic and techno-nationalist approach to standards, even a brief inquiry into China’s technology standards policy record reveals no single defining strategy, least of all mercantilism. In fact, China’s standards’ strategy and policy-making is significantly disjointed.<sup>1</sup> China’s government funds pursuit of unique exclusionary standards, most noticeably in information technology (IT), but it is also an active participant in international standards forums (Suttmeier and Yao, 2004; Suttmeier, et al., 2006). The same Chinese companies that pay hefty royalties for foreign standards often fight fiercely *against* efforts to implement ostensibly liberating mandatory domestic standards. At the same time, companies with massive export markets and vested interests in globally accepted standards, such as Huawei or Zhongxin Telecom (ZTE), also participate in development of unique Chinese standards. The same government agencies support certain standards, but torpedo others. These patterns hardly suggest a coordinated mercantilist strategy.

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<sup>1</sup> This is particularly interesting since, during the 1980s and 90s, China sought a developmental model to emulate. It found the Japanese developmental state model particularly appealing and compatible. Various attempts to emulate this model in areas such as employment practices and creation of integrated national champions ensued (Chan 1995). Despite adopting some aspects of the developmental state model, China generally does not follow the classic pattern and efforts to establish cartels or large national champions often fail (Kennedy 2008).

The overall puzzle intensifies when we realize that in terms of its own goals – the enhancement of indigenous innovation – the outcome of China’s standard policy has been generally negative.

The widely studied case of the third generation mobile telephony standard, TD-SCDMA, is highly illustrative of the confusion, the success, and limits of China’s policy. TD-SCDMA (Time Division-Synchronous Code Division Multiple Access) is a combination of Seimens’s Time Division Duplex technology and a smart-antennae-based Synchronous CDMA technology developed by CWill (later Xinwei) Telecom of Austin, Texas. TD-SCDMA has the advantage over other 3G technologies in that the time division technology enables very efficient use of bandwidth. The standard requires less spectrum as a single band carries data and voice traffic to and from the handset. In 1995, the Ministry of Industry and Information Technology (MIIT – then known as the Ministry of Posts and Telecommunications), working with the Ministry of Science and Technology and the State Planning Commission committed China to developing a 3G mobile telephony standard as a target under the Ninth Five-year Plan.

The decision to make 3G development a national objective is imminently rational. Mobile telephony is a critical industry, both rapidly growing and innovating. China has enjoyed excellent market conditions for mobile development – not the least having the largest mobile user-base in the world. However, the efforts to produce an “indigenous” 3G standard inhibited use of alternative standards, which were already commercially viable as early as 2001. This delay in usage meant that the Chinese mobile market, and the local companies supplying it, is on average seven years behind the current cutting-edge technology.<sup>2</sup>

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<sup>2</sup> By 2010 when finally TD-SCDMA was being aggressively rolled-out by China Mobile (whose hand was forced by the government), there are already successful fourth generation (4G) mobile network in operation around the world.

Technologically speaking, there were successes in the TD-SCDMA case. In 1999, Siemens and Datang Telecommunication Equipment Company (acting on behalf of China's telecommunications industry) jointly petitioned the International Telecommunications Union (ITU) to adopt TD-SCDMA as a 3G standard. The petition was successful and ITU approved the standard, alongside CDMA2000 and the European-preferred WCDMA (Suttmeier et al., 2006). However, while being strongly embraced by the government as an indigenous standard, the fact is TD-SCDMA relies heavily on foreign technology. Foreign participation has been crucial, in particular from Siemens who saw cooperation with China as a means to further develop its rejected Time Division Duplex technology (Gao, 2010).<sup>3</sup> All told, Nokia, Ericsson, and Siemens provided sixty-six percent of the core patent rights for the standard (Sinocast, 2006; Stewart, 2009; Stewart and Wang, 2009). In comparison, the largest Chinese patent-holder, Datang, holds only 7.3 percent.

Furthermore, the strong desire to secure a new standard in a chosen sector undermined China's ability to innovate in many other areas. Not only did China invest billions of RMB to develop a standard rather than investing it elsewhere, but also the government's refusal to permit the rollout of 3G services until TD-SCDMA was ready for commercial deployment delayed Chinese market and peripheral innovations for seven years (Marukawa, 2010). From 2000 to 2008, TD-SCDMA repeatedly struggled in various field and scale tests, each time forcing MIIT to announce another delay in licensing. Even as late as June 2008, experts were bemoaning TD-SCDMA's immaturity and unreadiness to compete with the established global standards. Although intended to secure technological independence and serve as a symbol of China's technological prowess, the record of TD-SCDMA was mixed at best.

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<sup>3</sup> Two hundred Siemens engineers worked with Datang Telecom, the commercial arm of the Chinese Academy of Telecommunications Research (CATT), which was in turned owned by the Ministry of Industry and Information Technology's (MIIT), on the standard (3GNews, 2001; AsiaTimes, 2006; Linden, 2004).

Standards are ostensibly created to reduce uncertainty, but China's standards development efforts have increased confusion. The sheer number of new standards issued and developed annually ensures uncertainty (see table 1). Even more worrying from the point of view of long-term commitment to action by industry is the fact that in China *standards or regulations can become mandatory at any time, without warning or industry approval*, such as in the case of the WAPI wireless internet standard. The end result of any such a deluge of competing and unpredictably mandated standards is increased uncertainty, which negatively impacts growth.

