Business and Politics

Volume 6, *Issue* 3 2004 *Article* 4

China Standard Time: A Study in Strategic Industrial Policy

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Abstract

China's industrial policy for high-technology industries combines key features of the policies pursued elsewhere in East Asia such as opening to foreign investors and supporting domestic firms. Leveraging its large market size, China has gone further than other developing countries by promoting standards for products that compete in China with products controlled by major electronics companies. This paper analyzes the experience to date of this Chinese policy in the consumer optical storage industry in the context of China's evolving national innovation system. China's standard-setting policy is politicized but ultimately pragmatic, which avoids imposing excessive costs on the economy. It may also have dynamic learning benefits for Chinese firms who are starting to compete in global markets.

KEYWORDS: product standards, China, industrial policy, national innovation system

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*The author is grateful for support from the Alfred P. Sloan Foundation through grants to the Competitive Semiconductor Manufacturing Center's HR Group at UC Berkeley, the Berkeley Roundtable on the International Economy (BRIE), and the Information Storage Industry Center at UC San Diego. The research was also funded in part by the Institute for Technology, Enterprise and Competitiveness (ITEC/COE) of Doshisha Business School. Thanks to Roger Bohn, Clair Brown, Steph Haggard, Jeff Hart, Scott Kennedy, Dave McKendrick, Elena Obukhova, Anne Stevenson-Yang, and three anonymous reviewers at Business And Politics for helpful comments and other assistance. Any opinions or errors in the text are those of the author.

1. Introduction

The integration of China into the world economy promises to be one of the major themes of the 21st century. Discussions abound about various aspects of China's ongoing transition from autarky to market economy. One point of contention is the speed with which China and its firms will close their technological gap with other nations and become innovators. This study sheds light on the debate over China's pace of technology development by examining the coherence and impact of the government's industrial policy within the context of the country's evolving national innovation system.

China's foreign-investment-fueled export boom is similar to those that had taken place elsewhere in East Asia, particularly the Southeast Asian nations of Singapore, Malaysia, Thailand, and the Philippines. However, China—home to one-fifth of the world's population in an area slightly smaller than the United States—presents a bundle of capabilities and potential that differs from its neighbors in a variety of important ways, including its leverage over foreign firms, its industrial structure, and its capacity for absorbing and developing technology. As a result, China is in a position to promote the development of large domestic firms to be industry leaders, as was done in Japan and Korea.

China's national innovation system has been changing steadily since the economy began to liberalize at the end of the 1970s. Extensive restructuring has rationalized the Soviet-inspired system of isolated government research institutes, state-owned firms, and state-run universities.

The Chinese government wields industrial policy to help improve the competitive standing of Chinese firms. It is now generally accepted that government intervention has at times played a positive role in promoting economic growth in the high-performing economies of East Asia.[1] China's policymakers have drawn on the same tool kit as those who have gone before.[2]

Industrial policy—measures that favor one or more industries (or firms) over others—can take a range of forms, such as educational programs, export subsidies, and preferential loans. Standard setting, the type of industrial policy considered here, can be a benign exercise in regulatory oversight or a focused effort to favor one set of firms over another.

China has adopted a policy of driving the development of product standards for a wide range of electronics products, including consumer video discs, digital televisions, integrated circuits, and cellular telephony. The

[1] World Bank (1993).

[2] For example, the tools used to promote the electronics industry in Korea and Taiwan include public research, trade protection, sector-specific financial incentives, selective government procurement, control of foreign participation, relaxed antitrust regulation, and provision of training and education for sector-specific skills (Dahlman (1993), Table 16.1). China has employed all of these, and differences are more of degree than of kind.

electronics industry has been a major contributor to growth in East Asia.[3] In China, the industry is again assuming a central role, having become the nation's largest industry in 1998 on the strength of both foreign- and domestically-controlled production. In 2002, electronics production in China accounted for approximately 3 percent of the country's GDP and 15 percent of the total worldwide electronics output that year.[4]

Chinese standard setting is designed to decrease dependence on foreign know-how by developing domestically-controlled intellectual property (IP). The indigenous development of IP is a point of national pride, secures China a measure of technological independence, and reduces burdensome royalty payments by domestic producers of high-tech goods.

This paper analyzes the experience of this Chinese high-technology policy in the consumer optical storage (video disc) industry—the first major example of this Chinese strategy—in the context of China's continuing transition to a market-based economy. It begins with a brief overview of the unique aspects of the Chinese economy relative to others in the region. Next it reviews the ongoing transition of China's Soviet-inspired innovation system to a market-based footing, then presents a case study of China's standard setting for two successive generations of optical storage: VCD and DVD. Examples of similar Chinese policies in other industries are given, and a final section analyzes theoretical and practical aspects of China's standard setting.

The background research for this paper was conducted over a period of six years using publicly available resources on the Internet, subscription news databases, and—to a lesser extent—industry interviews, as part of the author's ongoing research on the globalization of the electronics industry and industrial policy in East Asia. Pains were taken to make this research exhaustive given the absence of field research in the methodology. Access to an interview-based study by Scott Kennedy of China's video compact disc (VCD) deliberations was helpful in sorting out some of the discrepancies in publicly-reported versions.[5]

2. Chinese Exceptionalism

China, because of its potential market size and growth rate, enjoys advantages in crafting and implementing industrial policy in areas such as industrial structure, technology transfer concessions, and absorptive capacity that most other developing economies do not. These advantages of size are similar to those enjoyed by the United States from the late 19th century.[6]

[3] Ernst and O'Connor (1992).
[4] "China's Electronics Industry - Analysis and Outlook," *Nikkei Electronics Asia*, June 2003.
[5] Kennedy (forthcoming)
[6] Nelson (1990).

a. Industrial Structure

Industrial structure is an important area in which China stands apart from its neighbors. Development in other countries in the region has been led by either large or small firms while China is developing a dual industrial structure.

With respect to industrial structure, one of the most common comparisons in the development literature is that between Taiwan and South Korea, each of which offers benefits and disadvantages.[7] Korean policies favored the development of large conglomerates that can marshal sufficient resources to become globally competitive. At the same time, Korean business groups absorb the bulk of the financial resources needed for technology development at the expense of small- and medium-size firms. Taiwan, in sharp contrast, has developed largely on the strength of smaller firms with limited internal resources. Small firms in Taiwan's technology sector have often turned to the government or other external sources for technology support.

Both approaches have also demonstrated deeper weaknesses. Many Korean conglomerates became overextended financially, and the 1997 Asian financial crisis brought about the collapse of some (e.g. Daewoo) and the major restructuring of others (e.g. Hyundai). At the other extreme, the small Taiwanese firms have generally failed to develop profitable global brands of their own, with Acer, a top-five brand in personal computers, being the best-known exception.

