2013

Innovation in China: Fragmentation, Structured Uncertainty, and Technology Standards

Michael Murphree
Sam Nunn School of International Affairs

Dan Breznitz
Scheller College of Business

CARDOZO LAW REVIEW
de•novo

INNOVATION IN CHINA: FRAGMENTATION, STRUCTURED UNCERTAINTY, AND TECHNOLOGY STANDARDS

Michael Murphree and Dan Breznitz∗

TABLE OF CONTENTS

∗ Michael Murphree is a PhD Candidate in the Sam Nunn School of International Affairs at Georgia Tech. Dan Breznitz is an Associate Professor in the Scheller College of Business at Georgia Tech. Breznitz and Murphree thank the Kauffman Foundation and the National Science Foundation whose generous support under grant number SES-0964907 enabled this research.

INTRODUCTION

If there is one economic miracle that continues to inspire awe and significantly transform the global economy, it is the economic resurgence of China.[1] The country—the most populous in the world—recently enjoyed the longest period of sustained rapid economic growth in history, with over two decades of more than ten percent annual gross domestic product (GDP) growth, and it continues to grow. In 2010, China GDP grew by 10.3%, in 2011 it grew by 9.2%, and in 2012 it grew by nearly 8%.[2] This growth continues even as the advanced industrial economies of Europe and the United States contend with their worst economic crisis since World War II.[3] Indeed, the slowdown in the advanced economies has accelerated the apparent rate of China's climb; China's GDP is now second only to the United States.[4] Since the 1970s, this growth has lifted hundreds of millions out of poverty and fundamentally changed the face of China from an agrarian society to an industrial and urbanized one.[5] China has rapidly climbed the ranks as both a producer and consumer of high technology goods and services. By some measures, China may already have the world's largest technology-based economy.[6]

In high technology, the country is now the world's largest patent filer.[7] It is second only to the United States in total annual publications

---

1 This research was based on 24 months of fieldwork in 2007 and 2008, three months of fieldwork in 2009 and 2010 and three months of work in the spring and summer of 2012. Using a seven-point research theme instrument with various stakeholders in China's technology standards bodies, government ministries, technology companies, academia, and consulting firms, we performed nearly 400 semi-structured interviews. Interviewees included both Chinese and foreigners, providing a wide range of insights and perspectives into China's innovation and technology standards system and policies. All interviewees agreed to speak on the condition that their names and other identifying information would be excluded from any publications. Therefore, due to privacy requirements in our research protocol, this Article will not cite the interviewees in any identifiable detail.

2 2000–2011 NIAN GUO MIN JINGJI HE SHE HUI FA ZHAN TONG JI GONG BAO [2001–2011 CITIZENS' ECONOMIC AND SOCIAL DEVELOPMENT STATISTICS REPORTS], NAT'L STATISTICS BUREAU OF THE PEOPLE'S REPUBLIC OF CHINA, OECD (2006); OECD, INFORMATION TECHNOLOGY OUTLOOK 2006 139–40, *available at* http://dx.doi.org/10.1787/it_outlook-2006-en. *See generally* NAT'L STATISTICS BUREAU OF THE PEOPLE'S REPUBLIC OF CHINA [NSBPRC] (2001–2012).

3 *See, e.g.*, Gordon Isfeld, *Effects of 'Great Recession' Linger*, GAZETTE (Feb. 22, 2013), http://www.montrealgazette.com/business/Effects+Great+Recession+linger/8000381/story.html.

4 Chester Dawson & Jason Dean, *Rising China Bests a Shrinking Japan*, WALL ST. J., Feb. 14, 2011, at A1, *available at* http://online.wsj.com/article/SB10001424052748704593604576140912411499184.html.

5 *See generally* TOM MILLER, CHINA'S URBAN BILLION (2012).

6 *See* Alan L. Porter, Nils C. Newman, J. David Roessner, David M. Johnson & Xiao-Yin Jin, *International High Tech Competitiveness: Does China Rank #1?*, 21 TECH. ANALYSIS & STRATEGIC MGMT. 173, 173–193 (2009) (comparing three selected indicators that cover national technology-based competitiveness and concluding that the indicators all suggest a dramatic continuing increase in the competitiveness of China's technology-based economy).

7 WORLD INTELL. PROP. ORG., WORLD INTELLECTUAL PROPERTY INDICATORS (2012),

of peer-reviewed academic journal articles.[8] Similarly, thanks to a steady increase in research and development (R&D) spending over the last decade, China is also second only to the United States in R&D spending. The 11th Five Year Plan called for raising the level of R&D spending to over two percent of GDP by 2010 and, although not met, R&D spending grew sharply during this period.[9]

While China's accomplishments are legion, all is not as it appears. For one, China's miracle, particularly in high technology is very one-sided. Although high technology exports account for 29% of China's total exports in 2011, and these exports continue to grow at over sixteen percent per year, over ninety percent of these goods are from a single industry: electronics and information and communication technology.[10] Notably, China's growing research and publication capabilities and accomplishments in nanotechnology, biotechnology, aerospace, genetics, and materials science have not yet translated into major economic activity. Second, in addition to being highly imbalanced, the actual innovation capabilities of Chinese firms lie not in novel-product innovation (the creation of wholly new goods and services), but rather in incremental and second generation innovation.[11] These innovation capabilities have developed in response to the constraints facing organizations in China over the last thirty years, particularly in terms of access to human resources and physical and financial capital.[12] Chinese firms have created a powerful manufacturing capability in the country and thus enabled ongoing improvement and competitiveness even as input factor prices, particularly labor, continue to rise.[13] What is

available at http://www.wipo.int/ipstats/en/wipi/.

[8] ROYAL SOCIETY, KNOWLEDGE, NETWORKS AND NATIONS, RS POLICY DOC. 03/11 (2011), *available at* http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2011/4294976134.pdf.

