The Middle Kingdom Galapagos Island Syndrome: The Cul-De-Sac of Chinese Technology Standards

BY STEPHEN J. EZELL AND ROBERT D. ATKINSON | DECEMBER 2014

China has committed to developing unique national standards for dozens of high technology and ICT products—even where international standards already exist—developing homegrown standards for everything from 3G mobile telecommunications services and wireless local area networks to encryption technologies and the Internet of Things.

China has made the development of indigenous technology standards, particularly for information and communications technology (ICT) products, a core component of its industrial development and economic growth strategy. China has done so believing that indigenous technology standards will advantage domestic producers while blocking foreign competitors and reducing royalties Chinese firms pay for foreign technologies. But, as Japan experienced to its detriment, by asserting indigenous, rather than using global, technology standards for ICT products, China risks engendering a "Galapagos Island" effect, isolating its ICT technologies and markets from global norms.

While this may produce interesting technologies domestically, it increases the risk that China's ICT enterprises won't gain access to non-Chinese markets, essentially dooming them to irrelevance. Thus, while indigenous standards may seem like a good idea in the short run by boosting domestic market share held by Chinese firms, they represent a fundamentally bad idea in the long run as they make it much harder for Chinese firms to achieve the global scale so critical for success in ICT industries. Even a Chinese market with 1.36 billion consumers is not large enough to give Chinese firms the scale they need to compete globally with foreign ICT firms that embrace globally interoperable standards.

INTRODUCTION

China has made the development of indigenous technology standards a central component of its technological upgrading and economic development strategies, seeking to use homegrown standards as a way to gain competitive and, hopefully, monopolistic advantage.[1] As China's 15-year "Medium- to Long-Term Plan for the Development of Science and Technology" (MLP), launched in 2006, stated, "The state should establish a platform to service standards, support and speed up the transformation of advanced foreign standards into domestic standards, and give key support to enterprises that promote the formation of technological standards with ourselves as the dominant factor through re-innovation."[2]

As part of this effort, China has committed to developing unique national standards in dozens of high technology areas, even where international standards already exist.[3] For instance, China has adopted or sought to develop unique Chinese standards across a wide range of information and communication technologies, including Internet protocols, mobile telephony, wireless local area networks, digital video players, audio/visual codec standards, optical media storage, home networking, radio frequency identification technology, encryption, software asset management, mobile TV, mobile phone charging, and the Internet of Things.[4]

Moreover, China's technology standards development process has evolved at odds with the voluntary, transparent, market-led and global approach to standards development that is the norm across most of the world. Indeed, China has developed most of these standards without international consensus, and with at best limited foreign—or even, public—input. And even when foreign participants have been allowed to participate in China's standards-setting process, they've often been able to do so only as observers, without voting rights.[5]

China has sought to develop its own ICT standards for three principal reasons:

1. To give its domestic ICT enterprises a competitive advantage in domestic ICT markets, in part by erecting unique technology standards that make it more expensive for foreign competitors to compete in Chinese markets or block them out entirely;

2. To free China from reliance on, and from paying for, foreign technology standards. In other words, to reduce or eliminate royalty payments that Chinese enterprises must pay for foreign technologies; and

3. To earn revenues for Chinese companies as foreign firms are forced to sell compliant products in China, or as products utilizing Chinese standards and technology are sold to overseas markets.[6]

Yet despite the apparent benefits from China's indigenous ICT standards development strategy, it risks a number of unintended and adverse consequences that collectively make the costs of an indigenous standards strategy far outweigh the benefits. Conceptually, five risks in particular stand out. The first, and most significant, is that China risks experiencing the "Galapagos Island Syndrome," in which the adoption of proprietary standards gives rise to the development of isolated markets for ICT products. (The reference to the Galapagos Islands derives from the fantastically and uniquely evolved, yet isolated, species of animals Charles Darwin found in the ecosystem of the desolate islands.) The same symptom afflicted Japan's mobile phone industry when Japanese mobile phone enterprises chose to focus primarily on domestic markets for arguably very innovative mobile products, but the products couldn't compete at scale in global markets. Second, when a country establishes domestic technology standards in an attempt to advantage domestic competitors—for example, by raising the cost for foreign competitors to compete because they have to insert a non-global standard into a product to serve a local market—it shields the domestic competitor from genuine global competition, undermining its ability to thrive in the really tough competition outside the protected home market.

A third risk is that a country actually succeeds in setting a standard, but gets the standard wrong or develops an inferior standard that leads to the production of inferior ICT products. A fourth, related, risk of unilateral standards development—and one apparent on several occasions in China—is that the time-consuming process, often fraught with bureaucratic interagency in-fighting and conflict (or simple bureaucratic inefficiency), delays the introduction of the standard so long that the international community moves on (to another standard or next-generation of a technology) and the country and its ICT enterprises miss the opportunity to compete, both domestically and globally, in the particular technology market. Finally, even when a country does succeed at mandating domestic technology standards, this only raises the costs (or decreases the quality and functionality) of ICT products, compromising the ability of downstream ICT-consuming industries and enterprises to leverage ICT as a fundamental general purpose technology (GPT), and decreasing aggregate consumer welfare. In other words, by imposing proprietary technology standards, governments ultimately only harm local consumers and businesses. And these costs can be significant: the Organization for Economic Cooperation and Development (OECD) estimates that complying with economy-specific technical standards can add as much as 10 percent to the cost of an imported product.[7] And higher ICT costs reduce ICT usage by businesses and consumers.[8]

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Aside from the damage that indigenous technology standards inflict on a country's domestic market, they also damage the global innovation system—and especially markets for innovative products such as ICTs—again in a variety of ways. First, they fragment global markets, reducing scale. This is problematic because most ICT products exhibit high fixed costs (it costs a lot to develop the first product) but lower marginal costs (it costs less to produce subsequent products). Balkanized markets mean higher global costs of production which mean both higher prices and lower profits, the latter of which is important because companies need to earn profits in order to reinvest them in the risky and expensive investments required to produce the next generation of innovative technologies, such as next-generation semiconductors or mobile phones. In other words, because innovative industries principally compete not by making existing products cheaper but by inventing next-generation versions of the product (e.g., Intel competes not by making existing semiconductors cheaper and cheaper over time, but by inventing next-generation microprocessors), profits from one generation of innovation are vital to financing investment in the next.

Second, indigenous technology standards add unnecessary costs for enterprises developing ICT products, such as by forcing them to develop a variety of versions of mobile phones or tablet computers to accommodate differing wireless network technology or encryption standards in different countries. And because those dollars could have gone into lower prices or investments in innovation and technology development instead of accommodating differing technology standards, countries' requirements for indigenous technology standards lower the global stock of innovation, to the detriment of all consumers globally. Third, by specifying indigenous technology standards that artificially support the competitiveness of domestic enterprises, domestic technology standards engender excess competition in global markets, leading to more competition than market forces alone might otherwise produce.[9] Such policies permit weak or uncompetitive firms to remain in the market, drawing off sales from stronger firms and reducing their ability to reinvest in innovation. Put simply, indigenous technology standards are bad for the countries that implement them, the countries and their enterprises affected by them, and the broader global innovation economy.