China's large market potentially allows it to have the strengths of both models without the weaknesses. China, after studying the experience of Japan and Korea, restructured many of its small, uncompetitive state electronics producers into larger groups such as China Electronics Corporation and SVA Group (formerly Shanghai Audio and Video).[8]

However the groups that China created are still relatively small by regional standards and active only within vertical markets so that the country currently lacks horizontally diversified groups in the image of those in Japan and Korea.[9] China's market is large enough to support horizontally diversified conglomerates, but none have emerged so far.

At the other end of the scale, China has steered resources toward nurturing entrepreneurial activity in science park incubators. As in the United States, dynamic small firms can play a complementary role to flagship businesses by exploiting small, but profitable, niches, or perhaps most importantly, by pursuing disruptive innovation that established businesses avoid.[10] The number of domestic, privately-owned start-ups in China (excluding sole proprietorships) accelerated

[7] See Hamilton and Biggart (1988), Fields (1995), Hong (1997), and Mathews and Cho (2000) for examples of the many comparative studies of Korean and Taiwanese industry.
[8] Keister (1998).
[9] Lee and Woo (2001).
[10] Christensen (1997).

steadily during the 1990s to reach 1.5 million in 1999.[11] Programs targeting high-tech start-ups include research grants and incubator premises within high-tech industrial parks that also attract leading state-owned and foreign firms.[12] The government has also been working to clarify and improve the legal rights of private firms, although this remains a work in progress.[13]

In summary, China has fostered a dual industrial structure in electronics that includes large state-owned groups and a sizable pool of small start-ups with both public and private sources of finance.

b. Foreign Investment and Technology Transfer

China's market size has also given it extraordinary leverage over foreign investors, who are a key ingredient of the development recipe followed elsewhere in the region.[14]

Although initial development policies during economic reform pursued import substitution, these gave way after a few years to policies that favored foreign investment combined with technology transfer requirements.[15] China has received foreign direct investment (FDI) on an astonishing scale, especially in the 1990s. In 1993 it received the world's second largest inflow of FDI after the United States as multinational corporations began to pursue low-cost export platforms and sales in the China market itself in response to China's strong growth and steady economic liberalization. The $25.8 billion of FDI in 1993 was more than double the $11.1 billion of 1992 and greater than the entire accumulated inflow from 1979-1991.[16] Inflows continued at a torrid pace, with significant investments in all electronics sectors, including computing, communications, consumer, and components.[17]

The ability of policymakers to demand concessions in exchange for access to a large domestic market reaches its apotheosis in China. The Chinese government has been able to demand and entice technology transfers on a large scale from eager investors vying for the opportunity to market and manufacture their goods there. For example, among the thousands of foreign investments in all industries are more than a hundred research and development laboratories, the best of which are performing research with global applications.[18]

In the electronics sector, the government has exerted its influence repeatedly to extract technology from foreign companies seeking entry, especially

[11] Gao (2002).
[12] ibid.
[13] "China Raises Status of Private Firms," *Wall Street Journal*, 15 October 2003.
[14] Lim and Fong (1991) provide a detailed account of foreign direct investment in four of the region's economies in the electronics and auto industries.
[15] Huchet (1997).
[16] UNCTAD (1994), p. 67.
[17] UNCTAD (2001), p. 26.
[18] ibid.

into government-controlled markets. In 1990 for example, three firms – Alcatel (France), NEC (Japan), and Siemens (Germany) – were given exclusive rights to sell expensive telecom switches in China in exchange for transferring integrated circuit (IC) technology to Chinese IC manufacturers.[19]

c. Absorptive Capacity

A third way in which China stands out among its neighbors is it absorptive capacity for technology. The concept of absorptive capacity was developed at the firm level,[20] but is also applied to the national level to describe the ability of productive agents in an economy to learn and implement technology developed elsewhere.[21] This capacity resides in firms, but is rooted in an economy-wide "social capability" that encompasses the educational system and capital markets, among other institutions.[22]

Most of the countries of East Asia began the post-war years with limited social capability, including the infrastructure for technical education. China invested considerable resources in targeted industrial programs, particularly those that were defense-related, which led to notable achievements such as a successful satellite launch in 1970. China's university system, which dates back more than a century, was not up to the task of educating large numbers of engineers, but social attitudes valuing education as a means to get ahead were already in place at the start of China's economic reforms.

Although China's technology was years behind that of the West in most cases, the basic attitudes and institutions were suitable for adaptation to global competition, as the next section discusses in more detail. As a result, Chinese firms have been able to absorb and apply the technology transfers that the government has negotiated with a rapidity that was unattainable in most other high-growth Asian economies, such as Malaysia and Thailand.

Taken together, these three advantages—a dual industrial structure, leverage over foreign investors, and strong absorptive capacity—position China to close the technological gap with more advanced nations. Without them, China would be limited to supplying cheap labor to the global electronics sector, much as Thailand and Indonesia have been.

3. China's Innovation System in Transition

China already had a relatively well-articulated—albeit dated and dysfunctional—innovation system of its own before opening to outside forces at the end of the 1970s. In the decades before opening, China managed "episodic ventures" of innovation including nuclear weapons development and the world's

[19] "Peking Using Digital Switching Market," *Business China*, 24 December 1990.
[20] Cohen and Levinthal (1990).
[21] Dahlman and Nelson (1995).
[22] Abramowitz (1995).

first synthesis of insulin.[23] Overall, however, the country's technological base was very weak in global terms, and Chinese policymakers have made a concerted effort to update it.

In absolute terms, China's technological resources are considerable. According to World Bank data, China reports 530,000 personnel engaged in research and development compared to about 1.2 million in the United States,[24] a ratio just under 1:2. We now turn to a consideration of the efficiency of the system in which these research personnel are deployed.

A national innovation system, the "set of institutions whose interactions determine the innovative performance… of national firms," consists of many diverse elements.[25] We focus here on the primary domestic institutions in the China system: research institutes, universities, and firms. Multinational firms, which have driven China's remarkable export boom, increasingly figure in China's innovation system, as indicated by the earlier discussion of technology transfer. They will figure in the case studies that follow, but their still-developing role is not addressed in this section.

