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Abstract

China's industrial policy for high-technology industries combines key features of the policies adopted elsewhere in East Asia: judicious opening to foreign investors and support for local firms.

However, unlike the developing economies of East Asia, China is a transition economy that already had a relatively well-developed, if somewhat dated, technology base of its own before its opening to outside investors at the end of the 1970s. Although the initial technology level of individual firms was low, a network of universities and government research institutes provided a strong foundation for future developments.

Like the other high-growth economies of East Asia, China has attracted foreign investment to rapidly expand its industries. But China has been able to leverage the enormous attractiveness of its domestic market to obtain technology transfers from its foreign investors on a scale that was unattainable in the regions other countries.

Today, revamped state-owned firms and a host of newly-minted private ones are steadily building local competitive advantage.

China's effort to move beyond dependence on foreign know-how to develop its own intellectual property (IP) in the electronics industry has been moving forward on several fronts, including optical storage, digital television, semiconductor design, and cellular telephony. The indigenous development of IP is a point of national pride, secures China a measure of technological independence and may serve a role in reducing burdensome royalty payments by local producers of high-tech goods.

This paper analyzes the experience of this Chinese high-technology policy in the optical storage industry. It begins with a brief overview of industrial policy for the electronics sector in East Asia, then discusses the relevant policies for two successive generations of optical storage: Video CD and DVD. Examples of similar policies in other industries are given, and a final section recaps and analyzes the optical storage case.

The research for this paper was conducted over a period of years using publicly available sources on the Internet and various news databases as part of the author's ongoing research on the evolution of the electronics industry in East Asia.

¹ ACKNOWLEDGEMENTS: 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, to the Berkeley Roundtable on the International Economy (BRIE), and to the Information Storage Industry Center at UC San Diego. Thanks to Roger Bohn, Clair Brown, Jeff Hart, and Scott Kennedy for helpful comments and other assistance. Any opinions or errors in the text are those of the author.

High-Tech Industrial Policy in East Asia

The development of the economies of East Asia has been said to follow such a predictable sequence that it has long been described by the metaphor of a flock of geese flying in formation (e.g. Bernard and Ravenhill, 1995), with Japan in the lead, followed by South Korea, Taiwan, Hong Kong, Singapore in the second tier, and Malaysia, Thailand, the Philippines, and Indonesia bringing up the rear. The technology gap separating Taiwan and Korea from Japan, particularly in the electronics industry, has become very narrow (Linden, et al., 1998), but the “flying geese” metaphor has remained a reasonable approximation for the regional development process.

The rapid technological progress of China has broken the mold however, as the mainland has used a range of policies to catch up to the world’s technology leaders with remarkable speed since its economy began to open to the outside in 1978. The electronics sector has been a major contributor to growth in East Asia (Ernst and O’Connor, 1992) and is the lens through which we will examine China’s industrial policy here.

In the high-growth economies of East Asia, it is generally accepted that government intervention has at times played a positive role in promoting economic growth (World Bank, 1993). Industrial policy can take several forms, from exchange rate management to “picking winners.” The type of industrial policy to be discussed here is “industrial targeting” (Dahlman, 1993), measures that promote a particular sector and, sometimes, specific firms. 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 (ibid., Table 16.1).

Korea and Taiwan offer China two ready – and very different – models of industrial technology policy.² These much-studied economies typify two extremes of industrial structure. Korean industrial development has been dominated by large conglomerates that 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 that rely on the government or other external sources for technology support.

Each approach has demonstrated weaknesses. The Korean conglomerates eventually became overextended financially and most have imploded, with Samsung being the notable exception. At the other extreme, the small Taiwanese firms have generally failed to develop valuable global brands of their own, with Acer being the best-known exception.

China’s large market potentially allows it to have the strengths of both models without the weaknesses. China has been able to foster the development of large electronics firms, such as Shanghai Audio and Video or Legend Computer, while still

² see Hamilton and Biggart (1988), Hong (1997), Levy and Kuo (1991), Linden et al. (1998), and Mathews and Cho (2000) for some of the many comparative studies of Korean and Taiwanese industry.

leaving room for entrepreneurial activity. As in the United States, radical innovation will most likely come from start-up firms, while the larger firms have the wherewithal to rapidly develop and commercialize new technologies.