This report surveys the state of Chinese standards development practices and argues that China has three fundamental choices before it. First, it can pursue a "Galapagos Island" strategy of isolated, indigenous, and perhaps even innovative technology standards development—a path unlikely to yield long-term success. Second, it can engage in the global standards development process, but with an aim to coopt the process in a way that advantages its domestic ICT enterprises. Or, China can engage as an equal participant in the development of voluntary, transparent, consensus-based, market-led standards for technologies—the path most likely to prove beneficial, successful, and sustainable in the long run for Chinese ICT enterprises and industries, the global ICT industry, and indeed the global economy.

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This report proceeds by explaining why the development of global, interoperable technology standards matters. It then explores Japan's experience with the "Galapagos Island Syndrome," explaining how Japan's isolation from global technology markets ultimately inflicted significant damage to an industry that had once been among Japan's most vibrant. The report then turns to examining China's standards development approach, its development of a variety of indigenous ICT standards, and the risks and shortcomings associated with China's indigenous standards approach, including evidence that China's approach has contributed to a number of adverse consequences. The report concludes by offering recommendations for how China can improve its approach to standards development in a way that benefits China's ICT enterprises, China's consumers of ICT products, and even the broader global economy. In particular:

- China should adopt an "open participation model" in product standards development processes and frameworks that is transparent, open, and non-discriminatory for all stakeholders.

- China should remove policies that inappropriately withhold access to standards-development organizations (SDOs) or other Chinese standards-making forums based on where a company or organization is headquartered.

- China should align its standards (including national, industrial, and provincial standards) with international standards and use international standards as the basis of Chinese standards and regulations wherever practical. China should not make minor alterations to existing international standards with the intent of developing a China-only standard. Rather, it should modify international standards only in cases where it is permitted to do so by the World Trade Organization (WTO) Technical Barriers to Trade (TBT) agreement, such as to achieve legitimate objectives including environmental, health, safety, or national security protections.[10]

- China should broaden its recognition of international standards to include any standard that meets the principles for the development of international standards identified by the WTO TBT agreement. In particular, China tends to define international standards too narrowly, to include only those standards developed by treaty- and non-treaty organizations such as the International Telecommunications Union (ITU), the International Organization for Standardization (ISO), or the International Electrotechnical Association. This definition excludes other significant SDOs, such as IEEE and ASTM International, and is not consistent with the development of international standards identified by the WTO's TBT rules. China's policies also do not recognize the importance of standards from organizations such as the World Wide Web Consortia (W3C) or the Internet Engineering Taskforce.[11]

- China's standards notification policies should adhere more closely to the WTO TBT Committee's *2000 Decision on Principles for the Development of International Standards* and to the TBT Code of Good Conduct policy. In particular, the latter calls for China to abide by a 60-day comment period for any newly proposed standards and calls for mandatory reply to all comments received by domestic and international stakeholders.

- Technology that is not developed or registered in China should still be considered for inclusion in Chinese standards. Currently, it is difficult for individuals, universities, or enterprises to get their technology considered for inclusion in Chinese standards if the technology is not developed or registered in China.

- China's funding of university or research institution research and development (R&D) activity should not be contingent upon nor reward the development of China-unique standards, but should support the development of workable technology solutions in general. This would change a policy in which the provision of research funding in China may take into consideration whether the institution intends to develop a China-unique standard as a result of the funding. Such policies ultimately limit needed engagement of Chinese academics with the global academic community.

- Wherever the majority of the rest of a global industry sector has developed a voluntary consensus standardization forum as the preferred venue for the development of certain ICT standards, Chinese industry should join the rest of the sector in the development of those standards.[12]

WHY GLOBAL, INTEROPERABLE STANDARDS MATTER

The more than 500,000 global technology standards in existence today provide the underlying foundation of the global technology marketplace.[13] Standards govern the design, operation, manufacture, interoperability, and use of nearly everything that mankind produces. They reduce uncertainty by creating a common technological platform upon which any actor can develop new applications. Moreover, the use of standards permits the rapid enlargement of markets and reduction of transaction costs, which increases enterprises' incentives to invest in R&D.[14]

Just consider the difference in a global traveler's experience with two different technologies, one that uses global standards and one that does not. Often foreign travelers seeking to charge their computers must take bulky adapters to plug into electric wall sockets. In contrast, when they turn on their computers in their hotel room, their Wi-Fi works in whatever country they are in. The reason of course is that when electricity plug and outlet standards were developed, global standards bodies were much less developed than today; Wi-Fi was established more recently when global standards bodies were more developed.

As this example demonstrates, the development of global standards for products and technologies has benefitted producers and consumers alike, augmenting innovation throughout the global economy. Consumers benefit from technology standards every time they are able to use the same USB port across multiple computing or consumer electronics products, to use their cell phones in different countries, or to communicate using audio and data standards.[15] Internationally compatible standards enable businesses to leverage technologies and manufacture products efficiently at economies of scale by reducing the costs that otherwise would be involved in producing specific variations of products to meet different jurisdictions' standards.

In today's globalized ICT marketplace, the ICT products that can achieve global scale are increasingly the ones that win.

Moreover, standards have become increasingly important both because they are ubiquitous in ICT products and services and because they directly affect up to 80 percent of world trade, with an estimated value exceeding $13 trillion.[16] In essence, standards form a bridge between markets and technologies.[17] But standards can also be used as a tool to block or limit foreign companies' access to domestic markets.[18] And that explains why countries' standards-setting policies and practices have become increasingly important in today's globalized, technology-based economy.

Successful standards, particularly with regard to ICT products, need to promote interoperability, and, crucially, be global in operation. Open, interoperable standards are indispensable for the global ICT ecosystem and have been fundamental to the development of digital applications such as email and the Internet. For example, before the advent of Web-based email, when services such as CompuServe, Prodigy, and MCI Mail dominated, it was only possible to exchange email if both the sender and receiver used the same email service provider, which significantly curtailed email exchange until interoperable Web-based services such as Hotmail arrived.[19] Likewise, today, while Japan leads the world in contactless mobile payments (an example of creative innovation in its "Galapagos Island" standards environment), it lacks a fully open, interoperable system whereby any electronic money service (e.g., Suica, Edy, Nanaco, etc.) operating on a smart card or mobile phone can interact with any reader terminal.[20] As a result, Japanese merchants must often have multiple point-of-sale (POS) terminals at checkout counters to accommodate the varying electronic money services their customers may use, both raising the merchants' costs and compromising Japan's ICT enterprises' efforts to sell a unified electronic money system to global markets.

This illustrates the essential point that in today's globalized ICT marketplace, the ICT products that can achieve global scale are increasingly the ones that win. Apple in particular succeeded by making its iPods, iPhones, and iPads virtually ubiquitous throughout the world, across North and South America, Europe, Asia, and Africa. Likewise, markets for routers, servers, laptops, printers, video players, flat screen TVs, and virtually all other ICT products have become globalized. That wasn't necessarily the case 25 years ago, particularly before the advent of the Information Technology Agreement (ITA), a trade agreement launched in 1997 that eliminated tariffs on trade for hundreds of ICT products and that has contributed to a five-fold increase in global two-way trade in ICT products since.[21] So while Japan might have thought its ICT industries could succeed by catering primarily to domestic consumption 25 years ago, and that a "Galapagos Island" approach of isolated technology standards and products could be viable, the limitations of that strategy became clear when Japan failed to successfully sell its mobile devices in global markets. As a result, many in Japan refer to this failed strategy as a "Galapagos Island" strategy: all sorts of innovative product evolution occurs, but it remains locked on the island of Japan. In short, the reality today is that success in ICT markets fundamentally depends on achieving global scale.