At the beginning of China's transition to a market economy, its innovation system was split into isolated silos, with government research institutes responsible for research, and enterprises responsible for production. Research institutes were narrowly aligned with whatever ministry controlled them, universities were similarly limited to narrow disciplines, and there was very little research within enterprises.[26]

The government's initial technology development efforts (1978-1985) were focused on improving the research institutes and universities.[27] The research institutes were corporatized and encouraged to obtain funds by competing for state-funded grants, performing contract research for enterprises, or by licensing their technology for a fee.[28] In some cases, research institutes were merged into enterprises, and others have spun off start-up companies.[29]

Meanwhile, China's universities are steadily being transformed to meet the needs of a market-based economy. Annual undergraduate entrants expanded from 400,000 in 1978 to 3.2 million in 2002, with more than a third choosing to study science or engineering.[30] In the mid-1990s, the government instituted a

[23] Fischer and Zedtwitz (2004).
[24] 1999 data from the World Bank's World Development Indicators database accessed at http://devdata.worldbank.org/dataonline on August 29, 2004. In per capita terms, China has 459 R&D personnel per million to 4,103 per million in the United States.
[25] Nelson (1993), p.4.
[26] Kong (2003).
[27] Leydesdorff and Zeng (2001).
[28] Liu and White (2001).
[29] Kong (2003).
[30] Sigurdson (2004). To some extent this rapid expansion favored quantity over quality as faculties needed to be built up in haste, but, as a research executive at a major multinational observed in a

system of competitive grants ("National 211 Project") for university projects that support "pillar sectors of industry" and initiated a nation-wide revision of curricula.[31] The government also encouraged universities to commercialize new technologies with the creation of science parks in close proximity to campuses.[32]

Post-graduate education underwent an even more dramatic expansion—from 10,000 entrants in 1978 to 200,000 in 2002—in addition to the 20 percent of Chinese postgraduates who were studying overseas.[33] Overseas study allows China to leverage resources, such as those of leading U.S. universities that will take its domestic universities many years to equal. From 1988 to 1996, more than 16,000 U.S. doctorates—primarily in science and engineering—were awarded to Chinese citizens.[34] Returnees from overseas are not only an important source of technology for firms and universities, but also act as entrepreneurs.[35]

At the enterprise level, China has managed its transition to open markets gradually in order to preserve and shelter its domestic firms so they can adjust to competition. While this has undoubtedly prolonged production in inefficient enterprises, it avoided throwing the baby out with the bath water and allowed some state-run firms, such as Haier and Konka, to develop globally competitive capabilities for low-end products such as small refrigerators and television sets. This contrasts sharply with the rapid attrition of state-owned electronics producers in Eastern Europe after the collapse of the Soviet Union.[36]

After 1985, Chinese policies increasingly encouraged technical development within state-owned enterprises.[37] The share of research expense attributable to business enterprises (regardless of ownership) rose from about 40 percent in 1991 to 60 percent 10 years later, even as total research spending grew by about four times over the period.[38] Among large and medium state-owned enterprises, the share of revenue attributable to new products rose from 10 percent in 1991 to 15 percent a decade later.[39] In recent years, government support has been expanded to a broader range of enterprises.[40]

September 2004 interview, Chinese universities still turn out a relatively large number of high-caliber engineers and scientists.

[31] ibid. and Li et al. (1996).

[32] Leydesdorff and Zeng (2001).

[33] Sigurdson (2004).

[34] National Science Foundation (1998). This was about twice the number of doctorates awarded to citizens from either India, Korea, or Taiwan during the period.

[35] Saxenian (2002).

[36] White and Linden (2002).

[37] Jiang (1997).

[38] OECD (2002) Chapter 9. According to Naughton (forthcoming), about a third of the year 2000 R&D spending by enterprises was attributable to state-owned firms. Twenty percent was accounted for by foreign-invested enterprises.

[39] Kong (2003), p.21.

[40] Naughton (forthcoming).

To summarize, the Chinese government has undertaken a consistent policy of restructuring the national innovation system to augment the technological resources of its firms and the supporting institutions. But firms, the central actors in that system, remain technologically weak in most cases, which leaves room for government policy to fill the gap while the better firms mature. We now turn to the specific case of policies that were pursued in the market for video discs as one of the early examples of how Chinese policymakers have sought to fill this role.

4. Video Compact Disc

Video Compact Disc (VCD) technology is little known outside Asia. Developed by Philips and Sony, the co-inventors of the audio compact disc, VCD technology uses discs that are the same size as audio CDs to hold about an hour of compressed video, with videocassette-quality image resolution and stereo sound. By comparison, the better-known Digital Video Disc (DVD) technology offers much higher image resolution (about four times as much detail), superior sound quality, and a capacity large enough to hold most feature-length films on a single disc.

In the years before DVD players came to market, VCD took on a prominence in mainland China that it never acquired elsewhere. The main reasons are:

—the absence of a large installed base of both audio CD players (a role that could be filled by VCD players) and VCRs;

—capabilities beyond video playback, such as karaoke;

—the low price of Video CDs (which cost half as much to manufacture as videocassettes); and

—a ready supply of cheap, pirated entertainment in the VCD format.

Very few Hollywood releases were ever legally licensed to the VCD format because copying restrictions were never built in. But about a thousand dollars of equipment is sufficient to make imperfect but salable illegal copies of video tapes, with high-volume copying facilities also well within reach of small-scale entrepreneurs. Not surprisingly, a wide selection of movies became available at street prices of as little as US$1.25 (10 yuan).

VCD players were first introduced in China, although the underlying technology (compact discs and “MPEG” video compression) were developed elsewhere. The initial producer was Wanyan Electronic of the Hefei High-Tech Industry Development Zone in Anhui Province.[41] Wanyan was a start-up company founded with money from the United States (DVS Corp.), Korea (Modern Electronics), and a government research institute (Anhui Modern TV Technology Institute). Wanyan acquired rights to the technology in 1992 and introduced the first players in 1994.[42]

[41] “High-Tech Industries in Vigorous Development,” *Beijing Review*, 16 November 1998.
[42] UNIDO (2001).

In the technology's inaugural year, only about twenty thousand VCD players, some priced at over US$500, were sold in China (see Table 1). The product proved a hit, serving for karaoke as much as for watching videos.[43] Other companies were quickly able to duplicate Wanyan's product, and by 1996 some 200 assemblers had entered the China market and prices began to fall. Hundreds more producers (most of them very small assemblers working from kits provided by component manufacturers) entered in 1997, and the price of a player fell to near US$100 per unit.[44] By 1997, China was by far the world's most important market for VCD players, accounting for about three-quarters of the fifteen million units sold worldwide.[45] Although most of the players sold in China were locally assembled, the key components (integrated circuits and the optical drive mechanism) had to be imported.

Table 1: VCD and DVD Sales in China (all brands and models)

Year	Number of VCD Players	Number of DVD Players
1994	20,000	-
1995	630,000	-
1996	2.85 million	-
1997	10.96 million	40,000
1998	14.30 million	300,000
1999	22.00 million	1 million
2000	21.50 million	3 million

Source: VCD data from Kennedy (forthcoming); used by permission. DVD data from various news reports; sources available on request.