With such results, there is a key puzzle to be answered: *Why do domestic standards continue to proliferate and be led and supported by government when there is evidence that standards policies are counterproductive in terms of fostering innovation?*

**<<Table 1: China's Standard Development Projects - 2007-2010>>**

The rich literature on China's technology standards policy has not, to date, uncovered any coherent logic to solve this puzzle. Scholarly attention to-date focuses on explaining specific standardization efforts, providing good predictive theories of the likelihood of the success of particular standard development efforts. However, it fails to look at the domain of technology standards from a broader systemic perspective which questions why different actors formulate standards in the first place. Accordingly, it does not help us to understand the boarder impacts of China's technology standard policy, nor its internal evolutionary dynamics.

Standards development efforts in China can only be understood if we take a systemic view which questions why standards development was stimulated in the first place, and why governmental efforts are accelerating even after it has become clear that the current policy does

not achieve is stated goals. We propose that standards in China proliferate due to a two-step self-reinforcing-sequence (SRS) (Breznitz, 2009b; Mahoney, 2000; Pierson, 2000a, 2000b, 2004).

The Chinese government's decision to foster indigenous technology standard creation, offering economic and social status incentives, activated the first step. As the central state still enjoys great legitimacy, influence and coercive power, incentives from the central government are very effective in encouraging new behavior by economic actors (Gilley, 2008).<sup>4</sup> Incentives include the recognition of technology standard development as national innovation indicator, provision of direct funding, and last, but not least, the possibility of legally mandating a standard for exclusive use in China, with the promise of securing monopoly rents to its developers. These state actions induced many organizations to enter multiple standard development efforts.

In the second step of the SRS, organizations that opted to refrain from domestic standard development realized that standards might grant rivals significant competitive advantage. In response they start their own development efforts or join standards alliances begun by others. This dynamic of action and counteraction has now become a classic innovation arm race where actors produce more and more standards in order to not be left behind (Barnett, 2008; Baumol, 2004; Derfus, Maggitti , Grimm, and Smith, 2008; Schelling, 1960). Some actors even join opposing alliances to ensure sustained advantage.

The un-intended consequence of this dynamic is a systematic increase in uncertainty and associated negative impacts on innovation. Firms cannot predict which standard will be adopted, making long-range planning difficult. However, standard development accomplishes other goals such as reducing royalty payments. Furthermore, by now the fortunes of influential groups in academia, bureaucracy, and industry are tied to the current standard policy, and hence act to

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<sup>4</sup> For this paper, we define the state as consisting of the bureaucracy at different levels. Hence the central state refers to the national-level bureaucracy based in Beijing.

ensure its continuation. Accordingly, we foresee that this situation will persist for the medium term.

In developing such an explanation we demonstrate the importance of politics and political decisions above market forces, presenting how such political actions influence the trajectory of technology and market development. We highlight the importance of the comparative political economy perspective to understanding economic evolution and growth.

The paper is organized as follows; it first briefly introduces the economic rationale behind technology standards and explains their growing importance. We then outline current explanations for China's standardization efforts, and advance our explanation for standardization in China using a two-step SRS political-economic dynamic. We then view this explanation in practice through an examination of two cases: the AVS video and sound encoding standard and optical storage media, two critically important niches for the Chinese ICT industry since the early 1990s. In both cases the state initiated and supported development efforts, ostensibly to encourage innovation but often succeeding only in producing large numbers of nominally useful standards. We conclude by examining the broader implications of Chinese standards policy and the logic which drives it for both advanced and emerging economies.

### Technology Standards, Trade, and Innovation

Technology standards are platforms on which other applications and innovations can be made. Standards ensure widespread use and interoperability of products and peripherals allowing enlargement of markets and increasing the incentive to invest in R&D (Albrecht, Dean, and Hansen, 2003; Heddergott, 2006; Kindleberger, 1983; Lecraw, 1987; Manivannan, 2008; Simcoe, Graham, and Feldman, 2009; WTO, 1995). Standards are not a pure public good since companies whose proprietary technology is embedded within many of them benefit

disproportionately. Thus developing technologies on which widely used standards are based is extremely lucrative. Technology standards reduce uncertainty by creating a uniform technological platform on which any actor can develop new applications thus ensuring would-be innovators that a market for their products will exist when they complete their research. Use of standards is an important step and contribution to creating necessary markets for technology (Arora et al. 2001), which encourages further investment in R&D and hence innovation as well as technology licensing and dissemination. However, where competing standards exist, firms may be forced to hedge their bets across several standards, reducing the ability to concentrate resources and achieve breakthroughs.

International standards are debated and approved by various international organizations. The most active are the International Organization for Standardization (ISO), the International Electrotechnical Commission, the International Association of Electrical and Electronics Engineers (IEEE), and the ITU. These organizations do not have independent enforcement capabilities and their standards are not legally binding. However, the WTO's inclusion of standards in the Technical Barriers to Trade agreement made adoption of international standards a prerequisite for member states (WTO, 1995). Members cannot knowingly use standards to discriminate or obstruct trade.

In addition to international agreements and standard making bodies, market forces create many de-facto ones such as Microsoft Windows (Funk, 2002). Market dominance is enhanced as more users or peripheral product developers adopt the platform. Through a network effect, de-facto standards become increasingly entrenched (Cusumano, Mylonadis, and Rosenbloom, 1992; Kindleberger, 1983). It becomes extremely difficult to challenge established standards without a radical new displacing technology. De-facto standards nearly always involve proprietary

technology and entail the payment of fees. As we discuss in our case studies, paying royalties can be crippling to manufacturers operating under thin profit margins.

*China in the World of International Technology Standards*

China has a large and rapidly growing high technology industry. Exports of high-technology goods totaled over \$492.4 billion in 2010, and accounted for over thirty percent of all exports (NSBPRC, 2009-2011). This industry juggernaut relies heavily on foreign proprietary technology (Breznitz and Murphree 2011; OECD, 2007). Consequently, China's manufacturers strongly feel the impact of international technology standards and royalties.