A key reason why scale matters is because innovation industries, such as ICT, are characterized by high fixed costs of initial research, design, and development but relatively low marginal costs of production. For example, it can cost a semiconductor manufacturer as much as $5 billion up front to design a next-generation microprocessor and build a fabrication facility to produce it, but individual integrated circuit chips come off the assembly line at marginal cost. Accordingly, access to large global markets better enables innovative industries to cover those high fixed costs, so that unit costs can be lower and revenues for reinvestment in the next generation of innovative products higher.[22]

This explains why firms in almost all innovation industries are global. If they can sell in twenty countries rather than five, expanding their sales by a factor of four, their costs increase by much less than a factor of four. This is why numerous studies have found a positive effect of the ratio of cash flow to capital stock on the ratio of R&D investment to capital stock.[23] The more sales, the more funds that can be plowed back into generating more innovations. This is also why a study of European firms found that for high-tech firms, "their capacity for increasing the level of technological knowledge over time is dependent on their size: the larger the R&D investor, the higher its rate of technical progress."[24] (Interestingly, not all industries have this characteristic: a study of over 1,000 European companies found increasing returns to scale for high-tech firms, but decreasing returns to scale for low-tech ones.)[25] But for ICT enterprises and industries, scale is one of the keys to success because they face declining marginal costs.

Related to the scale issue is that many ICT applications—such as the telephone, fax machine, and social networks—are characterized by network effects, meaning that their success depends upon accumulating a critical mass of users, and also that the value of the network increases as more users join it. As Kobe University professor Jeffrey Funk notes in "Standards, critical mass, and the formation of complex industries: A case study of the mobile Internet," "agreements on open standards facilitate the emergence of a critical mass of users."[26] But as Funk notes, "conflicts in standard setting are one reason why a critical mass of complementary products has not emerged in many industries/products such as digital audio tape, digital compact cassette, mini-discs, high-definition television, and AM stereo."[27] In other words, global standards are important because they help enable global markets for ICT products to emerge.

JAPAN'S GALAPAGOS ISLAND SYNDROME EXPERIENCE

As noted, some countries adopt domestic technology standards in part because they hope to give local companies a competitive advantage by keeping foreign competitors out of (or making it more difficult for them to compete in) their domestic markets. But the risk to this strategy is that even if the domestic standard helps native businesses by keeping foreign competitors out, it compromises their ability to compete in international markets; companies tend to focus on developing products attuned to their home markets' unique standards and thus neglect opportunities to build products that leverage global standards that can be sold at scale into global markets.

Global standards are important in part because they enable global markets for ICT products to emerge.

Such has been the case with Japan's "Galapagos Island Syndrome," which has seen the country's ICT enterprises develop quite advanced ICT products that were nevertheless isolated from global markets.[28] Japan's development and adoption of unique standards for second- and third-generation (2G and 3G) mobile networks contributed to Japan's leading mobile phone manufacturers, including NEC, Panasonic, and Sharp, dominating domestic markets with innovative mobile technologies and products. Indeed, in the early 2000s, many American commentators visiting Japan praised Japanese cell phone makers for being more innovative than American ones. But because they adopted Japan-only standards, these Japanese technology firms had difficulty exporting to foreign markets, thus giving rise to the term "Japan's Galapagos Island Syndrome."[29] And of course, these early leaders were soon left behind the global leaders who chose to use global standards.

In 1991, Japan's Ministry of Posts and Telecommunications (MPT) decided that a proprietary standard developed by the Japanese telecommunications company NTT—Personal Digital Cellular, or PDC—would become Japan's national standard for 2G services.[30] Though Japan's MPT attempted to convince neighboring East Asian nations to adopt the PDC standard, arguing that it offered a higher frequency spectrum than the GSM (Global System for Mobile Communications) standard then being developed in Europe, no mobile network operator outside Japan adopted the PDC standard, and so Japanese mobile phone manufacturers began to develop mobile devices unique to the PDC standard. Similarly, when third-generation mobile technologies began to evolve by the early 2000s, Japan quickly moved to adopt its own advanced 3G standard, W-CDMA, in 2001. Accordingly, for many years, Japan's telecommunications industry utilized wireless communication standards, mobile data standards, and frequency bands quite different from those used in other parts of the world.[31]

To be sure, PDC and W-CDMA were robust mobile network standards, and their capabilities enabled Japanese mobile network operators such as NTT Docomo to respond by developing hugely popular e-commerce and content services such as i-Mode, one of the world's first mobile Internet services, allowing users to access the Web and send mobile messages from their cellular phones. Indeed, Japanese cell phones set the pace in almost every industry innovation at the turn of the millennium: e-mail capabilities in 1999, camera phones in 2000, third-generation networks in 2001, full music downloads in 2002, electronic payments in 2004, and digital TV in 2005.[32] And, as ITIF has written, Japan has since the mid-2000s convincingly led the world in deployment and adoption of contactless mobile payment systems, something Apple's iPhone is only now beginning to offer.[33]

Buoyed by the world's most sophisticated mobile phones, Japanese manufacturers dominated their home market, and the rapid growth of Japan's cell phone market from 1995 to 2005 gave Japanese companies little incentive to sell their products to overseas markets (which lagged technologically at the time). Moreover, as the *New York Times'* Hiroko Tabuchi wrote in a seminal 2009 article, "Why Japan's Cellphones Haven't Gone Global," both because Japan's mobile phones catered so strongly to Japanese tastes and because they used a Japan-only telecom standard, they "evolved in isolation from the global market" and struggled to make headway overseas.[34] In essence, Japan's cell phones had become so advanced that they had little in common with mobile devices in the rest of the world; they had actually become too advanced for most other markets.[35] Yet when growth in the Japanese mobile phone market dried up by the mid- to late-2000s—just as growth across the rest of the world began to accelerate—Japan's mobile phone manufacturers remained locked into the country's fragmented and isolated marketplace, and proved unable to adapt to the demands of global markets for mobile devices. Perhaps the most striking evidence of this is that, in 1990, three Japanese manufacturers were among the top five in global handset sales, but, by 2004, even the Japanese manufacturer with the largest global share held just 2.3 percent of the global market.[36] As Gerhard Fasol, president of the Tokyo-based IT consulting firm Eurotechnology Japan, laments, "Japan is years ahead in any innovation. But it hasn't been able to get any business of out it."[37] In other words, success comes not necessarily from being first to market, but from being first to the global market.