The affordability of VCD players was further helped by the willingness of the primary patent holders to forgo their royalties in China.[46] The patents covering the VideoCD 1.0 and 2.0 standards are owned by Japanese and European companies (Matsushita, JVC, Sony and Philips). The motivation of these companies, all of whom have large-scale investments in China, has not been made public, but they may have found compensation in other areas and chose not to make waves.[47] For example, by the mid-1990s, China was virtually the only

[43] ibid.
[44] "Multimedia Popularity of disc players catches market off guard," *China Business Review* (*South China Morning Post*), 11 December 1997.
[45] Parker (1998).
[46] "China flexes standards muscle," *Electronic Engineering Times*, 24 November 1997.
[47] An industry expert responding to an earlier draft of this article suggested that the companies might not have been confident of getting a fair hearing on the issue had they raised it. Nevertheless, their gains from other product areas would still have been a factor in the decision whether, and how aggressively, to pursue the royalties.

remaining market for the relatively slow 1x CD-ROM drives, allowing Philips and Sony to receive income from technology that was obsolete in major world markets. Furthermore, non-enforcement of royalty rights is not unique to the optical storage market. The patent holders for the GSM cellular standard, all of whom have multiple activities in the China market, have reportedly also overlooked royalties from Chinese manufacturers which could have reached $4 each on tens of millions of units a year.[48]

5. A Chinese Standard for VCD

The importance of the China market for the VCD industry potentially gave the country strong leverage over the technology, a fact which was not lost on the country's policymakers.

The key technology for VCD players is embedded in the integrated circuits (commonly called "chips") that contain the algorithms for decompressing the video signal. The three leading suppliers to the market during its boom period were all U.S.-based: C-Cube Microsystems (which claimed a 70 percent share of the market in 1997), ESS Technology, and Oak Technology.[49] These companies—all eager to leverage their technology base in the potentially enormous China market—were central to the effort to launch an updated standard since Chinese chip firms at that time lacked the necessary know-how.

In September 1997, China's Ministry of Electronics Industry (MEI) held a meeting with the Chinese VCD vendors and the leading (U.S.-based) suppliers of VCD chips to announce plans for new extensions to the VideoCD 2.0 standard that added Internet connectivity and other interactive features.[50] The ministry hoped that the next generation of VCD players would become a multi-purpose platform for emerging Internet, game, and educational applications. This would not only place a uniquely Chinese fingerprint on a popular product, but also, with luck, develop into a homegrown export.

The VideoCD 3.0 standard favored by the ministry—basically a minor augmentation of 2.0 that would require a change only in the main chip—had been proposed by ESS and EnReach Technology, a ten-person Silicon Valley start-up.[51] As part of the deal, EnReach, founded two years earlier by a Chinese expatriate, agreed to share several of its patents with China in hope of earning royalties on the rights that it retained.

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[48] "China's handset makers prepare to call overseas," *Electronic Engineering Times*, 26 July 2004.
[49] ibid.
[50] "China carves a role in consumer design Initiative on Video CD 3.0," *Electronic Engineering Times*, 4 October 1997.
[51] The multimillion-dollar fixed cost of a chip redesign was easy to justify with a potential market of millions of units selling at tens of dollars each.

An advanced VCD was just one of the standards-development projects being pursued by MEI in 1997.[52] In each case, the government (represented by either MEI or the Ministry of Post and Telecommunications) sponsored a standard that varied from a dominant global standard. The immediate goal was to own intellectual property that could be used to reduce royalty payments by domestic manufacturers either directly by selling their own product or through use as a bargaining chip in royalty negotiations. A secondary goal may have been to skew the playing field to favor local firms over foreign competitors with a form of non-tariff measure, although not one, it should be noted, that has acted as a barrier to trade.

Nine products beside VCD were chosen, including digital cameras, TV broadcast equipment, DVD players, laser disk players, digital VCRs, digital audio tape players, set-top boxes, analog phones, and digital phones. The first standard released in this program concerned analog cordless phones, where China adopted a 45/48 MHz standard instead of the prevailing 46/49 MHz.[53] Several notable projects of this type are described in more detail in a later section.

To further enhance the intellectual property position of Chinese standards, the government began collecting and pooling patents from its own agencies and from foreign and domestic companies, universities and research institutes to form a foundation for the domestic high-tech industry. Acer, a major Taiwanese electronics producer, is reported as agreeing to "patent pooling" with China prior to its release of a PC/VCD hybrid product in the China market.[54]

6. Policy Meets the Market

While the government-sponsored standard was still under development, a competing VCD standard was demonstrated by C-Cube Microsystems and received backing from a coalition of Chinese VCD assemblers. CVD (for “China Video Disc”), the standard proposed by C-Cube, had a lower picture resolution than the government standard, but not so much that the difference could be detected on the pre-digital TV sets most commonly in use at the time.

The field got even more crowded with a competing proposal, HQ-VCD, from the primary VCD patent holders and a fourth option from MEI’s own working group.[55]

In June 1998, the Ministry of Information Industry (MII, a super-ministry which had absorbed MEI) held an industry meeting to settle on a format, with the various proposals under consideration differing mainly in how close their screen resolution would come to the eventual rival technology, DVD.[56] At the time of the

[52] “China flexes standards muscle,” *Electronic Engineering Times*, 24 November 1997.
[53] ibid.
[54] ibid.
[55] “Factions battle for upper hand in setting Video CD spec,” *Electronic Engineering Times*, 19 June 1998.
[56] ibid.

meeting, DVD component suppliers were rounding up support for the format among Chinese electronics producers, but DVD players would initially cost more than twice as much as VCD players – a high barrier in the price-conscious mainland market.[57]

C-Cube and its partners forced the issue by rolling out players supporting the CVD format ahead of the official standards meeting in a maneuver typical of consumer electronics standards battles in less-controlled markets.[58] However, this gambit apparently backfired when MII announced in July that the final standard would combine HQ-VCD (the standard owned by the major international electronics firms) and unspecified intellectual property from MII's internally developed format.[59]

The new standard, officially known as Super VCD (SVCD), was announced in September 1998.[60] In light of the fact that hundreds of thousands of players supporting CVD had been sold, it was also required that next-generation VCD players sold in China be able to play discs of both types (SVCD and CVD). Chip companies rapidly introduced the necessary modifications, and by mid-1999 SVCD players were outselling VCD 2.0 players as the total size of the market continued to grow.[61] The Chinese government also registered SVCD as an international standard.[62]

VCD and SVCD players became, briefly, an important export item. In 1999, 6 percent of China's audio-visual exports were VCD players. Tens of millions of units were exported, with other Asian countries as the primary market.[63]

The VCD industry as such did not offer a very attractive target for policy intervention, having a relatively short expected market window before the price of DVD players would fall to a level that would make it the dominant player. China's technocrats tried to evade obsolescence by evolving the VCD player into an internet appliance, but, like many such efforts in the private sector, it suffered by comparison with the more-versatile personal computer.

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[57] "DVD suppliers work on a jump-start from China," *Electronic Engineering Times*, 13 February 1998.

[58] "Factions battle for upper hand in setting Video CD spec," *Electronic Engineering Times*, 19 June 1998.

[59] "China chooses consortium plan for Video CD," *Electronic Engineering Times*, 17 July 1998.

[60] "Electronics manufacturers ready SVCD systems for market," *Electronic Engineering Times*, 13 October 1998.