[9] *China's R&D Spending Surges 21.9%*, CHINA DAILY (Feb. 22, 2012, 5:32 PM), http://www.chinadaily.com.cn/bizchina/2012-02/22/content_14670805.htm; *Facts and Figures: China's Main Targets for 2006–2010*; CENT. GOV'T CHINA (Mar. 6, 2006), http://english.gov.cn/2006-03/06/content_219504.htm.

[10] *Nian Guo Min Jing Ji He She Hui Fa Zhan Tong Ji Gong Bao [2000–20012 Citizens' Economic and Social Development Statistics Reports]*, PEOPLE (Feb. 23, 2013, 5:09 AM), http://politics.people.com.cn/n/2013/0223/c1001-20574506.html; NSBPRC (2012); *2011 Nian Wo Guo Gao Ji Shu Chan Pin Guo Ji Mao Yi Zhuang Kuang Fen Xi [2011 China's High Technology Product International Trade Situation]*, NAT'L STATISTICS BUREAU OF CHINA, *available at* http://www.sts.org.cn/tjbg/gjscy/documents/2012/20120702.htm.

[11] Second generation innovation is innovation around existing inventions, goods, and services. This includes improvements, simplifications, new applications and uses, new processes, and new ways of producing existing products.

[12] DAN BREZNITZ & MICHAEL MURPHREE, RUN OF THE RED QUEEN: GOVERNMENT, INNOVATION, GLOBALIZATION, AND ECONOMIC GROWTH IN CHINA (2011) [hereinafter BREZNITZ & MURPHREE, RUN OF THE RED QUEEN].

[13] Labor costs in China have been rapidly rising. While other emerging economies stand to benefit from some low-margin industries that are leaving China—garment assembly in particular—China remains a highly-valued destination for investment. *See The End of Cheap*

interesting is that while the rest of the world stands in awe of the country's achievement, China's leaders fret China's lack of "innovativeness."[14]

Since Opening and Reform began in 1978,[15] China has sought to accomplish a primary overarching goal: China is to become a moderately well off country.[16] Cultivating economic growth and innovative capacity is essential to realizing this goal.

The question therefore is why, even after attaining such industrial and R&D power, has China failed to become independently innovative, particularly in information and communication technology (ICT)? Despite the accumulation of manufacturing capabilities and the gradual integration of the product chain within China, core technologies and the architecture for critical platforms continue to be developed, and protected by intellectual property rights (IPR), by foreign firms located outside the country.[17] To combat this apparent weakness of Chinese firms' slim IPR portfolios, China's leaders have pursued a variety of policy initiatives. Since the 1980s, there have been an array of centrally, regionally, and locally directed programs including the well-known 863 and Torch Programs, the 973 Program, and the "Mega-Projects" of the Medium-Long Range Plan for Science and Technology.[18] These programs aimed to foster commercialization of Chinese-developed technologies, push development of basic R&D, and encourage development of globally competitive capital-intensive technology industries. By the late 1990s, these efforts concentrated on achieving the goal of bringing about "indigenous innovation," namely, products, technology, and brands that are designed, developed, and owned by Chinese companies.[19] Most recently, the push for indigenous innovation has come to include the promotion of technology standards.[20] This

---

China, ECONOMIST, Mar. 10, 2012, at 83.

[14] *See President Hu Jintao: Chinese R&D Needs More Innovation*, ASIAN SCIENTIST (July 9, 2012), http://www.asianscientist.com/academia/chinese-president-hu-jintao-research-and-development-innovation-2012.

[15] *See generally The Second Long March*, ECONOMIST, Dec. 13, 2008, at 33.

[16] John Ross, *'Moderately Prosperous Society' is Key Goal for China*, CHINA.ORG.CN (Nov. 14, 2013), http://www.china.org.cn/opinion/2012-11/14/content_27108452.htm.

[17] *Tian Suning: Di San Ci Gong Ye Ge Ming He Xin Ji Shu Zhong Guo Ji ben Mei You [Suning Tian: China Basically Lacks any Core Technologies of the Third Industrial Revolution]*, HEXUN (Nov. 29, 2009), http://news.hexun.com/2012-11-29/148520505.html; *Zhuan Jia: Zhong Guo He Xin Ji Shu Luo Hou Guo Wai Liang Dai: Bu Neng Mang Mu Le Guan [Expert: China's Core Technology Lags Foreign Countries' by Two Generations: China Cannot be Blindly Optimistic]*, XINHUANET (Apr. 17, 2007), http://news.xinhuanet.com/tech/2007-04/17/content_5985993.htm.

[18] *See* Cao Cong, Richard P. Suttmeier & Denis Fred Simon, *China's 15-year Science and Technology Plan*, PHYSICS TODAY, Dec. 2006, at 38–43.

[19] *See Issue Brief: New Developments in China's Domestic Policies*, U.S. China Business Council, Jan. 2010, at 1, *available at* https://www.uschina.org/public/documents/2010/domestic_innovation_policies.pdf.

[20] For a discussion of technology standards efforts, see *infra* Part I.

effort has attracted wide attention from business and government. Many foreign observers fear China is using technology standards as a protectionist tool.[21] However, to date none of these policy initiatives or attempts at domestic technology standards have yielded the level of technological independence or indigenous innovation sought by the Chinese central government.

This Article discusses the history of China's attempts to develop indigenous technology standards. A case study is presented on China's attempts to develop digital optical storage media standards, the failure of which we attribute to fragmentation of production and structured uncertainty in China's economy. Despite the market failures of China's domestic standards development efforts, we conclude by highlighting some of the appurtenant benefits they produce for Chinese manufacturers.