While Japan's adoption of unique standards for mobile networks is the quintessential example, throughout the 1990s and 2000s Japan developed unique standards for many other technologies. For example, Japan developed 1-seg as a unique "mobile TV" standard to provide a digital terrestrial TV signal to mobile phones. And Sony developed a proprietary standard for FeliCa, an integrated circuit chip that enables contactless mobile payments.[38]

Japan chose unique technology standards, in part out of the hope that it could achieve global adoption of these Japanese standards, thus locking in Japanese preeminence, and also in part to make penetration of Japan's markets more difficult for foreign competitors (especially in the ICT sector), thus giving a competitive advantage to Japanese companies in their home market. Indeed, unique standards made it more challenging for foreign competitors seeking to compete in Japan's markets because it forced them to invest in the development of mobile phones and other equipment specifically for the Japanese market, which could not be marketed anywhere else.[39] While this gave Japanese mobile phone manufacturers a temporary competitive advantage in their home market, it caused them to neglect global business development opportunities. And over time, as R&D and software development costs rose, lack of global scale made it more difficult for Japan's mobile phone manufacturers to compete—not just in global markets, but also ultimately in domestic ones. Put simply, Japan went down a fundamentally different path, creating isolated species of ICT technologies, whose manufacturers, lacking global scale, got crushed when they were forced to compete in global markets.

For instance, in August 2013, Japan's NEC, which had once held the largest share of Japan's market for super-feature phones (the generation of mobile devices that preceded smart phones such as Apple's iPhone) announced its decision to terminate smartphone production.[40] As *Eurotechnology Japan* wrote, a key factor that precipitated "NEC's fall from No. 1 to an impending exit from the mobile phone sector" was that "NEC focused on mobile phone production for Japan's domestic market and failed to build a viable global mobile phone business outside Japan." This "lack of scale meant that while NEC was a temporary No. 1 in Japan, NEC never had sufficient scale on a global level in mobile phones or smartphones."[41]

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The Galapagos Island effect has also impacted Japan's manufacturers of tablet computing devices. In fact, when Sharp introduced a new line of tablets and smartphones in 2010 it actually christened them "Galapagos," "as a tongue-in-cheek tribute to Japanese 'insular' genius."[42] But within two years, Sharp had pulled from the global market two of the three versions of its "Galapagos" tablet, with market analysts noting that "all other Japanese tablet sales are struggling here and abroad, at least partially because of the country's tablet isolation."[43] Meanwhile, Sony still suffers acutely from the Galapagos Island Syndrome. As Yoichi Washida, Associate Professor at the Graduate School of Commerce and Management at Hitotsubashi University, notes, "even Sony suffers from the Galapagos Syndrome; many of their products can't be exported outside Japan."[44] This is precisely because Sony didn't embrace globally interoperable standards, believing, in vain, that its own standards would win. If they had, Sony would have profited tremendously, but because they didn't, Sony was severely damaged.

Another reason why Japan's ICT and mobile industries began to fall behind the global competition was the rise of software-based, as opposed to hardware-based, innovation as a key driver of innovation in the global ICT industry, as Arora, Branstetter, and Drev write in "Going Soft: How the Rise of Software-Based Innovation Led to the Decline of Japan's IT Industry and the Resurgence of Silicon Valley."[45] As the authors write, that trend was exacerbated by the American firms' greater ability to tap into foreign-born talent.[46]

Those types of impacts accumulate over a decade, and the Galapagos Island effect—by precluding Japanese information and communications technologies companies from capturing a larger share of global markets for ICT products—has clearly been a factor in explaining why Japan's share of global ICT exports has fallen from 12.8 percent in 2003 to 5.3 percent in 2012, a decrease of almost 60 percent, as Figure 1 shows.

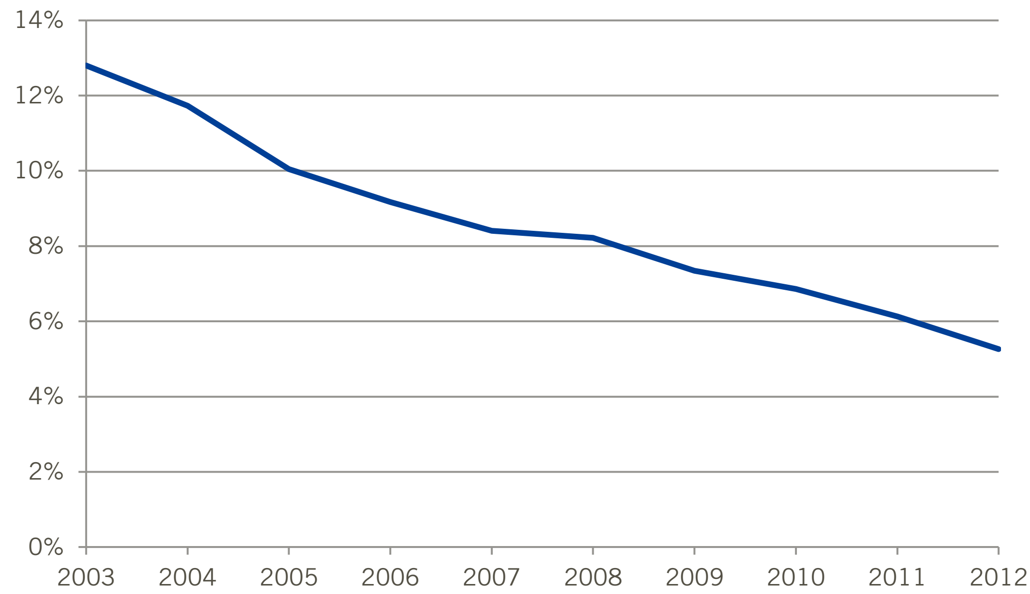

Figure 1: Japanese Share of Global ICT Product Exports, 2003-2012[47]

And while some portion of that loss can be explained by China's dramatic increase in exports of ICT products over that decade-long period, the reality is that Japan's relative decrease in its share of global ICT exports has been much steeper than that of the United States over the same period. In fact, as Figure 2 shows, the United States' share of global ICT exports declined by just 28 percent from 2003 to 2012, meaning that Japan's loss of share was twice as extensive as that incurred by the United States. And while again many factors are at play in explaining these trends, clearly the U.S. ICT enterprises' greater adoption of global technology standards has enabled U.S. firms to sell products such as Apple iPhones, Cisco routers, and Intel core processors at greater scale in global markets.

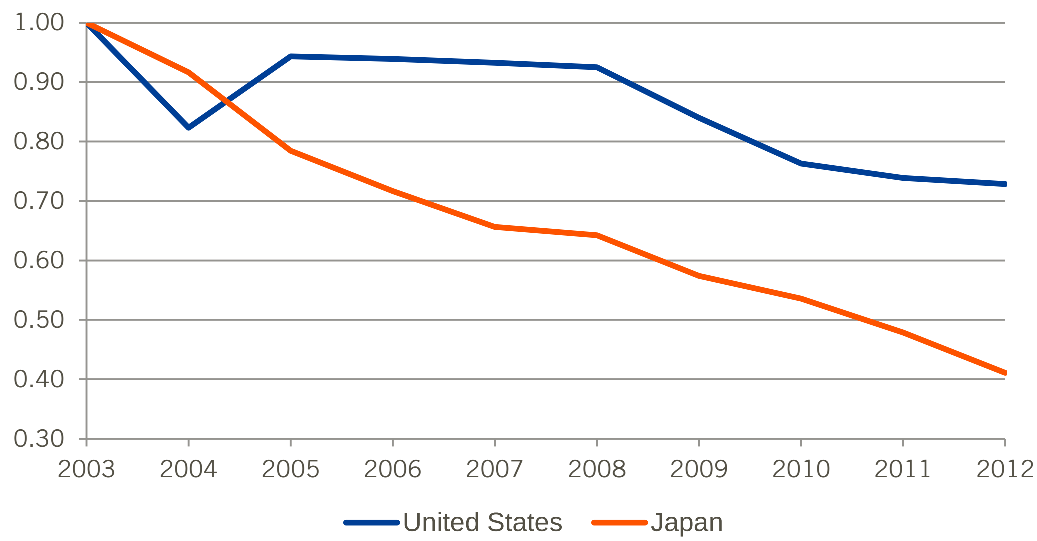

Figure 2: Change in U.S. and Japanese Share of Global ICT Products Exports, Indexed to 2003[48]