China's market size has insulated it from another hard choice faced by policymakers in the other East Asian economies – whether to favor foreign investors over local firms. Smaller economies, such as Singapore, an island-nation with a population of about 3 million, emphasized foreign investors without initially worrying about the development of local firms. South Korea, on the other hand, with a population more than ten times larger, obliged major foreign investors to work with leading local firms that were being groomed for the global market.

The leverage available to policymakers with a potentially large local market reaches its apotheosis in China. The Chinese government has been able to demand technology transfers from interested investors who were vying for the opportunity to market and manufacture their goods there.

In the electronics sector, the government has deployed this tool repeatedly to extract technology from foreign companies seeking entry, especially into government-controlled markets. When China opened up to foreign suppliers of telecommunications gear in the early 1990s, the first three companies to earn access were Alcatel, Siemens, and NEC – all of whom had promised to transfer technology to local firms for the production of integrated circuits.³ The same strategy extends beyond the electronics sector. In the case of “maglev” high-speed trains, China favored a proposal from a consortium willing to transfer technology so that a Chinese company could produce maglev rolling stock.⁴

A related and critical advantage China has over its regional counterparts is its absorptive capacity for technology (Cohen and Levinthal, 1990). Most of the countries of East Asia emerged in the post-war years with little in the way of an industrial base, including the infrastructure for technical education. China, on the other hand, invested considerable resources in numerous industrial programs, particularly those which were defense-related, and has a university system dating back more than a century.

It is therefore more appropriate to think of China as a transition, rather than simply a developing, economy because of the significant technological base that was already in place when it began opening to market forces. Although domestic technology was years behind that of the West in most cases, China has been able to absorb and apply the technology transfers it has negotiated at a rate that was unattainable in other high-growth Asian economies such as Malaysia and Thailand.

These advantages make China uniquely able to rapidly close the technological gap with more-developed nations. Without them, China would be limited to supplying cheap labor to the global electronics sector, much as Thailand and Indonesia have been.

We now turn to the specific case of video discs as one of the early examples of how Chinese policymakers have begun to interact with the global electronics industry.

³ “China Telephone Market Opens Up,” *Business China*, December 24, 1990.

⁴ Karby Leggett, “Can Maglev Help German Firms Unlock New Contracts in China?” *WSJ.com*, January 1, 2003.

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 \$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.⁵ Wanyan was a start-up company founded with money from the U.S. (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 1994.⁶

In the technology's inaugural year, only about 20,000 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.⁷ 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.⁸ By 1997, China was by far the world's most important market for VCD players, accounting for about three-quarters of the 15 million

⁵ Wei Liming, “High-Tech Industries in Vigorous Development,” *Beijing Review*, v.41n.46, November 16, 1998.

⁶ UNIDO, “China's Re-entry: Innovative, Learning, and Catching-up Capabilities – Third Draft”, July 6, 2001.

⁷ *ibid.*

⁸ Helen Johnstone, “Multimedia Popularity of disc players catches market off guard,” *China Business Review* (South China Morning Post), December 11, 1997.

units sold worldwide.⁹ 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.

The affordability of VCD players was further helped by the willingness of the primary patent holders to forgo their royalties in China.¹⁰ The patents covering the VideoCD 1.0 and 2.0 standards are owned by Japanese and European companies (Matsushita, JVC, Sony and Philips). These companies, all of whom have large-scale investments in China, presumably found compensation in other areas and chose not to make waves. For example, by the mid-1990s, China was virtually the only remaining market for 1x CD-ROM drives, allowing Philips and Sony to receive income from technology that was obsolete in major world markets.

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, 2003; used by permission.
DVD data from various news reports; sources available on request.

A Chinese Standard for VCD

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

In September 1997, China's Ministry of Electronics Industry (MEI) held a meeting with the Chinese VCD vendors and the leading (US-based) suppliers of VCD chips to announce plans for Chinese extensions to the VideoCD 2.0 standard that added Internet connectivity and other interactive features.¹¹ 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

⁹ Parker, Dana J., 1998 "The people's republic of video CD," EMedia Professional 11:3 (March), p.54.