[61] "Super VCD players outclass VCD in mainland China," *Asian Sources*, 26 May 1999. ESS Technology has been the leading chip supplier to the VCD market since 1998, showing that C-Cube's strategy was unsuccessful.

[62] "China's Info Ministry Uses Technical Standards to Boost VCD Market," *Xinhua News Agency* via *Asia BizTech*, 12 September 2000.

[63] "Bargains abound in mature VCD player industry," *Global Sources*, 3 November 2000.

Another problem from the perspective of industrial policy is that the once-profitable product line offered no barriers to entry, so VCD support efforts didn't translate into stronger domestic electronics firms. The necessary chips, mechanisms, and cases were readily available, and kit assembly offered little or no economies of scale. The number of mainland firms assembling VCDs hit 500 in 1998, with many of these being very small. Prices naturally plummeted even for players that included proprietary features, and at least 200 producers closed up shop during 1999.[64]

Perhaps surprisingly, VCD player production remained relatively stable, with some 50 million units manufactured in China in 2002.[65] Although DVD player prices have dropped significantly since their introduction, VCD prices declined even more, creating a price ratio of 3-to-1 or better as of late 2004.[66]

VCD's price-quality trade-off has continued to prove attractive in rural China and in many developing countries. After experiencing a decline, China sales actually grew in 2003 to 23 million units. Growth markets for VCD player sales have emerged in India (18 million units in 2003) and in Eastern Europe (15 million).[67] The export growth has not, however, benefited backers of China's Super VCD standard, since those players remain virtually unsold outside China.[68]

7. DVD

Even as the VCD standards rivalry was playing out in a high-profile contest that extended to competing TV ads, large Chinese electronics assemblers were converting some of their VCD lines for the assembly of DVD players.[69] Initial acceptance of DVD technology was limited by its higher price and its anti-piracy measures whereas the ready availability of pirated movies on VCD had been a major contributor to its success.[70]

Entry by assemblers was more difficult than for VCD, which also tended to keep prices higher. DVD player production lines are more expensive and complex than those for VCD players.[71] Nevertheless, mainland output of DVD players rose rapidly. In 2000, some 3.5 million players were produced, of which nearly 2 million were for export.[72] By 2003, China's DVD player output had soared to 70 million units—about three-quarters of worldwide output—of which

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[64] "Pricing mayhem throws supply into a tailspin," *Asian Sources*, 23 September 1999.
[65] "Prices for VCD player chips to be stable by year-end," *DigiTimes.com*, 5 September 2003.
[66] "ESS product to vie with VCD players," *People's Daily Online*, 10 August 2004.
[67] ibid.
[68] ESS Technology Inc. Form 10-K for the fiscal year ended December 31, 2003. Many models of DVD players are backward compatible with SVCD.
[69] "China's DVD Players to Go on Market Soon," *Xinhua Electronics News* via *IDG China News*, June 1998.
[70] "Pregnancy highlights new VCD pirate tactic," *South China Morning Post*, 25 September 1998.
[71] "Hong Kong confident of potential of no-frills DVD," *Asian Sources*, August 1999.
[72] "DVD sales to soar," *Global Sources*, November 10, 2000.

some 5 million were sold domestically.[73] This massive output permitted economies of scale for the largest producers that facilitated vigorous price-based competition in a product market with few options for differentiation.

The Chinese government didn't ignore the advent of DVD technology. It initially sought to gain leverage by supporting local development of the key components that account for most of the value of a DVD player: the optical pick-up and the video decoder chips.[74] The entrenched position and advanced know-how of the global electronics giants was, however, too strong to permit much progress in this direction.

In theory, entry was more costly in the DVD market because the patent holders required license fees of US$15 to US$20 per player. In addition to two DVD patent pools, other license fees were owed to Thomson Multimedia, Dolby Labs and several other owners of compression and copy protection technology.[75] Chinese-owned companies ignored the requirement as long as they could, but finally relented in the face of pressure from the patent holders against a backdrop of China's acceptance into the World Trade Organization.

In 2002, the primary patent holders (Toshiba, Matsushita, JVC, Mitsubishi, Hitachi, and Time Warner) negotiated a rate of about US$4 per player.[76] A second group of patent holders (Philips, Sony, and Pioneer) was reported to have arranged for another US$5 per unit, but both groups conceded royalties on units sold within mainland China at least through the end of 2002,[77] although the issue remained unresolved in mid-2003.[78] The value of the initial concession was on the order of US$50 million.[79]

The royalty issue, largely undisputed in the case of VCD players, came to a head for DVD players because of their greater salience for the Japanese patent holders. Whereas VCD players are mostly for internal Chinese consumption, or for developing markets, exports of DVD players from China displaced higher-priced Japanese exports to the U.S. market.[80] This helps explain why the patent holders ultimately settled for royalties on exported players only.

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[73] "Patent fees drag down DVD player exports," *People's Daily*, 3 August 2004.

[74] "China's components makers to benefit from DVD boom," *Asian Sources*, 12 April 1999; and "CAS develops proprietary 650nm DVD laser, production commences," *Asian Sources*, 24 November 1999.

[75] "Chinese DVD Player Makers Avoiding Patent Fees," *Asia BizTech*, 22 January 2002.

[76] "Export prices of Chinese DVDs up US$10 due to patent fees," *ChinaOnline*, 8 August 2002.

[77] "Chinese manufacturers agree to pay patent fees to DVD-technology developers," *ChinaOnline*, 10 October 2002.

[78] "China DVD makers expected to pay 100 mln USD royalties in 2003 – report," *AFX-Asia*, 3 June 2003.

[79] "Japan, U.S. Give Up Part of DVD Patent Fees in Row with China," *Jiji Press Ticker Service*, 5 October 2002.

[80] "China-made DVD players dominate U.S. market," *ChinaOnline*, 19 August 2002.

8. EVD: A Chinese Standard for DVD

Even as the royalty issue was being negotiated, the Chinese government began pursuing an alternative, but similar, format to DVD that could give it leverage in negotiations or at least lay the groundwork for a stronger position in future. A consortium of industry and government research institute (GRI) members was formed in late 1999 and given a $1.2 million subsidy to develop and manage the new standard.[81] During the next two years, they developed a standard called "Advanced High Density Disc System," (known as AVD) that utilized the DVD physical platform but was technically an enhanced version of Super VCD.[82]

The effort might have faltered in the face of the global acceptance of the DVD standard, but got a new lease from a related project in Taiwan that was started in early 2002, partly through the instigation of the Chinese working group. The Taiwanese research group, also made up of industry and GRI personnel, studied the proposed Chinese standard and developed a similar but still more advanced format they called "Enhanced Versatile Disc" (EVD) that was "basically compatible" with China's AVD.[83]

The incentive to pursue the alternative was relatively large, with Chinese authorities claiming that patent fees payable on EVD players would be just one-third those for the DVD equivalent.[84] EVD players would offer better-than-DVD resolution but be backward compatible with VCD, Super VCD, and DVD discs. EVD players would also be capable of connecting to home computers for interactive games or other uses. On the production side, the only major change from DVD players would be in the chips required.