Since emerging as a player in the global technology trade, China's technology savvy and sophistication have grown (Ernst and Naughton, 2007; Kroeber, 2007; Naughton and Segal, 2003; OECD, 2007; Segal, 2003). While Taiwan accomplished much technological upgrading through the reversal of the brain drain and incorporation of itself tightly into innovation networks with Silicon Valley (Saxenian and Hsu 2001), mainland China's upgrading approach is more comprehensive. Development of standards is an important component of this strategy. It is therefore unsurprising that China seeks a commiserate voice in standards debates (Sergers and Bredine, 2007). China's behavior, however, has been erratic, unpredictable and seemingly counter-productive.

China clearly benefits from conformity with the international system since adopting international standards enables manufacturers to secure overseas orders. It also aids companies to incrementally improve existing technologies, confident they will be globally accepted. Despite these advantages, influential voices in China's government and industry argue that while benefiting *absolutely* from international standards, *relative* benefits disproportionately favor foreign standard holders. In response, China's central government made development of Chinese

standards with indigenous intellectual property a national strategy (Linden, 2004; Suttmeier and Yao, 2004; Suttmeier, et al., 2006).<sup>5</sup>

To understand why China benefits disproportionately less from the international technology standards system, one must understand the structure of China's industry. Most of the activity is production of goods based on foreign technologies or the final assembly of products from components and sub-systems produced elsewhere. Looking at figures of added value in China, it becomes obvious that many Chinese firms are low-margin, high-volume manufacturing businesses (See Table 2).

*<<Table 2 – Value Added for Advanced and High Technology Manufacturing>>*

Furthermore, foreign subsidiaries in China produced eighty-three percent of China's high-technology exports in 2009. Much of their activity is also assembling imported components for export (OECD, 2007; Xinhua, 2010). Reliance on foreign standardized technologies and components places many Chinese firms at the low value-added end of the global production ladder. Chinese analysts estimate the value-added by manufacturers in China for high-level color televisions is approximately two dollars per unit, versus ninety dollars in Japan (ZGJM, 2004).

Royalties, usually at a constant price per unit, have become one of the highest cost items for manufacturers. Intense competition reduces the unit price while the cost of royalties remains constant. Consequently, the relative cost of royalties increases while profit margins decrease.

Chinese DVD player manufacturers claimed that until 2008 their annual royalty payments of

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<sup>5</sup> Researchers studying Asia's emerging economies such as Amsden typically argued that technological upgrading can and does occur through "learning" (Amsden 1989; Amsden 2001). One major method of learning is through technology transfer through joint ventures with global technology-leading MNCs. However, as Nam's research shows, at least in some sectors such as the automotive industry, international joint ventures do not lead to comprehensive upgrading of firm capabilities (Nam 2011). Innovation capabilities are thus not necessarily enhanced through learning and borrowing from advanced companies and countries. China's standards policy is a possible means of overcoming these difficulties.

three billion USD were substantially greater than the industry's total profits (Cai, 2009; Chen, 2008; Ding, 2009). This situation makes the central government's interest in promoting standards as a means of technological independence very understandable.

One of the most important accomplishments of China's technology standard policy has been its usefulness as a negotiation tool for reducing royalty payments. Whenever the state launches a new standards development effort and companies begin to join up, foreign standards bears take note. Rather than face the possibility of a closed Chinese market, foreign standards bearers tend to negotiate and offer lower royalty rates for Chinese manufacturers. China has successfully used indigenous standards development to pressure foreign standards owners to lower royalty rates.

#### State of the literature

The current understanding of technology standards in China uses political explanations to account for actors' behavior. The literature agrees that understanding the perspective and composition of the dominant political group is sufficient to predict the type of standard which will emerge and its likelihood of domestic approval (Kennedy, 2006, 2007a; Kennedy, et al., 2008; Kroeber, 2007; Lee and Oh, 2008; Linden, 2004; Liu, 2006; Suttmeier and Yao, 2004; Suttmeier, et al., 2006).

Three main frameworks are used to analyze Chinese standards debates: i) the spectrum of perspectives; ii) bureaucratic politics and iii) the logic of standards coalitions. At the micro-level each framework helps explain the results of specific standardization efforts. However, none of these frameworks deal with the macro level or tries to explain the systemic impact and the development of standards policy as a whole.

The spectrum of perspectives argument analyzes the course and outcome of standards debates based on knowable standpoints of different actors regarding international standards and their role in development (Kennedy, et al., 2008; Suttmeier and Yao, 2004; Suttmeier, et al., 2006). This argument proposes that understanding actors' perspective is enough to predict which standards they will support.

The most common position on the perspectives scale is “neo-techno-nationalism” (Kennedy, et al., 2008; Suttmeier and Yao, 2004). Neo-techno-nationalists argue that China should use state intervention to raise China's level of industry and technology. However, China should do so working within the international economic system. Neo-techno-nationalists do not oppose the international standards system but seek to increase China's share of relative gains. Consequently, they support creating Chinese standards but desire for these standards to compete and coexist with international ones. Researchers and enterprises should grasp international linkages, cooperation, co-development and interaction where possible, but only to the extent that such cooperation advances China's interests.