As noted, a key attribute of the Galapagos Island effect is that while it leaves ICT enterprises competitive for a time in serving home markets, its impact in preventing ICT enterprises from achieving global economies of scale eventually exposes them to stronger global competitors that encroach on their home turf, further weakening the entrenched domestic ICT incumbents and industries. Figure 3 shows that Japan's exports of ICT products as a percentage of its total merchandise exports fell by 40 percent from 2000 to 2012, reflecting, in part, the impact the Galapagos Island effect has had in reducing the significance of Japan's exports of ICT products as a share of the country's total exports.

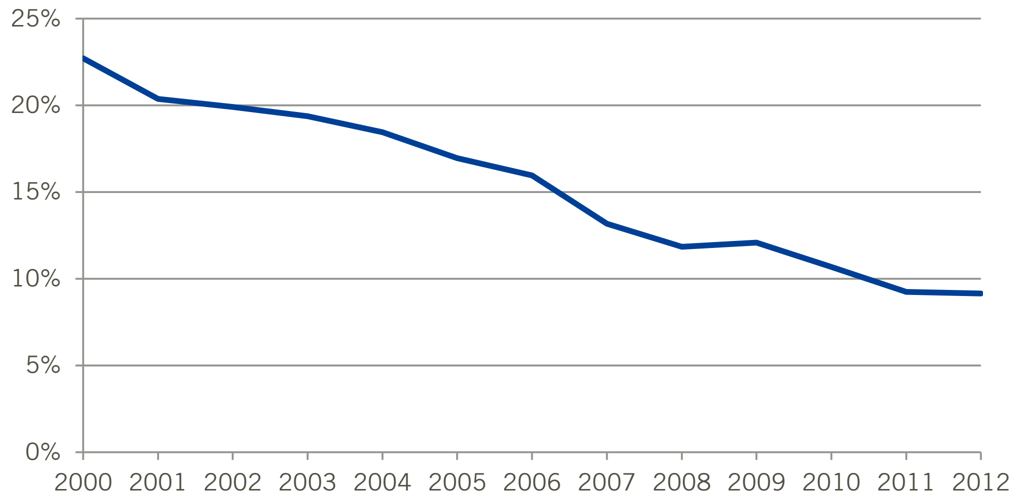

Figure 3: Japanese ICT Exports as a Percentage of Japan's Total Merchandise Exports[49]

It's also worth noting that the Galapagos Island Syndrome hasn't only affected Japan's ICT industries, but has also even impacted its otherwise highly globally competitive automotive industry. For example, Kei car (or K-car, meaning "light automobile") is an automotive class that exists only in Japan.[50] As Yoshio Takahashi writes in a *Wall Street Journal* article, "Japan as Galápagos Again–Now It's the Cars," the popularity of these small, low-cost, fuel-efficient cars can be attributed to Japan's narrow roads, short driving distances, high gasoline prices, and generous tax breaks for the vehicles.[51] And, to be sure, while proprietary technology standards aren't at issue in this instance, as Shigeru Shoji, chief executive of Volkswagen Group Japan KK, observes, Japan's car market is again evolving "out of touch with the rest of the world." Shoji notes that while "you can test things in Japan, even if it turns out to be an attractive product in Japan, it would be hard to make it a universal and global product."[52] While designing products that suit the tastes of local markets can certainly be a key driver of innovation, where companies get into trouble is when they rely principally or solely on local markets to the detriment of serving global marketplaces.

Despite the persistence of the Galapagos Island Syndrome in Japan, the country's leaders have recognized it as a threat to the competitiveness of Japan's industry in global markets and have taken steps to try to alleviate it. For instance, an interdisciplinary, 26-member Galapagos Island Study Group recently met monthly for one year to assess the impact of the Galapagos Island effect on Japan's mobile phone industry.[53] Study group convener Takeshi Natsuno, the famed inventor of NTT Docomo's iMode service and now a professor at Tokyo's Keio University, asserts that Japan's "handset makers must focus more on software and be more aggressive in hiring foreign talent, while cellphone carriers must set their sights overseas."[54] For his part, Yoichi Washida, the Hitotsubashi University professor, adds that while "Japanese technology designs were often insular," in order to gain success in foreign markets, Japanese companies must become more internationalized, in part by giving their regional operations more autonomy to develop business strategies and by tweaking products to better suit local markets. "Their focus should be in finding a local fit instead of Japanese standardization," Washida writes.[55]

CHINA'S INDIGENOUS TECHNOLOGY STANDARDS

Most technology and product standards around the globe are developed through international, voluntary, industry-led efforts. Firms meet and agree upon standards that are then used throughout the world. But China has taken a different approach. Like Japan, China's government has sought to shape technology markets as best it can to afford advantages to Chinese enterprises. Indeed, since at least the 1990s, China's government has funded the pursuit of unique exclusionary standards embodying Chinese proprietary technology as part of that effort.[56] China's institutions of standardization place the state at the center—making China's government the initiator, financer, and leader of most standardization projects.[57] As noted, China's animating goal has been to develop homegrown technology standards both as a way to gain competitive and, hopefully, monopolistic advantage, and to reduce Chinese dependence on foreign technologies and the royalties Chinese enterprises have to pay for those technologies.[58]

Because the Chinese government knows that it has considerable "market power" over foreign companies due to its sheer size, it knows that unless challenged by other governments or the WTO, it has leeway in unilaterally setting technology standards to favor domestic firms or to force foreign firms to pay licensing fees.

As the "Study on the Construction of National Technology Standards System" released by the Standards Administration of China (SAC) in 2004 framed it, China's standards approach sought to: (i) lessen the "control of foreign advanced countries over the PRC [People's Republic of China]," especially "in the area of high and new technology"; and (ii) increase the effectiveness of Chinese technical standards as important protective measures or barriers to "relieve the adverse impact of foreign products on the China market."[59] China's focus on developing technical barriers to trade, such as indigenous technology standards, only grew in importance after China joined the World Trade Organization in 2001, in part because, as China scholar Dieter Ernst notes, "China's accession commitments to the WTO have substantially reduced the use of most other trade restrictions such as tariffs, import quotas, and licensing requirements."[60] More recently, China's 12th Five-Year Plan (covering the years 2011 to 2015) proposed to "encourage the adoption and promotion of technical standards with indigenous intellectual property rights."[61] As one Chinese official explains China's prevailing view of technology standards: "Third tier companies make products; second tier companies make technology; first tier companies make standards."