¹⁰ Junko Yoshida and Mark Carroll, "China flexes standards muscle," Electronic Engineering Times, November 24, 1997.

¹¹ "China carves a role in consumer design Initiative on Video CD 3.0," Electronic Engineering Times Interactive, October 4 1997.

Chinese fingerprint on a popular product, but also, with luck, develop into a home-grown export.

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 US-based: C-Cube Microsystems (which claimed a 70% share of the market in 1997), ESS Technology, and Oak Technology.¹² These companies were therefore central to the effort to launch an updated standard.

The VideoCD 3.0 standard favored by the ministry -- basically a software upgrade from 2.0 that would require only a change in the main chip -- had been proposed by ESS and EnReach Technology, a 10-person Silicon Valley start-up. As part of the deal, EnReach, founded two years earlier by a Chinese expatriate, agreed to share several of its patents with China.

An advanced VideoCD was just one of the standards-development projects being pursued by MEI in 1997.¹³ 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 local manufacturers either directly 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 barrier.

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.¹⁴

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.¹⁵

Policy Meets the Market

While the government-sponsored standard was still under development, a competing VCD standard was floated by C-Cube Microsystems, backed by a coalition of

¹² “China carves a role in consumer design Initiative on Video CD 3.0,” *Electronic Engineering Times Interactive*, October 4 1997.

¹³ Yoshida, Junko, and Mark Carroll, “China flexes standards muscle,” *Electronic Engineering Times*, November 24, 1997.

¹⁴ *ibid.*

¹⁵ *ibid.*

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.¹⁶

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 ultimate rival technology, DVD.¹⁷ At the time of the meeting, DVD component suppliers were rounding up support for the format among Chinese electronics producers, but DVD players would cost more than twice as much as VCD players – a high barrier in the price-conscious mainland market.¹⁸

C-Cube and its partners actually rolled 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.¹⁹ However, this gambit apparently backfired when MII announced in July that HQ-VCD (the standard owned by the major international electronics firms) was chosen along with the inclusion of unspecified intellectual property from MII’s internally developed format.²⁰

The new standard, officially known as Super VCD (SVCD), was announced in September 1998.²¹ 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.²² The Chinese government also pursued SVCD as an international standard.²³

VCD and SVCD players became, briefly, an important export item. In 1999, 6% of China’s audio-visual exports were VCD players. Millions of units were exported, with other Asian countries as the primary market.²⁴

Nevertheless, the VCD industry as such did not offer a very attractive target for policy intervention, having only a small market window before DVD players would fall to a level that would make it the dominant player, which happened in the China market in

¹⁶ Yoshida, Junko, “Factions battle for upper hand in setting Video CD spec,” *Electronic Engineering Times Online*, June 19, 1998.

¹⁷ *ibid.*

¹⁸ Yoshida, Junko, “DVD suppliers work on a jump-start from China,” *Electronic Engineering Times Online*, February 13, 1998.

¹⁹ Yoshida, Junko, “Factions battle for upper hand in setting Video CD spec,” *Electronic Engineering Times*, June 19, 1998.

²⁰ Hara, Yoshiko and Junko Yoshida, “China chooses consortium plan for Video CD,” *Electronic Engineering Times Online*, July 17, 1998.

²¹ Cataldo, Anthony, “Electronics manufacturers ready SVCD systems for market,” *Electronic Engineering Times*, October 13, 1998.

²² “Super VCD players outclass VCD in mainland China,” *Asian Sources*, May 26, 1999.

²³ “China’s Info Ministry Uses Technical Standards to Boost VCD Market,” *Xinhua News Agency via Asia BizTech*, September 12, 2000.