At the far end of the scale is techno-autarkism.<sup>6</sup> The techno-autarkist perspective holds that national interests should be paramount, even at the expense of companies' desires (Kennedy, 2006; Kennedy, et al., 2008; Lee and Oh, 2008; Linden, 2004; Qu and Polley, 2005; Suttmeier and Yao, 2004; Suttmeier, et al., 2006; Yoshida and Carroll, 1997). Techno-autarkists believe standards are necessary for China to free itself from dependence on foreign technology. Additionally, they view technological-autarky as a security need, and argue that given China's vast market, access-seeking foreign companies will acquiesce to unique Chinese standards (Yoshida and Carroll, 1997). Finally, techno-autarks hold that passing mandatory standards will

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<sup>6</sup> Techno-autarkism is commonly called “techno-nationalism” although this is arguably a misuse of the term. For a useful definition of techno-nationalism see (Samuels, 1994).

increase China's ability to force technology transfer from foreign partners (Kennedy, 2006; Kennedy, et al., 2008; Linden, 2004; Suttmeier and Yao, 2004; Suttmeier, et al., 2006).

A second approach used in explaining the outcomes in Chinese technology standards efforts is bureaucratic politics (Allison and Halperin, 1972; Clapp, Halperin, and Kanter, 2006; Kennedy, 2007b; Kennedy, et al., 2008). Bureaucratic politics argues that government action should be viewed as the result of competition between different units within the state. Each unit has a predictable and relatively uniform interest. These interests are concrete objectives of increased authority and budget. Support for a given standard depends on whether or not it advances the interests of the bureaucratic unit. Bureaucratic politics are very useful in explaining that outcomes of some specific standardization efforts such as the battle between the Ministry of Industry and Information Technology's (MIIT) battle with the State Administration of Radio, Film and Television (SARFT) over the Audio-Video Standard (AVS) for digital media (see below). Bureaucratic politics also helps account for particular failures such as China's attempts to propose international standards (Kennedy, 2007b). In many cases Chinese representatives act on behalf of their various ministries' interests rather than advancing a national agenda.

Using elements from all these explanations, Scott Kennedy developed an integrated theory of political coalitions. Coalitions are formal or informal associations charged with examining, developing, promoting and ensuring compliance with a standard. Coalitions can also block standards that members believe detrimental to their interests. The supporting coalition's composition – government units, research institutes and enterprises – determines the viability of a standard. Kennedy found that for the twenty-four significant unique national standards adopted in China since the mid-1990s, those with a broad coalition are most likely to be developed, adopted, and implemented as national standards (Kennedy, 2006; Kennedy, et al., 2008).

These approaches to standardization in China are powerful tools for examining individual standardization efforts. Nevertheless, each takes standards as independent episodes with an outcome – success or failure – which needs to be explained. In this worldview, standards creation is taken as given and the research puzzle lies in why some are adopted or rejected. Fundamental questions about why the development of indigenous standards has been pursued with vigor in the first place, and whether, or what, function they have in the Chinese political economy, are not asked.

### The Logic of Chinese Technology Standards

While current research on the Chinese technology standards tries to understand success or failure, we seek to understand the logic and driving force behind the technology standard policy, its overall systemic outcomes, and its longevity.

We contend that the proliferation of standards in China occurs in a two-step SRS. First the central government initiated sets of policies in pursuit of what its leadership sees as the national interest. The goals of the policy are to foster technological innovation and control by Chinese firms, and thus ensure long-term sustained economic growth and job creation. Following the particular implementation of that policy enterprises perpetuate standardization efforts through their rational responses to the new incentives and the political economic reality created as more domestic standards are developed and approved (Breznitz, 2009b; David, 2001; Mahoney, 2000; Pierson, 2000a, 2004). The first step began with the central government's attempt to achieve its official goal: fostering indigenous innovation through promotion of domestic standards embodying self-owned intellectual property (Cao, et al., 2006; Kennedy, 2006; Kennedy, et al., 2008; Kroeber, 2007; Suttmeier and Yao, 2004; Suttmeier, et al., 2006).

To promote standard creation the policy utilized a dual-pronged approach making technology standard development high social status activities, and supplying large financial incentives. To ensure both, the creation of unique technology standards was enshrined as a major innovation goal in the Tenth and Eleventh Five Year Plans and in the 15-Year Mid-to-Long Range Plan for Science and Technology (Cao, et al., 2006; StateCouncil, 2006). In addition, the state encourages standardization by recognition of technology standard development as a national innovation indicator, direct funding of development, and offering the possibility of a standard becoming nationally mandated which promises monopoly rents to the standard owners.

Official recognition as an innovation indicator means that organizations that develop standards receive preferential access to subsidized R&D financing, and enhanced national stature. Official recognition acts as a strong incentive for organizations to participate in as many standards development projects as they can. For new enterprises in China, state recognition is a powerful marketing tool. This can help new firms improve their sales position vis-à-vis established firms. Enhanced status in the eyes of the state is critically important also for further improving access to future financing and grants. The prospect of state financial support is significant as financial constraints are one of the major challenges facing Chinese enterprises which seek to conduct R&D (Fuller, 2005; Kennedy, 2006; Kennedy, et al., 2008; Segal, 2003). Last, the possibility that the government will make a specific standard mandatory, means that possible future gains from developing a standard, as well as losses from not doing so, are considerable.

After implementing these policies to stimulate technology standards development, unintended consequences have taken hold. Some early adopters begin development of and contribution to standards in targeted sectors. Then, in the second step of the SRS, as first mover

organizations produce standards – or proposals for different parts of standards, other companies and organizations working in the same space have been pushed to do the same or face a potential competitive disadvantage. The result is an innovation “arms race” where more enterprises and organizations, responding to the growing number of standards under development, produce more and more standards (Barnett, 2008; Baumol, 2004; Derfus, et al., 2008; Khalil, 1997; Schelling, 1960). Unsure which standards will be adopted, some companies join different alliances producing competing standards to ensure they are on the winning side. As more organizations follow this path the standards-creation arms race intensifies. Confusion in market and regulatory circles for the viability of different standards increases. Uncertainty leads to a systemic slow-down in innovation in the sector in question. Thus, while all actors individually behaved completely rationally, the systematic outcome is less than. Actors which committed time, staff and resources to standards development seek to ensure the state continues to support and promote their standard by lobbying for protection and fighting against newer alternatives.