This mindset has led China to pursue an aggressive standards development strategy. In fact, by the late 2000s, China was launching well over 10,000 standards development, reform, or implementation projects per year.[62] While most of those standards are comparable or identical to international standards, the reality is that China continues to pursue unique national standards in a number of high technology areas, even where international standards already clearly exist.[63] As a result, China lags significantly behind other nations in developing a pro-innovation standards policy. In fact, according to the WTO, in 2007 only 46.5 percent of Chinese national standards were equivalent to international standards.[64] Moreover, as of 2007, approximately 14.5 percent of national standards, 15 percent of professional standards, and 19 percent of local standards in China were mandatory.[65] (And even voluntary standards can become mandatory if they are referenced as part of mandatory conformity assessment procedures.) Moreover, China does not have a history of allowing foreign participation in its standards-setting process. As noted, China drafts many of these standards without foreign, or even public, input. And in many cases, even if foreign representatives are allowed to participate at all, they can do so only as observers with no voting rights.

But because the Chinese government knows that it has considerable “market power” over foreign companies due to its sheer size, it knows that unless challenged by other governments or the WTO, it has leeway in unilaterally setting technology standards to favor domestic firms or to force foreign firms to pay licensing fees. And in no sector of the economy has the Chinese government been more aggressive in developing indigenous technology standards than with regard to information and communications technologies; it has developed its own standards in wireless networking, mobile television, wireless storage, computer security, terrestrial television, digital satellite television, Internet protocol television, video codecs, digital rights management, the Internet of Things, and many other technologies, as the following section elaborates.[66]

China’s Development of Indigenous ICT Standards

China has established a wide array of homegrown technology standards in the ICT sector. In fact, as Table 1 shows, there are more than 15 international information technology standards that every country has adopted through a regular, open, industry-led standards-setting process for which China has established, or is trying to establish, its own domestic standards—several of which the country has sought to make compulsory in products sold in China.

It’s important to note that a core component of China’s strategy is to remove or change key portions of international standards for the purpose of creating China-unique standards. Why does China do this? What’s the value to the global economy to have a competing standard when the global community has already collaboratively developed an effective standard? The answer in many cases is that China is essentially trying to strip others’ intellectual property from these standards in order to avoid paying royalties.

The following section provides an overview of China’s efforts to develop unique indigenous technology standards across six key ICTs: wireless telecommunications networks, wireless local area networking, encryption technology, audio/video encoding, optical storage media, and the Internet of Things (IoT). China’s Ministry of Industry and Information Technology (MIIT) has played a central role in developing many of these standards.[67]

Technology-Product Category	International Standard(s)	Chinese Standard(s)
Wireless—Home Networking (Local Area Network Encryption)	Wi-Fi (i.e. IEEE 802.11i)	WAPI
Wireless—Metro Area Network	WiMAX	McWill
Mobile Telephony	WCDMA, CDMA2000, LTE	TD-SCDMA, TD-LTE
Mobile TV	DVB-H, T-DMB, MediaFLO	CMNB, T-MMB, CDMB, DMB-T, CMB
Radio Frequency Identification	ISO 18000 and others, EPC/GS1, Uid	NPC
Security—Personal Computers	TPM (Trusted Protocol Manager)	TCM (Trusted Cryptographic Manager)
Consumer Electronics—Terrestrial TV	DVB-T	DTMB (Compulsory)
Consumer Electronics—Satellite DTV	DVB-S	ABS-S
Consumer Electronics—IPTV	Open IPTV	CCSA
Digital Video Players	SVCD, DVD, Blu-Ray, HD-DVD	VCD 3.0, CVD, EVD, HDV, HVD, CBHD
Video Codec	Various MPEG formats	AVS
DRM (Digital Rights Management)	Marlin, OMA DRM, or DTCP-IP	China DRM
Home Networking	DLNA, UPnP, KNX, ECHONET	IGRS, ITopHome
Digital Trunking	TETRA, iDEN	GoTa, GT800
Document Formatting	ODF, OOXML	UOF
Mobile Phone Charging	None	YD/T 1591-2006

Table 1: Unique Chinese Standards Development Efforts (1993-2010)[68]

Wireless Telecommunications

The Chinese government made development of a 3G mobile network standard a central objective of China's Ninth Five Year Plan, released in 1995 (covering the years 1996 to 2000).[69] China's government assigned the Chinese Academy of Telecommunication Technology (CATT) primary responsibility for development of the standard, and CATT created a commercial entity, Datang Telecom, to manage commercial development of the standard and compatible transmission equipment. Thus, Datang Corporation developed the country's domestic 3G wireless standard—Time Division-Synchronous Code Division Multiple Access, or TD-SCDMA—with explicit Chinese government support, limited foreign participation (some technology development by Siemens), and without international consensus.[70] Although China submitted the standard for approval by the International Telecommunications Union in 1998 and it was subsequently approved, this was a mere formality. By some estimates, China invested over $700 million in the development of TD-SCDMA technology, primarily channeled through Datang.[71]

China's intent in developing TD-SCDMA as an indigenous 3G standard was primarily two-fold: 1) to free Chinese firms from reliance on foreign wireless standards and their embedded patents; and 2) to force foreign telecommunications equipment manufacturers to adopt the standard in order to sell their products to Chinese service providers in the potentially huge and lucrative Chinese 3G wireless market. Not only would they be forced to design their equipment to conform to the standard, they would also have to pay royalties to Datang to use it. By doing this, China further sought to give its wireless telecommunications equipment manufacturers and operators a competitive advantage by developing a domestic standard and then forcing foreign companies to adopt it for their Chinese products and operations.[72]

MIIT protected the nascent TD-SCDMA standard by refusing to offer operating licenses for any other 3G services in China for eight years until the domestic TD-SCDMA standard was deemed ready to compete.

The only problem for China was that TD-SCDMA needed a lot of development before it could compete with the existing 3G standards—CDMA2000 and W-CDMA—which made China hold off on granting wireless licenses for operators to deploy 3G services until TD-SCDMA was ready for prime time. In fact, development delays caused eight years to elapse between ITU approval and TD-SCDMA's commercial launch. Yet during those eight years, MIIT protected the nascent TD-SCDMA standard by refusing to offer operating licenses for any other 3G services in China until the domestic TD-SCDMA standard was deemed ready to compete. This ultimately caused MIIT to postpone launching nationwide 3G services until December 31, 2008, seven years after Japan launched 3G services in 2001 and six years after U.S. mobile operators began offering them in 2002.[73] When it did so, the Chinese government forced China Mobile, the world's largest mobile operator, to adopt the TD-SCDMA technology. (At the time, MIIT gave competitors China Unicom a WCDMA license and China Telcom a CDMA2000 license.) But because China Mobile encountered difficulties—including the lack of TD-SCDMA compatible handsets and the fact that TD-SCDMA technology proved less reliable than the WCDMA and CDMA2000 technologies—China Mobile's share of 3G wireless subscriptions has significantly trailed the share of 2G wireless subscriptions it garnered. Moreover, the TD-SCDMA standard has found little interest outside of China.[74] In the meantime, Chinese handset manufacturers Huawei and ZTE have been doing well enough abroad with no help from the TD-SCDMA standard.[75]

As mobile networks now move into fourth generation wireless technologies (4G), the Chinese government is following the same script it used before. Specifically, the Chinese government has supported the development of TD-LTE, a high-speed version of TD-SCDMA, employing similar tactics as the ones it used in promoting TD-SCDMA, including providing subsidies for R&D and giving priority to TD-LTE in licensing network operators to offer 4G services.[76]