I. TECHNOLOGY STANDARDS AS A CASE FOR CONSTRAINTS

Over the past fifteen years, China has used technology standards promotion as a possible policy tool for encouraging indigenous innovation.[22] However, as with other attempts to promote indigenous capabilities, China has struggled to develop indigenous technology standards that use wholly or mostly Chinese-developed embedded technologies. The continued failure to do so stems from the intersection of two forces: the global fragmentation of production and China's political economic climate of structured uncertainty.[23] These two forces do enable specific types of innovative activities and standards development. Indeed, they make China highly competitive within those specific fields. Yet, at the same time, they also constrain the options for policy and practice available to firms and organizations in an economy. These constraints limit the effectiveness of technology standards as a

---

[21] SCOTT KENNEDY, RICHARD P. SUTTMEIER & JUN SU, STANDARDS, STAKEHOLDERS AND INNOVATION, NAT'L BUREAU OF ASIAN RESEARCH, NBR SPECIAL REPORT NO. 15 (Sept. 2008) [hereinafter KENNEDY ET AL., STANDARDS, STAKEHOLDERS AND INNOVATION]; RICHARD P. SUTTMEIER & XIANGKUI YAO, CHINA'S POST-WTO TECHNOLOGY POLICY: STANDARDS, SOFTWARE, AND THE CHANGING NATURE OF TECHNONATIONALISM, NAT'L BUREAU OF ASIAN RESEARCH, NBR SPECIAL REPORT NO. 7 (May 2004); RICHARD P. SUTTMEIER, XIANGKUI YAO & ALEX ZIXIANG TAN, STANDARDS OF POWER? TECHNOLOGY, INSTITUTIONS AND POLITICS IN THE DEVELOPMENT OF CHINA'S NATIONAL STANDARDS STRATEGY, NAT'L BUREAU OF ASIAN RESEARCH, NBR SPECIAL REPORT NO. 10 (June 2006); DAN BREZNITZ & MICHAEL MURPHREE, U.S.-CHINA ECON. & SEC. REV. COMM'N, THE RISE OF CHINA IN TECHNOLOGY STANDARDS: NEW NORMS IN OLD INSTITUTIONS (2013), *available at* http://origin.www.uscc.gov/sites/default/files/USCC%20Report%20%20The%20Rise%20of%20China%20in%20Technology%20Standards.pdf [hereinafter BREZNITZ & MURPHREE, THE RISE OF CHINA IN TECHNOLOGY STANDARDS].

[22] *See* KENNEDY ET AL., STANDARDS, STAKEHOLDERS AND INNOVATION, *supra* note 21; Greg Linden, *China Standard Time: A Study in Strategic Industrial Policy*, 6 BUS. & POL. 1 (2004).

[23] *See infra* Parts I.A–B.

means of fostering the development of wholly new indigenous technologies. Nonetheless, as discussed below, even if the policies to encourage indigenous innovations have failed to result in a commercially successful indigenous technology standard, the policies do succeed in encouraging Chinese actors to capitalize on the skills they currently possess.

A. *Technology Standards and China's Historical Framework*

Technology standards are agreed-upon technology platforms for interconnection, operation, or function on which other applications, improvements, and innovations can be made;[24] they are integral to modern life. Information technology, and particularly technologies' ability to effectively communicate information, is entirely based on widely-adopted and accepted standards. Whether these standards are internationally developed, as was the International Organization for Standardization's (ISO) Open Systems Interconnection (OSI) suite, or domestically developed, as was the United States Defense Advanced Research Projects Agency's (DARPA) predecessor to the Transmission Control Protocol and Internet Protocol (TCP/IP),[25] such common protocols are necessary for electronic devices to communicate and exchange data. To illustrate, the Universal Serial Bus (USB), which was developed by an initial group of U.S. computer firms including Intel, IBM, and Microsoft, has become the global standard for interfacing computer peripherals with the main system.[26] The uniform incorporation of USB into computers and computer peripherals (keyboards, printers, disc drives, etc.) replaced the need for multiple incompatible jacks, which had made it difficult to design and market products for any and all types of personal computers. Use of USB helped alleviate market confusion and increased the market for peripherals, as buyers can now confidently purchase new hardware assured of its compatibility with their in-place computer systems.

While there may be, and often are, competing standards for a given technology, technology standards often achieve quasi-monopoly status in world markets. For example, consider Microsoft's Office Suite: although there are competing software options, including free open-source and online tools, Microsoft's Office Suite still dominates the

---

[24] Charles P. Kindleberger, *Standards as Public, Collective, and Private Goods*, 36 KYKLOS 377 (1983).

[25] These technologies were the first networking standards designed to enable computers to share and transmit data. The OSI standard was developed and approved under ISO, while TCP/IP grew out of military research. TCP/IP is the main technology that makes the Internet possible. *See generally* JERRY FITZGERALD, BUSINESS DATA COMMUNICATIONS AND NETWORKING (11th ed. 2011).

[26] Peter Seebach, *Standards and Specs: The Ins and Outs of USB*, IBM DEVELOPER WORKS (Apr. 26, 2005), http://www.ibm.com/developerworks/power/library/pa-spec7/index.html.

global market in "business productivity software" with nearly 90% of the market.[27] This monopoly enhances Microsoft's brand value and makes it difficult for competing—even potentially better—technologies to take root in the market. Firms whose technology is incorporated into a dominant standard can earn massive returns, while those who supported a losing standard can find their R&D investment wasted.

Technology standards can be divided into de facto (market-based) and de jure standards.[28] De facto standards, such as Sony Blu-Ray, are set through market competition where the winning standard or format pushes competitors. De jure standards are developed, set, and administered by institutionalized technology standards bodies. These bodies can be non-governmental organizations with global membership, such as the Institute of Electrical and Electronics Engineers (IEEE), or state membership-based bodies, such as the International Telecommunication Union (ITU) and the ISO.[29] At the national level, there are non-governmental bodies, such as the American National Standardization Institute (ANSI) or European Technical Standards Institute (ETSI),[30] that define national or regional standards. Within these international or national-level organizations, specific technical committees are established to develop standards for a given technology or area of interest.[31] Under technical committees, working groups of experts propose, test, debate, and adopt protocols to incorporate into the final standard. Generally speaking, inclusion of technologies or approval of protocols is accomplished through consensus and majority vote.