In this second stage, the state has not lost control of the process. Rather, it has been very successful in encouraging firms to participate in standards development. The problem is that the central state is not sufficiently cohesive and coordinated to ensure a single standard will emerge or to force enterprises to back a given standards coalition. Since there is no certainty over which standard will be adopted, they proliferate and uncertainty increases despite the best intentions of central policy makers in promoting standards development.

An interesting question is whether the Chinese technology standards are a case of bureaucratic capture (Stigler, 1971). While we surely can see growing influence and more intense lobbying by economic actors on policy makers as the importance of the domestic technology standards grows, the capture of these policy makers has been, at most, partial. The

state had a significant, if not exclusive role in initiating all of the major and controversial standards efforts. Indeed, the state pushes for standards often in spite of industry interests (Kroeber, 2007). However, as the economic stakes grow and often the regulators are also co-owners of the standard developer the system does have some of Stigler's characteristics.

Since standards are now enshrined in the national plans, have been given the status of national indicators, and as many organizations and individuals have invested both their political and actual capital in these policies and in the promotion of domestic technology standards, there is very little political will to rethink the system. Many of the actors developing standards in academia or government research institutes are subject to bureaucratic rules of promotion where having promoted a standard is a boon (Zhou, 2001). Consequently, we predict that it would continue for at least the medium if not the long-term. This is especially true as the development of standards has accomplished several critical goals within the Chinese political economy such as reduction of royalties that have nothing to do with promoting indigenous innovation, but are of significant economic consequences.

With this two-step process in mind, we now move to analyze two key cases, fleshing out the above discussed mechanisms and motivations.

### *Audio Visual Standards*

China's attempt to develop a successor standard to the global MPEG-2 digital audio-visual encoding standard followed a distinctly open path. Foreign companies participated in the effort which was generally considered open and fair. Nonetheless, the state still played a profound, if highly confused, role.

In digital media such as digital television, Internet video and music, and optical drives as DVD players, data is encoded to facilitate storage and transfer. Different standards for encoding

and decoding are used to make the process of data storage and retrieval compatible across an array of formats. Since the MPEG-1 standard used on VCDs in the early 1990s, each generation of standards has increased the amount of data which can be stored in a given amount of space and increased the speed at which it can be accessed or transferred. As with other standards, international standard bodies – particularly the ISO and IEC but also ITU – are highly active in the debate, certification and approval of digital media encoding standards.

In 1988, an alliance of twenty five experts from an assortment of media companies and research institutes created the Moving Pictures Expert Group (MPEG) to develop standards for digital media. The group has grown to 350 experts representing 200 companies and is formally a working group under ISO-IEC (MPEG, 2010). In the 1990s, MPEG formed a separate licensing authority (MPEG-LA) to handle the patent licensing and payment of royalties for use of the standard. MPEG-LA represents eighteen patent holders (CNetAsia, 2003). Rates for MPEG-2 (the standard used for DVDs) were \$2.50 for every player sold. MPEG's successor standard – MPEG-4 AVC – initially set its royalty rates at \$0.25 for each player and \$0.04 for every hour of recorded media. Hence every standard two-hour movie DVD would cost additional \$0.04 in royalty to MPEG-LA (Liu, 2003).

As a result of its position as the global manufacturer of digital media players, China's manufacturers and standard developers considered MPEG-2 to be "extortionate" and MPEG-4 to have too harsh of a patent policy (AVS, 2007). To combat the dominance of foreign standards, China's Ministry of Information Industry (MII), authorized and established the Audio Visual Standards (AVS) Workgroup in June 2002. The Workgroup's mission was to develop an indigenous digital video and audio encoding standard free from foreign royalty payments. By December 2003, the AVS Workgroup had completed the system standard and a first draft of the

video frequency standard. One year later the video standard was submitted to MII. On April 30, 2005, MII approved the AVS standard (including audio, video, system, and media copyright protection). Because of its mandated reliance on public technologies and the willing participation of members, royalty rates were approximately \$0.12 per device, for a technologically comparable solution (ChinaDaily, 2003a).

However, instead of the Chinese state and industry supporting this inexpensive, indigenously developed, and technologically sophisticated standard, political battles ensued. A major setback was that The State Administration for Radio, Film and Television (SARFT), which has final authority over media content, sabotaged AVS's chances by announcing China would use MPEG-4, not AVS (Kennedy, et al., 2008; Suttmeier, et al., 2006). It has been argued that SARFT's action was done to preserve its jurisdiction (broadcast media) against policy-making authority encroachment by MII.

On the more positive side, from the point of view of the local industry, MPEG decided to preempt the threat from AVS. After the completion of the difficult video portion of the AVS standard, the head of MPEG-LA visited China in September 2003. He proposed linking AVS to MPEG's standards. The AVS alliance refused. At least partially in response, MPEG-LA cut royalties to \$0.20 per device in November 2003 (Liu, 2003). MPEG-LA further announced that the first 100,000 units off the production lines would be royalty free. Finally, they capped the media royalty at \$0.02 per title.

Such royalty reductions should be considered a clear Chinese success. While the indigenous innovational breakthroughs of AVS may be subject to debate as the standard was based on public technologies and included foreign participants such as On2 Technology, the standard was highly successful in forcing foreign standard holders to alter their behavior to the

benefit of Chinese manufacturers. China's government successfully developed a standard, which was then largely abandoned, but not before it managed to force the global standard setters to back down.