Wireless Local Area Networks (WLANs)

Aside from TD-SCDMA, China's development of the Wireless Local Area Network Application and Privacy Infrastructure (WAPI) networking encryption standard is probably the most infamous case of state-led technology standardization in China.[77] In June 1997, the Institute of Electrical and Electronics Engineers (IEEE) approved the IEEE 802.11 wireless local area network (WLAN) standard, more commonly known as WiFi.[78] WiFi rapidly became the global de facto WLAN standard to which electronics manufacturers all conformed, as a single global market emerged in WLAN equipment with parts and systems interchangeable across borders and device platforms.[79]

Yet despite the widespread global adoption of WiFi as an international standard since 1997, in 2003 China's Ministry of Industry and Information Technology announced that, by June 2004, the WAPI standard would become mandatory for both domestic and foreign companies to use for wireless technology. Moreover, the Chinese central government required, through informal administrative guidance and through government bidding documents, that Chinese telecommunications providers, which are state-owned enterprises (SOEs), only sell devices that are WAPI-based. While the government claimed WAPI was justified because it was more secure than the existing standard, there was no evidence of this. Its true motivation was to force foreign companies to pay license fees to Chinese companies and to surrender U.S. technology.[80]

Specifically, while MIIT required all WLAN products in China to be WAPI-compliant, the WAPI encryption standard was closed, as only 11 companies—all of them Chinese—had access to the WAPI encryption algorithms.[81] Thus, before U.S. (or other foreign) companies could use the WAPI standard they needed to obtain the encryption algorithms and, to do that, they had to give up proprietary technical specifications to their Chinese competitors, something foreign ICT enterprises viewed as a "thinly veiled attempt at industrial espionage."[82] When the U.S. government threatened to file a WTO complaint against China for violating the WTO's Technical Barriers to Trade Agreement by mandating a standard that constituted an illegal trade barrier, China's government dropped its mandate.[83]

However, as Professor Michael Murphree of the Darla Moore School of Business at South Carolina University writes in "Building Markets: The Political Economy of Technology Standards," "while WTO rules do not permit the adoption of exclusive national standards when international alternatives exist, firms are free to adopt internal standards as they see fit."[84] But China's major telecommunications players are SOEs and, because they completely dominate their industries, their internal standards effectively become national mandatory standards, such that "this arrangement can effectively circumvent WTO restrictions on protectionism by the state while accomplishing the same goals in practice." And that's why the United States Trade Representative's Office (USTR) noted in its "2014 Section 1377 Review On Compliance with Telecommunications Trade Agreements" that "one of the reasons the Chinese Government still owns and controls the three major basic telecom operators in China's telecommunications industry is that it appears to see these entities as important tools in broader industrial policy goals, such as promoting indigenous standards for network equipment."[85] In fact, as Murphree quotes one Chinese interviewee in "Building Markets":

> It actually wasn't the Chinese government which forced foreign mobile phone makers like Apple and Microsoft to conform to the WAPI security standard. China's phone network operators like China Mobile and China Unicom set their own security requirements for WiFi security, which meant the phone makers had to conform to the WAPI standard since only WAPI met these requirements.[86]

In other words, China's government leveraged the fact that it exerts control over leading SOEs to subvert its WTO commitments. The Chinese government continues to support the standard by requiring WAPI to be used in all government procurement of WLAN technologies. As the United States Trade Representative's Office noted in its "2014 Report on Technical Barriers to Trade," "the United States continues to have serious concerns regarding China's 2009 unpublished requirement that its WAPI wireless local area networks (WLAN) standard be used in mobile handsets."[87] As the USTR report continued, "as of 2013, China's Ministry of Industry and Information Technology remained unwilling to approve any Internet enabled mobile handsets or similar handheld wireless devices unless the devices were WAPI enabled."[88]

Since China's major telecommunications players are SOEs, and because they completely dominate their industries, their internal standards effectively become national mandatory standards.

In another case, on August 4, 2011, the China Communication Standardization Association (CCSA) released Enhanced Ultra-High Throughput (eUHT) standards for final review. EUHT is a wireless LAN standard proposed by the Chinese company Nufront. The idea is for the Chinese government to require use of this standard in China, even though it has deficient technical specifications and was developed with a non-transparent process.[89] Moreover, before it promulgated the eUHT standard, MIIT provided a comment period of less than 30 days, hardly sufficient to facilitate translation and expert review of the standard.[90]

Encryption Technologies

As noted, one of China's common practices is to alter a standard slightly, creating a version that doesn't have the international intellectual property embedded in it, so that a Chinese enterprise doesn't have to pay the royalties. Another good example of this practice pertains to encryption and authentication technologies. Every computer contains a microchip that manages the security features of the machine (e.g., authentication). TPM (Trusted Protocol Manager) was established as an international standard in 2008. TCM (Trusted Cryptographic Manager) is China's version of TPM. China's trusted computing module requires the use of Chinese algorithms and requires conformance with TCM specifications, which until recently were only available to Chinese companies. As Georgia Institute of Technology professor Peter Swire writes, "these policies effectively shut the global TPM standard out of China's domestic market. Further, China uses commercial encryption regulations as the rationale for prohibiting the import of platforms that employ TPMs into China."[91]

Another incidence relates to China's introduction, at the beginning of 2012, of a Chinese government-developed 4G Long-Term Evolution (LTE) encryption algorithm known as the ZUC standard. The European Telecommunication Standards Institute (ETSI) 3rd Generation Partnership Project (3GPP) approved ZUC as a voluntary LTE encryption standard in September 2011. However, in early 2012, China's MIIT, in concert with the State Encryption Management Bureau (SEMB), informally announced that only domestically developed encryption algorithms, such as ZUC, would be allowed for the network equipment and mobile devices comprising 4G TD-LTE networks in China.[92]

However, such a mandate of a particular encryption standard would contravene a commitment that China made to its trading partners in 2000, which clarified that foreign encryption standards were permitted in the broad commercial marketplace and that strict "Chinese-only" encryption requirements would only be imposed on specialized IT products whose "core function" is encryption. Moreover, China's ZUC mandate contravened China's commitment in 2010 to the U.S.-China Joint Commission on Commerce and Trade (JCCT) regarding technology neutrality, in which China had agreed to take an open and transparent approach with regard to operators' choices and not to provide preferential treatment based on the standard or technology used in 3G or successor networks, so that operators could choose freely among whatever existing or new technologies might emerge to provide upgraded or advanced services.[93] In response to concerted push back from the international community, at a December 2012 JCCT meeting China agreed that it would not mandate any particular encryption standards for commercial 4G LTE telecommunications equipment.[94]

Audio/Video Encoding

Audio/video encoding standards translate the analog sound and light waves of audio and video recordings into a digital format that can be compressed and stored on media such as CDs and DVDs.[95] In the early 2000s, the prevailing audio/visual encoding standard was MPEG-2. But Chinese manufacturers felt the royalties they paid to license the MPEG-2 technology (needed to manufacture digital video disc, or DVD, players) were too steep. Accordingly, the Chinese government set out in 2002 to create an alternative to the established international standard, giving rise to the Audio Visual Standard (AVS), a state-initiated standards development effort led by government actors in the form of university labs.[96] China's clear intent in developing AVS was to keep Chinese companies from having to pay high licensing fees to foreign companies and to give them an edge over their American competitors.[97] In fact, some "considered [it] a strategic project designed to break the control foreign intellectual property (IP) holders hold over standardized technologies in digital electronics."[98] Accordingly, the development of the AVS technology was largely closed to foreign participation.