In the fall of 2002, participants from both sides of the Taiwan Strait signed a cooperation agreement for the development of EVD products, but the Taiwanese companies, for reasons that have not been disclosed, went their own way by backing FVD, yet another breakaway standard under development in a government lab.[85]

The resolution of license fee disputes with DVD patent holders in late 2002—with its large concession for players sold in China—undercut the potential

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[81] "China's EVD Video Push Is a Bid To Climb Electronics Food Chain," *WSJ.com*, 19 February 2004. One of the lead firms in the consortium, Jiangsu Shinco Electronic Group, reportedly spent $3 million on EVD development.

[82] China Proposal to International Electrotechnical Commission, Technical Committee 100, "*Advanced High Density Disc Systems*," dated 10 September 2001, accessed electronically at http://www.y-adagio.com/public/confs/oitda/iopto_0207/refs/China%20proposal.pdf.

[83] "Taiwan joins Chinese effort on proprietary DVD format," *Electronic Engineering Times*, 24 May 2002.

[84] "Now, a 'super DVD' made in China," *The Straits Times (Singapore)*, 17 July 2002.

[85] "DVD, EVD, now FVD: OES announces new development," *DigiTimes.com*, 6 January 2004. No FVD products have come to market as of this writing (October 2004). The reasons for the collapse of cross-strait collaboration on EVD have not become public.

China market for EVD players by keeping domestic DVD prices low. Royalties on domestically-sold DVD players are about $12 each versus $21 for exported players.[86]

EVD players (using chips from U.S. company LSI Logic) came to market in January 2004, but faced a host of negatives that would limit sales.[87] First, relatively few movies are available in the format, whereas pirated DVDs have become ubiquitous in China since the format's anti-piracy system was overcome.

Second, the first EVD players cost about twice as much as DVD players. This was not helped by the $15 royalties negotiated for providing DVD compatibility in EVD players.[88] Although only two-thirds the royalty on exported DVD players, the fee is slightly higher than the previously agreed level for domestically sold units.

Third, the relatively low quality of the vast majority of TV sets in China made the HDTV-quality video output of the EVD format unnoticeable.

Fourth, two more China-born extensions of DVD, known by the confusingly similar acronyms HVD and HDV, have appeared on the market and created additional confusion in the minds of Chinese consumers.[89]

It seems fairly certain that EVD hardware will amount to nothing more than a small footnote to the DVD market as the global leaders prepare to bring to market their next-generation optical storage formats (Blu-ray and HD DVD), further narrowing EVD's market window. Nevertheless, it is possible, based on the timing of various announcements discussed above, that EVD played a role in the DVD royalty negotiations between China and the global electronics giants by improving the fallback position of the Chinese who could, in the event of a dispute, have placed restrictions on the sale of non-EVD players in China.

9. Chinese Standard Setting For Other Products

In the optical storage industry alone, we have seen that the Chinese have, on two occasions, developed a local variant of foreign technology to improve the competitive position of Chinese firms. The pattern has been repeated in other electronics markets, and this section will briefly review a few of the most prominent cases with a view toward demonstrating that, while China's efforts are widespread and ambitious, its approach is ultimately pragmatic.

One of the highest profile standards efforts by China, which as of 2002 became the country with the world's largest number of cellular subscribers, is that of next-generation ("3G") cellular telephony, designed to handle data as well as voice. In the mid-1990s, Chinese scientists began work on a variant of existing

[86] "China bares technology standards," *Electronic Business*, June 2004.
[87] "EVD players proving not so hot on market," *China Daily*, 10 January 2004.
[88] "China's EVD Video Push Is a Bid To Climb Electronics Food Chain," *WSJ.com*, 19 February 2004.
[89] "China's EVD Standard becomes the industrial one," *China Economic Net*, 21 July 2004.

3G systems. The government joined with Germany's Siemens to create a partly-China-owned cellular system by agreeing to further develop Siemen's TD-SCDMA, a 3G technology that had failed to become a major standard.[90] China and Siemens submitted a joint proposal to the International Telecommunications Union, which accepted TD-SCDMA as a standard alongside the two leading 3G standards, W-CDMA and CDMA2000.

TD-SCDMA has garnered support from major telecom firms in the run-up to the awarding of 3G contracts in the China market. Most notably, Holland's Philips and Korea's Samsung (one of the world's largest producers of cellular handsets) have thrown their weight behind the system, at least for the China market, by entering a joint venture with one of the largest Chinese producers of telecom gear, state-owned Datang.[91] Other key companies that have started development projects related to the technology are Texas Instruments, the largest supplier of chips for cell phones, and Nokia, the largest producer of handsets.[92]

The government officially set aside spectrum for TD-SCDMA in October 2002 and conducted trials in April 2003.[93] However, because of slower-than-anticipated development of commercially viable TD-SCDMA hardware, the final award of 3G licenses has been delayed until at least 2005, at which time it will become known whether a TD-SCDMA-based network will actually receive one of the valuable 3G operator licenses.[94]

High-Definition Television (HDTV) broadcast technology is another area where China has worked to develop its own standard alongside those of the United States, Europe, and Japan. The development effort, a broad government-university-industry program, started in 1994 and led to the demonstration of a prototype in 1998.[95] A final decision about the national standard was due in 2003, but has been delayed due to the unsatisfactory performance of the domestic standard in early trials.[96]

Computer chips are another product where China is striving to implement its own intellectual property. The most technologically, if not commercially, significant progress to date is the development of an Intel-compatible microprocessor, called the "Godson" (sometimes translated as "Dragon") chip,

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[90] "Chinese Challenge Mobile Giants With Third-Generation Technology," *WSJ.com*, 5 June 2000.
[91] "Joint venture gives Chinese 3G spec a boost," *Electronic Engineering Times*, 20 January 2003. Datang owns core patents for the TD-SCDMA standard.
[92] "Nokia-TI venture takes aim at China's 3G market," *Electronic Buyer's News*, 1 March 2002.
[93] "China's 3G Mobile Standard Is Set to Hit Market in 2004," *Dow Jones Newswires*, 31 October 2002; "China's 3G drive prompts industry maneuvering," *Electronic Engineering Times*, 21 April 2003.
[94] "China Prepares for Full Launch Of Its Homegrown 3G Standard," *Wall Street Journal*, 23 June 2004.
[95] "China stages HDTV prototype trial," *Electronic Engineering Times*, 15 September 1998.
[96] "Consumer electronics donning more video apps," *EETAsia.com*, 1 January 2004.