*Optical Storage Media: The Case of Competing Indigenous Standards*

China has a history of standards efforts in optical storage media going back to the early 1990s. Each time the state desired a single new standard, several ended up being produced, and the state proved unable to select between them. As the technology progressed each generation of standards was discarded in favor of a new wave of competing domestic standards, a pattern that persists to this day. Hence, the case of optics storage media is highly illustrative of the two step SRS dynamic leading to the continued proliferation of multiple competing standards development efforts.

Efforts to develop a standard began in the mid-1990s with two new standards for the Video Compact Disc player called China Video Disc (CVD) and VCD 3.0. VCD 3.0 enjoyed strong state support; the Ministry of Electronic Industry strongly supported the standard as an alternative to the foreign-controlled DVD standard and as an indigenous technology. However, the rival CVD alliance moved to preemptively win market share by successfully pushing its products onto the market, without waiting for formal approval. The Ministry responded by integrating the original foreign VCD patent holders' standard with some elements from VCD 3.0 into a single standard – Chaoji VCD, known internationally as SVCD (Linden, 2004). It then successfully applied for SVCD's adoption as an international standard and forced the next generation of players to support both the mandated SVCD and the rival CVD standards.

Production of video compact disc players exploded but was followed by a sharp crash; in 1999 over 200 manufacturers, out of 500 in total, went bankrupt (Kennedy, 2005).

By the late 1990s the DVD player standard, developed by an alliance of Japanese, American and European companies, became popular and hundreds of Chinese manufacturers established production lines. DVD players enjoyed a larger export market and could play DVDs and SVCDs, ensuring a large domestic market. Production exploded from 3.5 million DVD players in 2000, to 70 million – seventy-five percent of world output – by 2003 (Linden, 2004). Despite their production capabilities and large scale exports, profit margins for Chinese companies remained thin, falling to one dollar per unit in 2004 (Kanellos, 2004). High royalty rates became a source of friction and led Chinese manufacturers to take action, including filing a lawsuit in the United States accusing DVD's patent holders of abusing their monopoly power (ChinaDaily, 2005; Pyyny, 2005). None of these efforts significantly lowered royalty rates for the Chinese manufacturers; the case and appeal were dismissed in 2006 and 2008, respectively (Meisner and Lewis, 2008).

In 1999, China's government entered the fray and suggested development of a Chinese standard as an alternative approach to alleviating DVD producers' financial trouble (Clendenin, 2006; Zhang, 2008b). Under MII, several government research institutes and DVD manufacturers formed an industry alliance under an incorporated entity called Beijing E-World Technology (Clendenin, 2006; PeoplesDaily, 2003). MII and the State Trade and Economic Commission provided \$1.2 million USD to begin development of the standard (Smith, 2003). In 2001, E-world released the Advanced High Density Disc System (AVD) – China's first red laser standard. The alliance paired the AVD system with a "basically compatible" Taiwanese system called Enhanced Versatile Disc (EVD). The Taiwanese partners, for reasons never fully

disclosed, backed out of the arrangement shortly thereafter. The arrival of AVD-EVD was shortly followed by a royalty-rate concession from the DVD standard holders. The major patent holders agreed to only charge full royalties, twenty-one dollars, for exported DVD players whereas domestic market DVD players were only charged about twelve dollars (Linden, 2004).

In a repeat of the VCD scenario, competing alliances formed and initiated their own standards development efforts. Three months after AVD-EVD became commercially available, nineteen consumer electronics manufacturers, including Skyworth, Changhong, and TCL – also members of the E-World alliance – announced creation of another alliance to promote a competing standard, the High-clearness Video Disc (HVD), in April 2004 (CTN, 2004a). At the same time a third group led by Beijing K-City High Definition Electronic Technology Company formed an alliance to promote its own high definition standard – High Definition Video (HDV) (AsiaInfo, 2004). In response to uncertainty over which standard would prove viable, Skyworth, Changhong, and TCL joined this alliance as well. As MII debated which standard to adopt as the national standard, a fierce political battle between AVD-EVD and a united front of the HVD and HDV alliances ensued, leading MII (the key force behind the AVD-EVD standard as well as the national regulator) to relent. AVD-EVD was adopted as China's national standard in 2005, but it was neither mandatory nor exclusive (CTN, 2004b; Powell, 2006).

While being touted as China's means to free itself from dependence on foreign proprietary technology, AVD-EVD relied on foreign technology. The VP5 and VP6 codecs were developed and owned by On2, a US company. The decoder was developed in cooperation between a US company, LSI Logic, Beijing Homaa Microelectronics Technology, and E-world (CTN, 2003; Frauenheim, 2004; McDonald, 2006; Powell, 2006; Yoshida, 2003).

While not great commercial successes, these standard efforts had significant positive impacts on two fronts. They may have given the first extensive R&D and upgrading experiences to many Chinese companies such as Skyworth that have since routinized innovation activities (Nelson and Winter, 1982). Most significantly, by bringing China's challenge to global standards into the spotlight, they quickly led to a substantial reduction in the royalties Chinese manufacturers had to pay, which was also a major motivation for companies like Skyworth (Einhorn, 2003). In 2004, while broadly announcing intentions to displace DVD players in China's market with AVD-EVD, the Chinese government pushed for further reductions in royalties for Chinese companies per DVD player. Within a few months, royalty fees were reduced solely for Chinese manufacturers. The rate decreased from over twenty dollars per unit for Toshiba, Matsushita, JVC, Mitsubishi, Hitachi, Time Warner, Philips, Sony, and Pioneer technologies to \$13.80 USD, (Linden, 2004; PeoplesDaily, 2004).