This system of technology standards organizations, which developed over the last century in the industrialized West, was only recently grafted onto China's political economy. While China joined the ITU and ISO in the first half of the twentieth century, after the 1949 Revolution, China's economic, political, and standards institutions were re-oriented towards the Soviet Union.[32] Accordingly, China's technology standardization system was then established under Soviet

---

[27] Shira Ovide, *Microsoft Hits Back as Google Muscles In*, WALL ST. J., July 16, 2012, at B1, *available at* http://professional.wsj.com/article/SB10001424052702303644004577525383396956086.html.

[28] Paul A. David & Shane Greenstein, *The Economics of Compatibility Standards: An Introduction to Recent Research*, 1 ECONS. OF INNOVATION & NEW TECH. 3 (1990).

[29] *See* ISO, www.iso.org (last visited Apr. 7, 2013); ITU, www.itu.int (last visited Apr. 7, 2013); IEEE, www.ieee.org (last visited Apr. 7, 2013).

[30] *See* ETSI, www.etsi.org (last visited Apr. 7, 2013); ANSI, www.ansi.org (last visited Apr. 7, 2013).

[31] *See, e.g.*, Stanley M. Besen, *The European Telecommunication Standards Institute: A Preliminary Analysis*, 14 TELECOMMS. POL'Y 521 (1990).

[32] BREZNITZ & MURPHREE, THE RISE OF CHINA IN TECHNOLOGY STANDARDS, *supra* note 21.

tutelage in the 1950s.[33] This Soviet-influenced system, which governed weights, measures, health, safety, and other generally non-controversial areas, endured in China until the rise of Deng Xiaoping in the late 1970s.[34] Withstanding various reorganizations and name changes, China's national technology standards body, now known as the Standardization Administration of China (SAC), has existed continuously since 1956.[35] It is important to note that structurally, and in terms of institutional culture, China's formal system of standardization is still influenced by the Soviet-designed planned economy standardization system. Soviet-style institutions emphasize top-down direction and state-leadership of technology development and economic initiatives. In interviews we conducted,[36] many industry and company representatives noted that to this day, there is reticence in Chinese industry to take the lead in standards activities unless the state has already declared its interests or initiated efforts.

During the Cultural Revolution, China's economic and industrial infrastructure, and even planning apparatus, largely collapsed. The 1978 initiation of Opening and Reform led China to rejoin the international standards community. In 1978, China was re-admitted to the ISO.[37] In joining Western-led standards organizations, Western norms and formal organizational practices regarding standardization practice and procedure were gradually grafted onto the then-reforming Chinese political economy.[38] China's legal and practical approach to, as well as use of, standards must thus be considered in the context of China's reforming and uncertain political economy in the last two decades of the twentieth century following its opening up to the Western world.

B. *The Role of Structured Uncertainty and Global Fragmentation of Product in China's Innovation System and Technology Standards*

Two leading forces have and continue to shape China's innovation system and the role played by, as well as the means of using, technology standards: structured uncertainty and the global fragmentation of production.

---

33 Ping Wang, Yiyi Wang & John Hill, *Zhong Guo De Biao Zhun Zhan Lue—Cheng Jiu Yu Tiao Zhan [China's Technology Standards Strategy: Achievements and Challenges]* 2 (East-West Center, National Bureau of Asian Research, Working Papers: Economic Series No. 107, Oct. 14, 2009), *available at* http://cdn.nbr.org/downloads/CS09_WANG_Ping_Paper_CH.pdf (in Chinese) and http://www.eastwestcenter.org/fileadmin/stored/pdfs/econwp107.pdf (in English).

34 *Id.*

35 *Id.* at 1–2.

36 *See supra* note 1.

37 Ping et al., *supra* note 33, at 2.

38 *See id.* at 2–4.

i. Structured Uncertainty in China

Structured uncertainty may be defined as an agreement to disagree about the proper objectives and methods of public policy or business practices.[39] In China's political economy, policy makers and administrators do not necessarily agree, nor do they unequivocally define, the appropriate or accepted patterns and limits for policy or business practice. In any given policy sphere, government influence is strong, but clear direction and limitations are often vague. As a result, it is impossible under the force of structured uncertainty for any actor—political or business—to know *ex ante* what behaviors (such as business activities or administrative innovations) will be encouraged or sanctioned. In such a climate, political actors and firms engage in short-term behaviors. Further, and particularly in China, firms often seek protection from the government by cultivating relations with the state at different levels.

Structured uncertainty, given the persistent lack of clarity, also implies that wherever there is clarity from government officials, all actors in the system will respond forcefully to those objectives or incentives. For example, while the final goals of China's Opening and Reform have never been clearly elucidated, since the 1980s, it has been abundantly clear that policies or practices which produce economic growth increase levels of investment, attract foreign investment, increase exports, and generate employment are always welcome and rewarded by the national government. Local and regional government officials respond by encouraging policies guaranteed to quickly produce these types of economic growth results. Similarly, firms move into industrial sectors or activities likely to yield quick results. Since 2002, the Chinese government has incorporated "standards" as goals in China's five year plans and provided funding for standards efforts.[40] This commitment of resources shows a high degree of state interest in developing indigenous technology standards to which firms and academic actors have forcefully responded—insomuch as they have become participants in the standards development process. The number of standards developed and submitted for approval by industrial ministries and the Standards Administration of China has increased rapidly since 2002.[41]

---

39 BREZNITZ & MURPHREE, RUN OF THE RED QUEEN, *supra* note 12, at 12.

40 Ping et al., *supra* note 33, at 4–6, 7–9.

41 For a comprehensive list of Chinese standards and spreadsheets on new applications, revisions, and programs, see *National Standard Information Sharing Infrastructure*, CHINESE STANDARDS SERVICE NETWORK, http://www.cssn.net.cn/pagesnew/libresources/lib_resources.jsp?libtype=NATIVE_CSIC#CN-GB (last visited Apr. 7, 2013).

ii. Global Fragmentation of Production

The global fragmentation of production is the process by which goods and services are no longer produced in single locations by vertically integrated, and nationally oriented, firms.[42] Rather, managers and engineers break the production process into modules that can then be outsourced and/or offshored. Fragmentation of production has industry-wide and often international effects, as it means that different regions can now specialize in individual stages of production, not necessarily the entire industry. For example, California's Silicon Valley was once a center for manufacturing of electronics and information technology hardware, but is now dominated by companies that specialize in the invention and design of new high technology goods and services.[43] The development, design for production, and manufacturing of these goods and services is now outsourced to dedicated firms, often located overseas.[44] This fragmentation has enabled the Silicon Valley region to specialize in certain stages of production, while other regions and firms can specialize in other stages. Thus, the fragmentation of production has fundamentally changed the way goods and services are produced.