developed by the Chinese Academy of Sciences in 2001.[97] The chip is relatively low-tech at 266 MHz—equivalent to the first Pentium chip introduced in January 1998—but was immediately put to use in network computers purchased by schools and government departments, with an alliance formed to develop additional applications.[98] "Godson" is just the first step on a development trajectory, and a more-advanced "Godson-2" is under development.[99]

One area where the government seems especially keen to encourage the development of domestic standards is networking. In July 2003, for example, a public-private group was formed for the development of communication standards for all types of devices that could be connected to a network.[100] Known as "Intelligent Grouping and Resource Sharing," the new standard is already being incorporated in prototype products that Chinese firms hope to bring to market ahead of products supporting a standard still under development by an international consortium known as the Digital Home Working Group that includes Intel, Sony, and Microsoft**.**[101]

China's standard-setting efforts became directly confrontational in December 2003 when, invoking national security concerns, the government announced a mandatory encryption standard (known as "WAPI") for all wireless networking equipment to be sold in China after May 2004. The technology is proprietary and could only be incorporated into products in cooperation with one of two dozen Chinese companies that were authorized for the purpose.[102] Because the proposed licensing procedure involved disclosure of sensitive information by the foreign manufacturers, many of the leading companies, including Intel and Broadcom, balked at the requirement. The dispute was escalated to the government-to-government level and was finally resolved in an April 2004 meeting of the US-China Joint Commission on Trade, at which China backed down from the requirement.[103]

Other areas in which China is pursuing domestically-driven standards development include digital cameras, rear-projection televisions, and video compression.[104] China's policymakers have also pursued standard setting in a

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[97] "China Develops First Home-Made CPU Called 'Godson'," *Xinhua News Agency* via *Asia BizTech*, 17 October 2001.

[98] "'Dragon Chip Industrialization Alliance' Founded," *People's Daily*, December 25, 2002, accessed via www.china.org.cn/english/scitech/.

[99] "Chinese start-up readies 64-bit processor," *Electronic Engineering Times*, 5 March 2003.

[100] "Legend and Four Other Enterprises Form Working Group to Embrace a New Vision of Industry Applications," Legend Group Press Release, 17 July 2003.

[101] "China promoting its own interoperability spec," *Electronic Engineering Times*, 20 May 2004.

[102] "Efforts on to squelch China's wireless encryption plans," *Electronic Engineering Times*, 27 February 2004.

[103] "China backs off of WAPI proposal," *Electronic Engineering Times*, 21 April 2004.

[104] "China's digital camera standard in pipeline," *Korea Herald*, 3 August 2004; "China to set standards for LCOS RPTVs, aiming to achieve self-reliance on technology," *DigiTimes.com*, 14 April 2004; "China to snub MPEG standard for own format," *CNETAsia*, 1 August 2003.

regional context. High-level meetings between representatives of China, Japan and Korea have led to cooperation in areas such as "fourth-generation" cellular telephony, open-source operating systems, and "smart tags" for tracking product inventory.[105]

10. Chinese Standard Setting in Perspective

As the previous section makes clear, the Chinese government is actively engaged in the development of product standards across a broad swath of the electronics industry. In this section we analyze this policy in terms of its theoretical justifications and its actual impact.

The current standard-setting system in China is highly politicized in comparison with the usual system for establishing standards in the global electronics industry. David and Greenstein (1990) provide a useful typology of normal standard-setting processes in the information technology sector, most of which take place at an international, rather than a national, level. The two main categories are *de facto* (settled in the market) and *de jure* (determined by industry or government committees).

In the electronics industry, the communications sector is most likely to implement de jure standards due to government ownership of the communications infrastructure in many countries. Standard setting in the computer and, especially, the consumer electronics industries is much more likely to be settled in the marketplace, with the classic case being that of the VHS-versus-Betamax struggle of the late 1970s.

China, for its part, retains the right to involve government in all standard-setting decisions.[106] This is not a unique state of affairs on a case-by-case basis, especially in Asia, where even an advanced economy like Japan uses government-led consortia to drive standards development for new markets such as networked digital products.[107] In Europe, the effort to create the very successful GSM cellular standard in the 1980s was initially led by state-owned telecom operators and the European Commission. But China seems far more committed to this path than any other country.

a. Justifications

We next turn to a consideration of what both observation and theory tell us about the justifications for this type of industrial policy.

The most frequently enunciated goal of the policy is to reduce royalty payments to overseas patent holders, which run to hundreds of millions of dollars

[105] "Japan, Korea, China Aim to Jointly Counter US Dominance," *Nikkei Electronics Asia*, 13 May 2004.
[106] Kennedy (forthcoming).
[107] "METI, Electronics Firms to Jointly Craft Net Appliance Standards," *Nikkei Electronics Asia*, 26 August 2004.

annually.[108] A more immediate potential benefit is leverage in negotiations over royalties. The DVD case is strongly suggestive of this because of the way in which EVD, the Chinese variant standard for DVD seems to have lost support once the royalty negotiations with patent holders were settled on relatively favorable terms. Events in the next-generation cellular telephony market may well be following a similar path since Qualcomm, the primary patent holder for CDMA cellular technology, agreed to royalty rates for domestic shipments of CDMA handsets made in China (2.65 percent) that were roughly half that for domestic shipments in Korea (5.25 percent), another important CDMA market.[109]

In game theoretic terms, the availability of a China-developed standard improves China's "threat point" (fallback position) during royalty negotiations. China's market is very important to the major electronics producers, and the prospect of Chinese companies turning out a renegade or incompatible product is an unappealing one for foreign producers. Although China's standards development undoubtedly enters as at least a nuisance factor in royalty negotiations, it is impossible to know how important it has been compared with the many other considerations taken into account during royalty negotiations, particularly the sheer size and growth potential of the mainland market.

A longer-term goal is to help leading Chinese firms to secure technological leverage. As the similar policies pursued for both the SVCD and EVD product generations demonstrate, the pursuit of this goal has been consistent. The advantages procured by such programs to date have been slight, but as China closes the gap with more advanced countries over the next ten years, the impact on global standards can be expected to increase as it has, for example, in Korea, where local firms with rapidly expanding patent portfolios have contributed intellectual property to worldwide video compression standards, among others.[110]

In the context of the still-evolving national innovation system discussed earlier, the government can be seen to be compensating for weaknesses in its firms, universities, and enterprises by acting as coordinator and guide. As some Chinese companies become technologically developed enough to pursue their own interests in global standard-setting procedures, the role of government will likely be reduced as has occurred with similar interventionist policies in Japan and Taiwan.

Such an evolution points to the potential dynamic benefits of the policy. Some of the firms participating in government-sponsored standards projects will

[108] "Patent war looming large in China: experts," *People's Daily*, 9 October 2003.

[109] "Korean telecom equipment firms expected to maintain current agreements with Qualcomm," *Korea Herald*, August 18, 2001. Renegotiation in Korea was apparently avoided by adopting a higher rate for exports from China (7 percent) than from Korea (5.75 percent).