The third stage of these efforts began in October 2005 when China announced plans for a new violet laser high-definition disc player. With broad state support, a three-part alliance formed to develop a high definition, violet laser-based, optical storage technology: China Blue High-Definition Disk (CBHD). The main developers were the Optical Memory National Engineering Research Center (OMNERC) at Tsinghua University, the China High-definition DVD Industry Association, and China Electronics Technology Group (CETC) (Ding, 2009; Yam, 2009). The standard took shape through subsidized research conducted at OMNERC and CETC. The leading commercializers of CBHD players, TCL and Shinco, enjoyed preferential state financing for development and production efforts. In addition, other manufacturers have received state subsidies to accelerate their development of CBHD player models (CDRInfo, 2009b). Once again, first movers hoped to gain monopoly rents from the standard. As Lu Da,

director of OMNERC stated: “China is a large potential market with more than one billion consumers, which is enough to support its own standard” (Ding, 2009).

CBHD was not universally supported within China. Zhang Baoquan of the Antaeus Group, which bought the AVD/EVD standard fought aggressively against the new standard. Zhang accused CBHD’s developers of not only stealing some of AVD/EVD’s technology but also of CBHD not being truly Chinese and therefore undeserving of access to state developmental funds. Similarly to other efforts, while touted as an indigenous standard, up to ninety percent of the technology within the CBHD player is derived from Toshiba’s HD-DVD standard (Hsu and Hwang, 2008). Toshiba, in a bid to win its global standards war with Blu-ray, cheaply shared its HD-DVD technology (Hirooka and Nakajima, 2009). By adopting Toshiba’s technology, China’s CBHD developers also acquired established pools of talent and technology. Companies such as Memory Tech that worked on HD-DVD now support the Chinese standard and offer advice and research assistance to the approximately 120 Chinese manufacturers interested in producing it (Hirooka and Nakajima, 2009).

As with earlier standards in optical storage media, CBHD, and its related technologies, was not the only locally developed standard in this field. A noteworthy project was Guangzhou Digital Rise Technology’s development of an audio-video codec – DRA – for Blu-ray. China’s government forced the Blu-ray Disc Alliance to adopt the Chinese DRA audio-video codec as part of the Blu-ray 2.3 package (CDRInfo, 2009a; ChinaSourcingNews, 2008). Adding the Chinese standard to the international standard was a quid-pro-quo for permitting the sales of Blu-ray products in China. Developing an alternative standard greatly enhanced China’s negotiating position for incorporating its technology. Development of CBHD as an alternative was sufficient threat to force the Blu-ray Alliance to bring in Chinese actors.

However, China did not only support the development of CBHD. The government also encouraged development of Blu-ray capabilities. CESI Technology, a subsidiary of the state-owned China Electronics Standardization Institute, opened the first Blu-ray certification center in Beijing in July 2008 (GlobalSources, 2009). By 2009, twenty-two Chinese companies had licenses to produce Blu-ray devices and use the Blu-ray logo.

More significantly for the overall profitability of Chinese companies, development of CBHD forced a two-part reduction in royalties. In the process of developing CBHD, the alliance secured access to Toshiba's by-then defunct HD-DVD technology at fire sale prices, keeping licensing rates low. Manufacturers need only pay eight dollars per player in royalties. For manufacturers adhering to the international Blu-ray standard, the reduction was also significant, with royalties going sharply down to \$9.50 per player (Ding, 2009; GlobalSources, 2009).

### *Discussion*

Both case studies illustrate the two-step SRS dynamics of standard creation in China as well as the underlying perpetuating mechanisms that ensure continued standards creation even with suboptimal innovation outcomes. For AVS, despite its clear technical advantages, enterprises remained unsure of which direction the state would finally go. They hedged their bets concerning AVS. Legend Holdings, the parent company of Lenovo, participated in the development and approval of AVS, yet at the same time invested in the development of the foreign Digital Home Working Group standard led by Sony, IBM, Intel, Nokia, and others. Keeping with hedging, Legend formed the Chinese IGRS home networking standard working group in China which uses AVS. At the same time, Chinese firms in the AVS group have also submitted over 20 proposals to MPEG since 1997 (ChinaDaily, 2003b). Other companies such as Digirise in Guangzhou pursued development of widgets and component software to incorporate

into foreign standards such as the Blu-Ray disc player, which utilizes the MPEG-4 AVC standard. Many companies joined forces to create the AVS standard, and many continue to support it although its current strength appears to be only within China. It continues mostly as the main encoding system for CBHD and as part of the Legend Group-led IGRS digital home standard. Although AVS remains a standard in use in China, many companies, including Lenovo, are active in the development of and participation in global standards. This ensures that although state support for AVS will continue, the uncertainty over the viability of a wholly Chinese standard, as well as the impracticability of displacing established foreign standards means companies will be forced to continue to develop more standards, and hedge their bets among those already in use.

In optical storage media, the SRS dynamic resulted in repeated rival standards development efforts even as none resulted in great commercial success. From SVCD through AVD/EVD to CBHD, the government initiated standards development efforts and provided financial incentives to participate in development. An alliance of early adopters formed to support the anointed project. A counter-alliance then formed to develop alternatives in order to block the primary standard from becoming mandatory. In addition, similarly to TD-SCDMA, all of the standards were largely based on foreign technology, thus not fully promoting “indigenous innovation.” However, all succeeded in forcing foreign standards-holders to lower their royalties for Chinese manufacturers, a unique and valuable advantage for Chinese firms given their position in international production chains. In all cases, the regulator also invested heavily in the commercialization of the standard and had significant vested interests in its continued promotion. Throughout the development of optical storage media standards in the 1990s and 2000s, the central government did learn from previous mistakes. The standards under development became

more open, and pledges to lock out foreign technologies less strident over time. The state also learned that a standard needed to be comprehensive if it were to be successful. Hence while AVD/EVD suffered from a lack of content, the CBHD alliance worked from an early date to secure the support and participation of foreign and domestic movie companies.