²⁴ “Bargains abound in mature VCD player industry,” *Global Sources*, Nov. 3, 2000.

late 2002.²⁵ The global market (primarily East Asia and Latin America) for VCD players still amounted to about 60 million players in 2002 but had entered a period of steady decline.²⁶

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 1999.²⁷

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.²⁸ Initial acceptance of DVD technology was limited by its higher price and its anti-piracy measures. The ready availability of pirated movies on VCD was a major contributor to its success.²⁹ 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.³⁰ 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.³¹

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.³² 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 \$15 to \$20 per player. In addition to two DVD patent pools, additional license fees were due to Thomson Multimedia, Dolby Labs and several other

²⁵ "DVD Takes Mainstream Position Of VCD In China," SinoCast China Business Daily News, November 29, 2002.

²⁶ "Prices for VCD player chips to be stable by year-end," DigiTimes.com, September 5, 2003.

²⁷ "Pricing mayhem throws supply into a tailspin," Asian Sources, Sep. 23, 1999.

²⁸ "China's DVD Players to Go on Market Soon," Xinhua Electronics News via IDG China News, June 1998.

²⁹ "Pregnancy highlights new VCD pirate tactic," South China Morning Post, September 25, 1998.

³⁰ "Hong Kong confident of potential of no-frills DVD," Asian Sources, August 1999.

³¹ "DVD sales to soar," Global Sources, November 10, 2000

³² "China's components makers to benefit from DVD boom," Asian Sources, April 12, 1999; "CAS develops proprietary 650nm DVD laser, production commences," Asian Sources: Nov. 24, 1999.

owners of compression and copy protection technology.³³ 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 \$4 per player.³⁴ A second group of patent holders (Philips, Sony, and Pioneer) was reported to have arranged for another \$5 per unit, but both groups conceded royalties on units sold within mainland China at least through the end of 2002,³⁵ although the issue remained unresolved in mid-2003.³⁶ The value of the concession was on the order of \$50 million.³⁷

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 firms. Whereas VCD players were mostly for internal Chinese consumption, exports of DVD players from China displaced higher-priced Japanese exports to the U.S. market.³⁸ This helps explain why the patent holders ultimately settled for royalties on exported players only.

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 working group of industry and government research institute (GRI) members was formed in late 1999 and developed an initial standard ("Advanced High Density Disc System", or AVD) during the following two years that utilized the DVD physical platform but was technically an enhanced version of Super VCD.³⁹

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" that was "basically compatible" with China's AVD.⁴⁰

³³ "Chinese DVD Player Makers Avoiding Patent Fees," Asia Biz Tech, January 22, 2002.

³⁴ "Export prices of Chinese DVDs up US\$10 due to patent fees," ChinaOnline, August 8, 2002.

³⁵ "Chinese manufacturers agree to pay patent fees to DVD-technology developers," ChinaOnline, October 10, 2002.

³⁶ "China DVD makers expected to pay 100 mln usd royalties in 2003 – report," AFX – Asia, June 3, 2003.

³⁷ "Japan, U.S. Give Up Part of DVD Patent Fees in Row with China," Jiji Press Ticker Service, October 5, 2002.

³⁸ "China-made DVD players dominate U.S. market", ChinaOnline, August 19, 2002.

³⁹ China Proposal to International Electrotechnical Commission, Technical Committee 100, "Advanced High Density Disc Systems," dated September 10, 2001, accessed at http://www.y-adagio.com/public/confs/oitda/iopto_0207/ refs/China%20proposal.pdf on Feb 21, 2003.

⁴⁰ Clendenin, Mike and Junko Yoshida, "Taiwan joins Chinese effort on proprietary DVD format," Electronic Engineering Times, May 24, 2002.

The incentive to pursue the alternative was relatively large, with Chinese authorities estimating that patent fees payable on EVD players would be just one-third those for the DVD equivalent.⁴¹ 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 format has not yet made it to market. Several factors have undermined the market opportunity for EVD products. For one thing, the license fee disputes with DVD patent holders were finally settled in late 2002 with a large concession for players assembled and sold in China, which undercut what was likely to be the largest market for EVD players by keeping domestic DVD prices low.⁴² Another factor is that the relatively low quality of the vast majority of TV sets in China made the enhanced video quality of the EVD format irrelevant.

In light of these negatives, it is unsurprising that talk of EVD faded entirely from the trade press by the end of 2002. Nevertheless, it is likely that EVD was a factor in the DVD royalty negotiations by improving the fallback position of the Chinese.