Fragmentation also implies that different regions, specializing as they do in different stages of production, will develop different sets of specialized capabilities and therefore have different approaches to both innovation and the management of innovation. To illustrate the impact of the interaction of structured uncertainty and the fragmentation of production on technology standards behavior in China, we now turn to an illustrative brief case study looking at China's digital optical storage media industry and standards. This case shows how these two forces have enabled and encouraged certain behaviors, while constraining others, just as has been seen throughout China's broader innovation system.

II. CONSTRAINED AND ENABLED: CHINA'S APPROACH TO DIGITAL OPTICAL STORAGE MEDIA STANDARDS

Common wisdom expressed in the popular press holds that as China has already gathered unto itself so much of the world's

---

[42] FRAGMENTATION: NEW PRODUCTION PATTERNS IN THE WORLD ECONOMY (Sven W. Arndt & Henryk Kierzkowski eds., 2001); Peter Gourevitch, Roger Bohn & David McKendrick, *Globalization of Production: Insights from the Hard Drive Disk Industry*, 28 WORLD DEV. 301 (2000); LOCATING GLOBAL ADVANTAGE: INDUSTRY DYNAMICS IN THE INTERNATIONAL ECONOMY (Martin Kenney & Richard Florida eds., 2003); Timothy J. Sturgeon, *Modular Production Networks: A New American Model of Industrial Organization*, 11 INDUS. & CORP. CHANGE 451 (2002).

[43] Timothy J. Sturgeon, *What Really Goes On in Silicon Valley? Spatial Clustering and Dispersal in Modular Production Networks*, 3 J. ECON. GEOGRAPHY 199 (2003).

[44] *Id.*

production capacity in IT hardware and electronics, deep understanding of, and eventual control over, this industry and the technological architectures governing it will soon follow.[45] Indeed, a widely read article claims the migration of manufacturing capacity and divorce of production from research and design will undermine the capabilities of outsourcers and benefit firms that retain or specialize in production.[46] Yet the story of China's attempt to develop a technology standard for digital optical storage media demonstrates how this theory may over-estimate the technology benefits producers reap in a world of fragmented production. Since the mid-1990s, China has attempted with little commercial success to develop unique technology standards for digital optical storage media.[47] These failed attempts show that despite China's ever-growing dominance in production, this has not translated into a transfer of novel-product innovative capabilities.

Digital optical storage media include CD and DVD players, computer disc drives, and high-definition discs. Many of the technologies included in standards for digital optical storage media are also included in standards for the digital transmission of analog data for online streaming media, such as used in Internet TV and much of high definition cable broadcasting.[48] Briefly stated, the technology behind optical media is a means of storing analog data (audio and video transmitted to the listener or viewer as waves) in digital (1s and 0s) format.[49] In order to convert digital data into analog signals, a device uses a laser to read the disc and then a software codec (encoder-decoder) converts the digital information back into an analog wave.[50] The writing process also uses compression algorithms to reduce the amount of space needed for storage, thus making discs smaller and increasing the capacity in a given amount of space.[51] All of these component technologies are subject to codification in standards for a given type of optical storage media. For example, a device using a standard based on one type of compression algorithm will not be

---

[45] Devon Swezey, *As Manufacturing Shifts Abroad, Innovation's Reward Dwindles*, BREAKTHROUGH (Sept. 16, 2010), http://thebreakthrough.org/archive/as_manufacturing_shifts_abroad; Charles Duhigg & Keith Bradsher, *How the US Lost Out on iPhone Work*, N.Y. TIMES, Jan. 22, 2012, at A1.

[46] *See* Stephen Denning, *Why Amazon Can't Make a Kindle in the USA*, FORBES (Aug. 17, 2011, 9:33 AM), http://www.forbes.com/sites/stevedenning/2011/08/17/why-amazon-cant-make-a-kindle-in-the-usa/.

[47] *See generally* Scott Kennedy, *The Political Economy of Standards Coalitions: Explaining China's Involvement in High-Tech Standards Wars*, 2 ASIA POL'Y 41 (2006) [hereinafter Kennedy, *The Political Economy of Standards Coalitions*].

[48] For example, the MPEG-4 standard is part of both digital optical media and wireless transmission standards for audio and video content.

[49] GRAHAM WADE, SIGNAL CODING AND PROCESSING 34 (2d ed. 1994).

[50] Matt Knouff, *Codecs Explained*, TOPTEN REVIEWS (2012), http://cd-burning-software-review.toptenreviews.com/mac-cd-burning-software/codecs-explained.html.

[51] *Id.*; WADE, *supra* note 49, at 34.

compatible with a disc designed in accordance with a standard using a different compression algorithm. The laser will be able to read the data, but the device will be unable to convert it back into the intended analog waves.