### Conclusion

This paper has argued that for a systematic understanding of the dynamics and outcomes of China's technology standard efforts, we must understand both the various goals for the development of technology standards in China and the particular political-economic dynamics unleashed by the specific policy actions followed by the government. Existing scholarship has explored China's various standards development efforts but not in a systematic manner. It has provided strong predictive theories which can be applied when studying standardization efforts in China and abroad by looking at the alignment of bureaucratic actors and the alliances which coalesce around different standards. However, in the social sciences we should not be content to examine the phenomenon of global standards regimes and their impact on domestic political economies on a case by case basis. For this reason, we have argued that a new theory which explains why standards are created and continue to proliferate is necessary.

We argued that this outcome is the result of a two-step self-reinforcing-sequence. First, standard creation was stimulated by the Chinese government's actions to foster it through various social and economic incentives. In the second stage, other organizations realized that standards might grant their competitors significant competitive advantage, including monopoly status, and began their own technology standard development efforts or joined others' efforts in alliances. This dynamic has transformed into a classic innovation arms race. The un-intended

consequence of this dynamic is a systematic increase in uncertainty with its negative impacts on the behavior of economic actors. However, standard development serves many other useful goals, which are critical to the Chinese industry, such as royalty payment reduction.

Furthermore, today many strong groups in academia, the bureaucracy, and industry have tied their fortunes to standards development. Consequently, we foresee that this situation will continue for at least the medium term.

Accordingly, we argue that if we want to understand technology standard development policy, we have to analyze both the particular political economy dynamics of countries like China, as well as the structure and position of their industries within the global production networks.

A general lesson from the Chinese technology standard case is that international bodies' governance decisions, assuming they can reach a prescribed outcome by importing institutions from the advanced wealthy countries into emerging economies, such as the case of standards and TBT by the WTO, often end with very different market outcomes in different countries. Since the political-economic institutional framework significantly differs, imported institutional regimes for the regulation of IP rights and creating platforms for free-market competition have different functional logics and strikingly different results.

Evidence can be seen outside of China as well. Other countries have used technology standards in unexpected ways. Most famously, Japan used standards policies and regulations to prevent rather than encourage trade throughout the 1970s and 1980s. It was largely due to Japan's creative reinvention of a Western political concept, standards, that the WTO made international standards conformity mandatory in 1994. Under global economic integration we can expect to see more such resourceful uses of existing policy to accomplish other goals.

Accordingly, it is important that technology standards in different political-economic systems be further comparatively studied.

We should also remember that China's performance in technology standards reflects the unique nature of its state. China only superficially resembles an East Asian developmental state. Taking government pronouncements for standards development or pushing technological independence at face value indeed suggests that China is a developmental state, carefully coordinating its economic policies and guiding economic actors, in this case often state-owned, to accomplish government-determined goals. However, viewing China's standards development system in practice reveals the SRS logic, not the action of a coordinated developmental state. China lacks a true pilot agency like Japan's Ministry of International Trade and Industry. China's bureaucracy (the state) is much more fragmented, as is industry, which means attempts to coordinate a standard as a coordinating technology is extremely difficult to execute. Some segments of the state may wish to use standards as a protectionist tool as done by Japan, but also France, the U.S. and the E.U. (Congress 1992; Crane 1979; Egan 2001; Krislov 1997; Milner and Austin 2001). However, the lack of coordination means these measures are largely ineffective, so the benefits to industry from standards in technological upgrading and royalty reduction are unintended but welcome benefits. Nonetheless, the state does exert enough influence to strongly incentivize enterprises to participate in standards development, thus initiating China's self-reinforcing system.

With debates about IPR regimes, such as patent laws, technology standards, and trademarks brewing in international bodies, it is important to remember that the immensely varied contexts in which these would be applied, should lead us to expect diverging, and not converging, outcomes and patterns of behavior. As such, theories which try to understand the

influence of international governance agreements, should not necessarily rely on insight from economic theory, but instead opt to develop a political contextual understanding if they are to offer relevant answers. A dogmatic belief in the universal meaning and working of theoretical concepts developed within specific institutional systems, by arguing that these systems embodies an optimal underpinning of a generally applicable free-market solution, only leads social science and policy makers astray.

	2007	2008	2009	2010	TOTAL
Total Proposed Standards	8617	2136	1877	2296	14926
Projects to Develop New Standards	7703	1823	1528	1195	12249
Projects to Revise or Amend Existing Chinese Standards	914	313	349	1101	2677
Projects Comparable to International Standards (ISO, foreign national, etc)	2815	636	610	846	4907
Standards to be "Enforced"/"Obligatory"	1065	261	204	277	1807
Standards to be "Recommended"	7467	1862	1654	2004	12987
Standards to be "Guides"	85	13	19	15	132

Source: CSSN (2007-2010)

**Table 2 – Value Added for Advanced and High Technology Manufacturing**

Type of Product	Value Added in China (%)
General Purpose Machinery	2.94%
Electrical Machinery and Equipment	2.26%
Measuring Instruments and Machinery for Cultural Activities and Office Work	2.35%
Communication Equipment, Computers and Other Electronic Equipment	1.13%

Source: National Economic Census 2004 Cited in (Bi, 2007)

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