Chinese Technology Policy For Other Industries

In the optical storage industry alone, we have seen that the Chinese have, on two occasions, developed a local variant of foreign technology. The pattern has been repeated in other industries, and this section will briefly review a few of the prominent cases.

One of the highest profile standards efforts by China 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 other 3G systems. Much as China found critical support in Taiwan for the EVD format, it found support from Germany’s Siemens for a partly-China-owned cellular system by agreeing to further develop TD-SCDMA, a next-generation technology that Siemens had initially developed.⁴³ 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-CDMA has continued to garner support 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 in the China market, by entering a joint venture with one of

⁴¹ Hsieh, David, “Now, a 'super DVD' made in China,” *The Straits Times* (Singapore), July 17, 2002.

⁴² “Chinese manufacturers agree to pay patent fees to DVD-technology developers,” *ChinaOnline*, October 10, 2002.

⁴³ Forney, Matt, “Chinese Challenge Mobile Giants With Third-Generation Technology,” *WSJ.com*, June 5, 2000.

the largest Chinese producers of telecom gear, Datang.⁴⁴ 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.⁴⁵

The government officially set aside spectrum for TD-SCDMA in October 2002⁴⁶ and conducted trials in April 2003.⁴⁷ As of this writing, however, it is too early to know whether a TD-SCDMA-based network will actually receive one of the valuable 3G operator licenses due to be issued in 2004.

High-Definition Television (HDTV) broadcast technology is another area where China has worked to develop its own standard alongside those of the U.S., Europe, and Japan. The development effort, a broad government-university-industry program, started in 1994 and led to the demonstration of a prototype in 1998.⁴⁸ HDTV development in China is being pursued by several parallel research groups, with a final decision about the national standard due in 2003.⁴⁹

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, developed by the Chinese Academy of Sciences in 2001.⁵⁰ The chip is relatively low-tech at 266MHz – 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.⁵¹ “Godson” is just the first step on a development trajectory, and a more-advanced “Godson-2” is due to be completed by the end of 2003.⁵²

⁴⁴ John Walko and Mike Clendenin, “Joint venture gives Chinese 3G spec a boost,” *Electronic Engineering Times*, January 20, 2003.

⁴⁵ Bruce Gain and Darrell Dunn, “Nokia-TI venture takes aim at China's 3G market,” *Electronic Buyer's News*, March 1, 2002.

⁴⁶ Andrew Batson, “China's 3G Mobile Standard Is Set to Hit Market in 2004,” *Dow Jones Newswires via WSJ.com*, October 31, 2002.

⁴⁷ Mike Clendenin, “China's 3G drive prompts industry maneuvering,” *Electronic Engineering Times*, April 21 2003.

⁴⁸ Liu, Sunray, “China stages HDTV prototype trial,” *Electronic Engineering Times*, September 15, 1998.

⁴⁹ Liu, Sunray, “China unveils digital broadcast strategy,” *Electronic Engineering Times*, March 28, 2001.

⁵⁰ “China Develops First Home-Made CPU Called 'Godson',” *Xinhua News Agency via Asia BizTech*, October 17, 2001.

⁵¹ “'Dragon Chip Industrialization Alliance' Founded,” *People's Daily* December 25, 2002, accessed via www.china.org.cn/english/scitech/ on March 6, 2003.

⁵² Clendenin, Mike, “Chinese start-up readies 64-bit processor,” *Electronic Engineering Times*, March 5, 2003.

Chinese Technology Policy in Perspective

We have now seen that the Chinese government is actively engaged in the development of industrial standards. In this section we explore the economic motivations behind this policy and whether it appears to be a success.

What justification can there be for such a policy? One of the plainest motivations is political gain and/or national pride. Chinese announcements about these standards programs tend to inflate their significance and understate the contribution of foreign technology sources. Such pronouncements promote a positive image of the government and probably encourage students to choose a career in engineering

A longer-term goal is to help leading Chinese firms to secure a measure of technological independence. As the similar policies pursued for both the Video CD and DVD generations demonstrate, the pursuit of this goal has been consistent and persistent. The advantage procured by such programs is slight, but as China closes the gap with more advanced countries over the next ten years, the contribution to global standards can be expected to vastly increase as it has in, for example, Korea, where local firms have contributed intellectual property to worldwide video compression standards, among others.