China began its efforts in optical storage media standards in the mid-1990s in the hope of protecting the Chinese market from the coming DVD standard.[52] However, the Chinese technologies developed in this field found little market acceptance outside of China.[53] Rather, despite the rapidly increasing scale of Chinese production capabilities in IT hardware and electronics, the international de facto DVD standard came to the forefront even within China.[54]

By the late 1990s, the DVD standard, which was developed by an alliance of Japanese, American, and European companies, became established. Although initially DVD players were an expensive luxury with a comparatively limited market, hundreds of Chinese manufacturers established DVD player production lines.[55] The explosion in production capacity resulted in a rapid decline in price that fueled mass-market demand for DVD players.[56] Production in China expanded rapidly, from 3.5 million DVD players in 2000, to 70 million—seventy five percent of world output—by 2003.[57] Although the potential global market was enormous, the profit potential for many Chinese firms, particularly for later entrants into production, was very limited. As a more-or-less fully developed and codified technology, DVD players left little room for Chinese firms to alter the standard or provide alternatives to foreign mandated patents and their associated royalties.[58] Profit margins for Chinese manufacturers fell to one dollar per unit by 2004.[59] High royalty rates became a source of constant friction with the foreign firms controlling the DVD standard.[60] While

---

[52] *See* Kennedy, *The Political Economy of Standards Coalitions*, *supra* note 47, at 48–56; Linden, *supra* note 22; Philip Qu & Carl Polley, *The New Standard-Bearer*, IEEE SPECTRUM (Dec. 2005), http://spectrum.ieee.org/computing/hardware/the-new-standardbearer; Junko Yoshida & Mark Carroll, *China Flexes Standards Muscle*, EE TIMES (Nov. 24, 1997), *available at* http://business.highbeam.com/3094/article-1G1-20027685/china-flexes-standards-muscle.

[53] Kennedy, *The Political Economy of Standards Coalitions*, *supra* note 47, at 51–56.

[54] *EVD Players Not Selling as Expected in China*, PEOPLE'S DAILY (Jan. 10, 2004), http://english.people.com.cn/200401/10/eng20040110_132291.shtml [hereinafter *EVD Players Not Selling as Expected in China*].

[55] SCOTT KENNEDY, THE BUSINESS OF LOBBYING IN CHINA (2005).

[56] Linden, *supra* note 22.

[57] *Id.* at 13.

[58] *Id.*; Tony Smith, *China Unveils 'DVD Killer' Video Disk Format 'HDTV quality'*, REGISTER (Nov. 20, 2003, 10:35 AM), http://www.theregister.co.uk/2003/11/20/china_unveils_dvd_killer_video/.

[59] Michael Kanellos, *DVD Player Profits Down to $1*, CNET NEWS (Aug. 9, 2004, 3:19 AM), http://www.smallcapinvestorblog.agoracom.com/ir/edigital/forums/discussion/topics/5953-dvd-player-profits-down-to-1.

[60] Petteri Pyyny, *Chinese DVD Player Manufacturers Take Patent Owners to Court*, AFTERDAWN NEWS (Jan. 20, 2005, 2:02 PM),

China clearly dominated production, it did not have the ability to change the standard—and hence reduce the royalties owed on embedded technologies—which was defined and controlled by an alliance of foreign firms. China's manufacturers specialized in the final assembly of DVD players. Nonetheless, China's position as final manufacturers offered little room for development of core research capabilities since the technologies with, and on which, they worked were already standardized and set.

A. *The Push for an Indigenous DVD Standard*

As early as 1999, China's government proposed development of a Chinese standard as a means of alleviating the looming financial troubles of its manufacturers.[61] Under the guidance of the Ministry of Information Industry (MII), several government research institutes and DVD manufacturers formed an industry alliance through an incorporated entity called Beijing E-World Technology.[62] MII and the State Trade and Economic Commission provided $1.2 million dollars to begin development of an indigenous Chinese red-laser based standard.[63] Two years later, the Beijing E-World alliance announced completion of a "new" Chinese standard, the Advanced High Density Disc System, later merged with a "basically compatible" Taiwanese technology known as Enhanced Versatile Disc (EVD).[64]

China's position in global fragmented production chains meant its firms, while involved in the E-World EVD development effort, were limited in their ability to offer fundamentally new technology. Indeed, while being touted as China's tool to free itself from dependency on foreign proprietary technology, EVD actually relied on core foreign technology for various aspects, including video compression. For example, the VP5 and VP6 software codecs were developed and owned by On2, a U.S. company.[65] The decoder was developed in cooperation

---

http://www.afterdawn.com/news/archive/5979.cfm.

61 Mike Clendenin, *China Taps U.S. Partner to Keep EVD Standards*, EE TIMES INDIA (Feb. 16 2006), http://www.eetindia.co.in/ART_8800407147_1800010_NT_32a4d728.HTM# [hereinafter Clendenin, *China Taps U.S. Partner to Keep EVD Standards*]; Yifan Zhang, *Xiao Shou Yu Leng EVD Die Jin Nian Nei Yao 'Tui Shi' [Sales Run Cold: EVD Players Will Exit the Market Within the Year]*, CHENGDU SHANGBAO, Mar. 8, 2008, *available at* http://news.hexun.com/2008-03-08/104291325.html.

62 *China to Issue Home-Developed EVD Standard*, PEOPLE'S DAILY (Oct. 28, 2003), http://english.peopledaily.com.cn/200310/28/eng20031028_127012.shtml.

63 Smith, *supra* note 58; Clendenin, *China Taps U.S. Partner to Keep EVD Standards*, *supra* note 61.

64 Mike Clendenin, *Taiwan Joins Chinese Effort on Proprietary DVD Format*, EE TIMES (May 24, 2002, 4:49 PM), http://eetimes.com/electronics-news/4043332/Taiwan-joins-Chinese-effort-on-proprietary-DVD-format.

65 *VP5 and VP6 to Be Included in China's EVD Standard*, CHINA TECH NEWS (Nov. 18, 2003), http://www.chinatechnews.com/2003/11/18/105-vp5-and-vp6-to-be-included-in-chinas-evd-standard.

among a U.S. company LSI Logic, Beijing Homaa Microelectronics Technology, and E-World.[66] Despite state investment, strong encouragement and broad-based industry participation, the standard development effort did not yield a wholly Chinese standard since significant technologies were foreign-owned and created.