[110] Albert, et al. (1998). Table 3A shows that U.S. patents in the information technology field filed by Korean inventors rose from 4 in the period 1982-1986 to 1,629 in the period 1992-1996.

internalize the process of developing advanced technology and dealing with international standard-setting bodies. Chinese firms are already increasing their participation in international standards groups. Chinese firms Konka, Huawei, TCL, and others, joined the Digital Home Working Group alongside industry leaders such as Microsoft, Sony, and IBM.[111] More significantly, China's largest telecommunications equipment firm, ZTE, was chosen in July 2004 by a committee of the Geneva-based International Telecommunication Union to draft two key aspects of a forthcoming "Next Generation Network" standard.[112]

This direct participation of Chinese firms in international standard setting demonstrates that the experience of China's official intervention in this area is part of a larger learning process for firms and for policymakers. To the extent the firms can develop new technologies of their own, they can become stronger global competitors.

Greater technological leverage against foreign producers won't necessarily translate into profits for Chinese firms. To the extent that domestically developed intellectual property is a public good freely available to many domestic firms, any profits, or what economists call "producer surplus," will be competed away allowing consumers to reap the benefits. This tendency to oversupply is evident in China's DVD market, where prices have dropped about 30 percent annually, and some 30 producers left the market in the first half of 2004.[113]

Lastly, a non-economic motivation for government-led standard setting is national pride. Chinese announcements about these standards development programs tend to inflate their significance and understate the contribution of foreign technology sources. Such pronouncements promote a positive, dynamic image of the economy and, by extension, the government both in China and abroad.

b. Evaluation

Having discussed the possible justifications for China's technology policy, is the policy a success? The short answer is that there has been little material benefit attributable to the policy to date, but it has laid a foundation for future developments.

China's standards development has so far been limited to adapting technologies that are primarily foreign-owned. Furthermore, the standards have had marginal impact even in the domestic market. On the plus side, China's delays in introducing new standards, such as those for digital television and next-

[111] "China promoting its own interoperability spec," *Electronic Engineering Times*, 20 May 2004. The DHWG was subsequently renamed The Digital Living Network Alliance (see http://www.dlna.org)

[112] "ITU pushing to deliver on next generation network standards," *CommsDesign.com*, 23 July 2004.

[113] "Enlightenment from the decline of China's DVD player industry," *China Economic Net*, 31 August 2004.

generation cellular telephony, may prove beneficial by allowing time for the technology to mature and equipment prices to fall as other nations incur the cost of acting as technology pioneers.

The ideal evaluation of these standard-setting policies would take the form of a cost-benefit analysis, but this is impractical for several reasons.

First, it is too early to make such an evaluation. The effects of technology policy may require a decade or more to become apparent. In Taiwan, for example, an ambitious technology policy for the chip industry was launched in the mid-1970s, a time when the island economy would have seemed to have little chance to participate in a fast-moving and technologically advanced sector. It was twenty years before the success of Taiwanese chip manufacturing became a reality and the technology gap with leading producers was closed.

China's efforts to date should be seen as a foundation on which future, similar efforts will build. As discussed above, Chinese engineers are learning about the requirements of the market and the politics of international standard setting, while the better Chinese companies are developing their global marketing and distribution channels. As the technology gap closes between Chinese firms and global market leaders, it becomes more likely that a Chinese company will contribute valuable intellectual property to a worldwide standard.

A second, but not insurmountable, impracticality of a cost-benefit analysis is the scarcity of data. Governments are notoriously reluctant to divulge how much they spend on various technology initiatives.

A third challenge is the impossibility of knowing what the outcome would have been in the absence of the policy, from which the true opportunity cost of the resources can be calculated. Any policy intervention distorts the market and creates social losses relative to a free market outcome.

The distortion due to China's standard setting is potentially large because the way in which proposed standards come to the attention of influential bureaucrats is politicized and opaque, as outposts of the country's vast and fragmented innovation system vie for patronage. The controversial "WAPI" wireless encryption standard that the government mandated was initially developed at a provincial university with alleged ties to the military that may have helped it escalate the technology to a level where it became the subject of bilateral China-U.S. negotiations.[114]

As a practical matter, it is particularly complex to calculate distortionary effects in a transition economy such as China where the state still controls many of the financial and industrial levers of power, such as energy prices and exchange rates, which adds confounding layers of distortion.

The level of distortion attributable to government-led standard setting may, however, be slight because China's standards have so far not been imposed

[114] "China Sees a New Way To Steer Tech Market: Touting Own Standards," *Wall Street Journal*, 23 April 2004.

on the market, apart from the anomalous experiment with WAPI. Prior to that, Chinese officials have regularly indicated a reluctance to force market outcomes. For example, Liu He, standing deputy director of the State Development Planning Commission's State Information Center, said in 2000: "China should take advantage of powerful market forces and establish its own technological standards according to market trends—and not governmental powers."[115] Similarly, China's Science and Technology Minister Xu Guanhua was cited as saying, with respect to China-developed standards, that the government would continue to support their development, but "will not interfere with market competition."[116]

Such pronouncements can easily fail to be borne out in practice, especially under an authoritarian regime such as China's. It is reassuring to note, however, that in the Super VCD example above, which is perhaps the only case of China's standard setting that has played out well into the life cycle of a product generation, the outcome allowed multiple variants of Video CD to co-exist in the market. The fact that China's EVD standard is being allowed to languish in the market while DVD players dominate provides further evidence that hard-headed pragmatism reigns among China's technology policymakers. In the case of WAPI, the government backed down relatively quickly in the face of pressure from various interest groups both inside and outside the country.

Such pragmatism—a necessary condition if the policy is to avoid imposing heavy costs on the economy—is a luxury that China's policymakers can afford. China's large, growing market allows them the scope to pursue local standards and to let the standards find their own way. In a smaller economy, the dominance of international standards would be assured, but in the large China market, with its vast size and a bewildering variety of local conditions, domestically-developed standards have a real chance to flourish at home and then, perhaps, to be exported.

As the optical storage case study and the other standard-setting examples make clear, China is pursuing the domestic development and application of intellectual property in a determined but pragmatic fashion. Larger Chinese electronics firms such as Haier (appliances) and Konka (consumer electronics) are already developing a brand presence in developed countries. Although most Chinese firms are little-known today outside their own industries, in ten to twenty years the elements described above—an evolving innovation system, maturing firms, a thriving economy, and government-supported technology development—will come together to build one or more industrial enterprises comparable to those of Europe, Japan, and the United States.

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[115] As paraphrased in "Official urges China to develop own standards for IT sector," *ChinaOnline*, 21 June 2000.
[116] "China to Spend $84.6 Billion on Tech R&D Over 5 Years," *Reuters*, 20 February 2003.

Colophon

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An earlier version of this paper was released as Information Storage Industry Center Report #2003-01: "Optical Storage In China: A Study in Strategic Industrial Policy."

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