Greater technological independence won't necessarily translate into profits for Chinese firms. To the extent that locally-developed intellectual property is a public good freely available to all firms, any profits, or what economists call "producer surplus," will be competed away, so consumers will reap the benefits. But some of the firms participating in government-sponsored standards projects will internalize the process of developing advanced technology and dealing with international standard-setting bodies. To the extent these firms can develop new technologies and an international presence of their own, they can become global competitors with valuable intellectual property whose value will not be so easily eroded. China's competition policy has favored the creation of large firms wielding the resources to compete on a global scale.⁵³ In electronics, the government has merged smaller state-owned firms to create larger ones, with the most notable being Shanghai Audio & Video (*Shanghai Guangdian*), one of China's top ten electronics producers, which was created by the merger of three Shanghai-area consumer electronics firms (White and Linden, 2002).

A third possible benefit of these policies is leverage in negotiations over royalties. The DVD case is strongly suggestive of this because of the way in which the Chinese variant standard for DVD seems to have become a non-issue once the royalty negotiations with patent holders were settled on unusually 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

⁵³ "Korean conglomerates model to remain a feature of policy," South China Morning Post, February 26, 1998.

roughly half that for domestic shipments in Korea (5.25 percent), another important CDMA market.⁵⁴

In game theoretic terms, the availability of a China-developed variant standard improves China's "threat point" (fallback position) during royalty negotiations. China's market is very important to the major electronics producers. The prospect of Chinese companies turning out a renegade or incompatible product is an unappealing one. And the same goes for litigation over the validity of Chinese intellectual property. China's technology development undoubtedly weighs as a nuisance factor in royalty negotiations, but 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.

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 advantage attributable to the policy to date, but it has laid a foundation for future developments.

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 semiconductor 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 20 years before the success of Taiwanese semiconductor manufacturing was globally acknowledged and the technology gap with leading producers was closed.

China's efforts to date must be seen as a foundation on which future, similar efforts will be built. As discussed above, Chinese engineers are learning about the requirements of the market and the politics of international standard-setting, while the largest Chinese companies are developing their global marketing and distribution channels. As the technology gap closes between the Chinese market and those of the more-developed economies, it is only a matter of time before one or more Chinese companies owns valuable intellectual property that can be contributed 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. It is therefore important to ask how distortionary these standards development efforts are. This is particularly complex in a transition economy such as China where the state still controls many of the financial and industrial levers of power, which adds confounding layers of distortion.

Perhaps surprisingly, the answer here may well be that the distortion is slight because China's development of alternative standards has not extended to imposing them

⁵⁴ "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).

as a market outcome. This reluctance to force the outcome is regularly enunciated by Chinese officials. 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."⁵⁵ 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."⁵⁶

Such pronouncements can easily fail to be borne out by events as the temptation to intervene in a large, semi-closed economy must be great. It is reassuring to note, however, that in the Super VCD example above, which is now one of the older examples of this type of technology policy in China, the outcome allowed multiple variants of Video CD to co-exist in the market.

China's large market allows its policymakers both the scope to pursue local standards and the luxury to let the standards find their own way in a semi-closed market. In a smaller economy, the dominance of international standards would be assured, but in the large China market, complicated by its vast size and a bewildering variety of local regulatory regimes, locally developed standards have a real chance to flourish domestically and then perhaps to be exported.

As the optical storage case study and the examples in the previous section make clear, China is pursuing the development and application of intellectual property in a determined and organized fashion. Larger Chinese electronics firms such as Haier (appliances) and Konka (consumer electronics) are already developing a brand presence in developed countries. Although they are little-known today, it's only a matter of time before all these elements come together to build a set of global industrial titans comparable to those of Europe, Japan, and the U.S.

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⁵⁵ as paraphrased in "Official urges China to develop own standards for IT sector," China Online, June 21, 2000.

⁵⁶ in "China to Spend \$84.6 Billion on Tech R&D Over 5 Years," Reuters, February 20, 2003.

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