However, the need to incorporate foreign technology makes sense in light of the conditions of global fragmentation of production and structured uncertainty in China. While central government support made it clear that a new standard was desired, it was never clear whether this standard would be simply adopted or made the exclusive standard within China.[67] Further, involvement of foreign firms was a pragmatic solution to ensure the standard could be produced in a timely fashion before government policies changed. Under fragmentation of production, Chinese firms' capabilities were mostly in final assembly of electronics, not the design, or even alteration, of software-intensive core technologies.[68] As a result, their ability to develop a wholly new standard was constrained.

Although manufacturing prowess has been stated as the first step toward technology and standard dominance, China's EVD standard was not a commercial success.[69] Despite much lower royalties that manufacturers owed to IP rights holders for producing EVD standard products ($2 per unit as opposed to $13–$20 for foreign standard units), the popularity and relative low-cost of DVD players meant that EVD never gained appreciable market share.[70] Arrival of the High-Definition Digital Video Disk (HD-DVD) and Blu-ray high-definition formats further eroded EVD's market potential. By 2006, it was clear the standard was commercially unsuccessful; the last players were removed from store shelves in late 2008.[71]

While EVD was neither a technological nor market success, by

---

66 Ed Frauenheim, *Report: China's Next-Generation DVD Faces Hurdles*, CNET NEWS (Jan 29, 2004), http://news.cnet.com/2100-1041_3-5150373.html; *Chinese Unveil Homegrown 'EVD' Technology*, WINNIPEG FREE PRESS, Dec. 7, 2006, at B9; *Out DVD, in EVD*, CHINA ECON. REV. (Dec. 1. 2006), http://www.chinaeconomicreview.com/node/48464; Junko Yoshida, *China Unveils Its Own Video Format*, EE TIMES (Nov. 18, 2003), http://eetimes.com/electronics-news/4046157/China-unveils-its-own-video-format-item-1.

67 Smith, *supra* note 58; Zhong Jing, *China's EVD Standard Becomes the Industrial One*, CHINA ECON. NET (July 21, 2004, 9:49 AM), http://en.ce.cn/Insight/200407/21/t20040721_1285100.shtml.

68 BREZNITZ & MURPHREE, RUN OF THE RED QUEEN, *supra* note 12.

69 Zhen Wang, *Xinke Dianzi Jituan Bei Tuoguo Chongzu: Guochan EVD de Yaozhe [Shinko Electronics Group Manages Restructuring: The Collapse of EVD]*, DI YI CAIJING RIBAO (Dec. 29, 2011), *available at* http://tech.163.com/11/1229/01/7MDF38RQ000915BD.html; Yifan, *supra* note 61.

70 *EVD Players Not Selling as Expected in China*, *supra* note 54; Linden, *supra* note 22, at 15–16.

71 Clendenin, *China Taps U.S. Partner to Keep EVD Standards*, *supra* note 61; Yifan, *supra* note 61.

bringing China's challenge to global standards into the spotlight, the standards effort quickly led to a substantial reduction in the royalties Chinese manufacturers had to pay.[72] The announcement of the EVD standard was shortly followed by a royalty-rate concession from DVD's standard bearers; major patent holders agreed to only charge full royalties for exported DVD players—a decline from $21 to $12 per DVD player.[73] For manufacturers located at the assembly end of fragmented global production, lowering the price for necessary intellectual property was a major victory. By early 2004, the overall royalty rate had been further reduced to $13.80 for any exported player as well.[74] Given the position of China's firms in fragmented production chains, the EVD standard yielded tangible benefits for the industry. It thus served the interest of China's firms, given their position in global production chains, even despite the lack of ultimate market success for the standard.

B. *A Second Wave of Indigenous Technology Standards Efforts in the High-Definition Era*

The success of standards efforts in reducing royalties would play out again in the high-definition era. Once again, Chinese firms would rely on foreign technology. Nonetheless, manufacturers would benefit from the standard as it pressured the dominant standard's patent holders to lower their royalty rates.

In October 2005, China announced plans to develop a new violet laser high-definition disc player.[75] With broad state support, a three-part alliance formed to develop the standard, titled China Blue High-Definition Disk (CBHD).[76] The main developers were the Optical Memory National Engineering Research Center (OMNERC) at Tsinghua University, the China High-Definition DVD Industry Association (CHDA), and China Electronics Technology Group Corporation (CETC).[77] The standard took shape through subsidized research conducted at OMNERC and CETC. The leading commercializers of CBHD players, TCL and Shinco, enjoyed preferential state financing in their development and production efforts.[78] In addition, other manufacturers received state subsidies to

---

[72] Bruce Einhorn, *Master of Innovation?*, BUS. WEEK (Apr. 13, 2003), http://www.businessweek.com/stories/2003-04-13/master-of-innovation.

[73] Linden, *supra* note 22, at 14.

[74] *EVD Players Not Selling as Expected in China*, *supra* note 54.

[75] Isabel Ding, *The Blu-ray Challenge in China*, CHINA INT'L BUS., Jun. 10, 2009.

[76] *Id.*; Marcus Yam, *CBHD Is China's Own Blu-Ray Disc*, TOM'S HARDWARE US (May 1, 2009), http://www.tomshardware.com/news/cbhd-china-blue-bluray-disc,7681.html.

[77] Yam, *supra* note 76.

[78] *TCL and Shinco Ship First CBHD Players in China*, CDR INFO (Apr. 23, 2009), http://cdrinfo.com/Sections/News/Details.aspx?NewsId=25238.

accelerate their development of CBHD player models.[79]

CBHD, however, was not entirely indigenous technology. It was heavily based on Toshiba's HD-DVD technology, acquired at fire-sale prices.[80] CBHD generally relied on foreign core technology in order to function.[81] According to some analysts, CBHD did not deserve state support or to even be called a "Chinese" standard as up to ninety percent of the technology was derived from Toshiba's HD-DVD standard.[82]

Yet, like EVD efforts, the development of CBHD again forced a reduction in royalties Chinese manufacturers owed to foreign IPR holders. The royalties for the CBHD players were set at only $8 per player.[83] As happened with the release of the EVD, Sony's Blu-Ray Alliance reduced the mandatory royalties for manufacturers of its players to $9.50 per player.[84]

As a testament to the nature of structured uncertainty, while CBHD enjoyed direct state support, it was not the only locally developed standard in this field. Firms hedged their bets to ensure their projects would find market outlets. Under structured uncertainty, there is always the risk that the government will withdraw support from a standard, or adopt an alternative, if one is not developed in a timely fashion. It was thus rational for firms to also support the entirely foreign Sony Blu-Ray standard. One noteworthy project was Guangzhou Digital Rise Technology's development of an audio-video codec (DRA) for the globally dominant Blu-Ray standard.[85] As part of an agreement permitting sales of Blu-Ray products in China, the Blu-Ray Disc Alliance accepted the Chinese DRA audio-video codec as part of the Blu-Ray 2.3 package.[86] As with EVD, the main benefit for Chinese firms in their locations in global production chains was through the

---

79 *Id.*

80 Jimmy Hsu & Adam Hwang, *Hollywood Movie Studios Not Supporting China-Developed CBHD, say Taiwan Optical Disc Makers*, DIGITIMES (Aug. 29, 2008), http://www.digitimes.com/news/a20080828PD215.html; Nobutaka Hirooka & Tsunoru Nakajima, *Next Generation DVD Formats Go Head to Head Once Again*, NIKKEI BUS. (June 1, 2009), http://business.nikkeibp.co.jp/article/eng/20090601/196293/.

81 Guo Ji Jin Rong Bao, *Zhang Bao Quan 'Pao Hong' Qing Hua Guang Pan Yan Jiu Zhong Xin [Zhang Baoquan Attacks Tsinghua Laser Disc Research Center]*, CNFOL (2005).

82 Hsu & Hwang, *supra* note 80; Hirooka & Nakajim, *supra* note 80.

83 Ding, *supra* note 75; *Blu-Ray DVD Players: Industry on the Rise, R&D in High-Gear*, GLOBAL SOURCES-ELECS. (June 15, 2009), http://www.electronics.globalsources.com/gsol/I/Blu-ray-player/a/9000000105354.htm.

84 Ding, *supra* note 75; *Blu-Ray DVD Players: Industry on the Rise, R&D in High-Gear*, *supra* note 83.

85 *China DRA Passes Technical Evaluation for Blu-Ray Disc Format*, CHINA SOURCING NEWS (July 15, 2008), http://www.chinasourcingnews.com/2008/07/15/16342-china-dra-passes-technical-evaluation-for-blu-ray-disc-format/.

86 *Id.*; *Chinese Audio Technology Included in the Blu-Ray Specifications*, CDR INFO (Mar. 20, 2009), http://www.cdrinfo.com/sections/news/Details.aspx?NewsId=25046.

lowering of royalty rates they had to pay to produce for the globally dominant standard. For manufacturing specialists, this benefit cannot be underestimated. When intellectual property is just one of many technology inputs, it is in the best interest of a manufacturer to reduce the cost of that input and thus raise potential profitability.

DISCUSSION AND CONCLUSION

In developing technology standards, China has not yet managed to find the "secret" of fostering independent novel-product innovation. China's standards, as shown in digital optical storage media, are still heavily reliant on foreign technology.[87] However, the development of standards does yield tangible benefits for Chinese manufacturers that face difficult cost challenges.[88] Under the fragmentation of global production, Chinese firms have come to specialize in the final assembly and integration of electronic goods.[89] However, through participation in the development of an alternative standard, these firms benefit by receiving lower royalty rates on the goods they already produce.[90]

The inability of Chinese firms to create globally successful standards can be attributed in part to structured uncertainty.[91] There is no clear assurance that a unique Chinese technology standard will have a guaranteed market in China. In the cases detailed above, there was state support for standard development, but never an unequivocal commitment to one standard or another, much less a guaranteed protected market. Without this potential market, firms are hesitant to invest heavily in a Chinese standard since there were, at least in the cases discussed here, existing and market-tested foreign standards. This weakens the potential for broad adoption by manufacturers, which is needed to push a new standard into the market. At the same time, some government funds are made available for standardization efforts.[92] These government grants and subsidies are important sources of R&D financing, especially in smaller firms. Yet, since there is no way to know how long the state will remain committed to, and financially supportive of, a given effort, it is necessary to join in early and attempt to complete the standard as quickly as possible, even if this means involving foreign firms and foreign technologies.[93]

It should come as no surprise that with this environment, technology standards policies and promotion result in creation of

---

87 *See supra* Part II.
88 *See supra* notes 59–60 and accompanying text.
89 *See supra* notes 12–13 and accompanying text.
90 *See supra* notes 72–74, 83–84 and accompanying text.
91 *See supra* Part I.B.1.
92 *See supra* notes 62–63, 76–79 and accompanying text.
93 *See supra* notes 65–66, 80–82 and accompanying text.

technologies and standards that reveal the strengths of Chinese enterprises. The standards show that China's firms are adept at building on foreign technological leads and bringing technologies to commercial fruition.[94] However, they remain unable to push their own breakthrough technologies and even indigenous standards remain reliant on core foreign technology.[95] With the climate of structured uncertainty, shortening time horizons, and fragmentation of production fostering specific capabilities, this result appears quite logical. For the short- to medium-term, we should not expect to see major market-shifting standardized technologies emerging wholly within China. The forces of structured uncertainty and global fragmented production act to constrain this outcome.[96] However, those same forces also enable Chinese firms, critical manufacturers for the whole global production chain, to benefit from the standards efforts that are created.[97]

94 *See supra* notes 80–81 and accompanying text.
95 *See supra* Part II.
96 *See supra* Part I.B.
97 *See supra* notes 72–74, 83–84 and accompanying text.