In April 2005, MIIT approved AVS as an industry standard. Yet despite explicit Chinese government support and adoption of the standard, the Chinese State Administration of Radio, Film, and Television (SARFT) actually rejected AVS in favor of the competing international standard, MPEG-4. While some local and provincial broadcasters have adopted the AVS standard, Murphree notes that "a limit to the acceptance of AVS is among very large Chinese firms."[99] For instance, China's three mobile telephony operators have chosen MPEG-4 over the AVS standard. Moreover, the AVS standard has found a weak market overseas.

Optical Storage Media

Related to the AVS case, China has sought to develop indigenous technology standards related to optical storage media—the plastic discs that contain encoded audio and video data which can be read by lasers and decoded via software. Again, the Chinese government sought to develop unique technology standards to reduce the royalties its manufacturers had to pay for foreign technologies and to give its companies an advantage in the optical disc market.[100] In essence, the Chinese government hoped to protect the Chinese market from the coming DVD standard.[101]

Accordingly, the Chinese government supported the development of indigenous standards for video compact disc (VCD) players, with these standards coming to be defined as China Video Disc (CVD) and VCD 3.0.[102] China's production of these video compact disc players boomed in the late 1990s; however, China's VCDs, developed with the indigenous standards, "struggled for sales outside of China and a few low-end consumer markets in Southeast Asia," and were bested by the Japanese manufacturers that originally invented the technology. Then the bottom fell out. In 1999, 40 percent of Chinese VCD manufacturers, 200 out of 500 in total, went bankrupt.[103] One Chinese official called this malady a "national tragedy."

Subsequently, the DVD standard won global adoption, which meant that if Chinese manufacturers wished to continue to produce video disc players, they would have to adopt the DVD technology. And they did so, capturing 75 percent of global manufacturing in the DVD marketplace by 2003. But Chinese DVD manufacturers argued that their profit margins were too thin (falling to $1 per unit in 2004 according to one estimate), in part because they felt they paid too much to license the DVD standard.[104] China's government resolved to reduce those royalty payments. After a host of efforts to reduce royalty payments failed—including filing a lawsuit in the United States accusing DVD patent holders of abusing their monopoly power—the Chinese government set out to develop an indigenous technology standard instead, providing a $1.2 million grant to the Beijing company E-World to develop an indigenous red laser-based optical storage media standard that became the Advanced High Density Disc System (AVD, also known as the Enhanced Versatile Disc, or EVD).[105]

EVD received the strongest official support, garnering some R&D funding and approval as a national (though not mandatory) standard in February 2005.[106] But the standard failed, in part because foreign movie studios refused to license content for the format. And while some video disc player manufacturers in China did develop devices with EVD/DVD interoperability, this only added to their costs and defeated the purpose of avoiding paying the DVD license fees. Moreover, with High-Definition Digital Video Disc (HD-DVD) and Blu-ray high definition formats gaining global traction by the mid-2000s, China's EVD standard fell behind.[107] Sales remained in the hundreds of thousands of units rather than the millions that were expected.[108] Accordingly, in early 2008, EVD players were "unceremoniously" withdrawn from store shelves in Beijing.[109]

But that did not end China's efforts to develop an indigenous optical media storage standard. In October 2005, China announced plans to develop a new violet laser high-definition disc player.[110] Again, with official state support provided by MIIT, an alliance formed to develop the China Blue High-Definition (CBHD) standard, led by researchers from the Optical Memory National Engineering Research Center (OMNERC) at Tsinghua University, the China High-definition DVD Industry Association, and China Electronics Technology Group.[111] As before, China's hope was that the CBHD could replace the HD-DVD and Blu-Ray standard in the Chinese market—thinking that China's large market size should be sufficient to support the viability of an indigenous technology standard for optical media. As Lu Da, the director of OMNERC, erroneously asserted, "China is a large potential market with more than one billion consumers, which is enough to support its own standard."[112] But again, as Murphree notes, "in the end, CBHD was largely commercially unsuccessful…. The international popularity of Blu-Ray, and the rapid increase in online high-definition content sapped market demand" before CBHD could gain traction.[113]

The Internet of Things (IoT)

China continues to favor the development of new and Chinese-exclusive standards for newly emerging technologies, including electric vehicles, cloud computing, and the Internet of Things. In fact, on February 13, 2012, MIIT published its "12th Five Year Plan for Internet of Things," which stated that over 200 national standards should be set before 2015.[114] Standards are considered a key factor for IoT usage because interoperability and compatibility are essential for different devices to be connected. As it has done in other ICT areas, China's central government leads standards development and supports the establishment of an IoT standards association with the hope that Chinese-developed standards will prevail internationally, even if that presents a risk that IoT deployment domestically will be hindered.[115]

Indeed, China believes that its role in international IoT standards is critical for the position of China's IoT industry in the global market. MIIT estimates that the scale of China's IoT industry exceeded 600 billion RMB (almost $100 billion) in 2013.[116] When the first general IoT standard initiated by China was passed by the International Telecommunication Union in 2012, Chinese officials saw it as a milestone. Furthermore, China is targeting not just IoT applications, but the core technology and industry value chain. For this reason, an inter-agency council was established in 2013 to coordinate the government's policy and action on IoT. The members include MIIT, the National Development and Reform Commission (NDRC), the Ministry of Science and Technology (MOST), the Ministry of Education, and the National Standardization Administration. With the support of this council, China issued a Directive on IoT industry development and an IoT Action Plan in 2013. The plan specifies targets for the industry by 2015 in terms of top-level design, standards formation, technology R&D, application and promotion, industrial support, business models, safety, government support, laws and regulations, and workforce training.[117]

Other Indigenous Chinese ICT Standards

Another indigenous Chinese ICT standards development effort of note includes the Chinese government's support for the development of a domestic radio frequency identification (RFID) standard, without international participation or consensus. China pursued this because it does not want to pay royalties to use the existing electronic product code (EPC) standard developed through a consensus process by EPCglobal with participants from numerous nations.[118]

Also, in April 2012, China's MIIT issued a "Draft Mobile Smart Terminal Administrative Measure," which proposes to establish a new regulatory framework for the mobile device market. The measure would impose numerous new obligations, technical mandates, and testing requirements on information technology and telecommunications hardware, operating systems, applications, app stores, and other related services.[119] According to the United States Trade Representative Office's "2014 Report on Technical Barriers to Trade," a particular concern is that including numerous voluntary standards and testing requirements relating to smart terminals in the measure will create additional trade barriers if these voluntary standards become mandatory through MIIT's testing and certification process.[120] In November 2013, MIIT finalized and implemented the measure along with two associated voluntary standards that did not take stakeholder views into account.[121]

The case study of China's attempts to develop indigenous technology standards for optical storage media platforms—running the gamut from the CVD to the EVD to the CBHD standards—demonstrates the risks of picking the wrong technology standard.

Risks of China's Indigenous Standards Development Approach

As the preceding case studies have shown, the central weakness of China's standards development strategy has been the development of China-only standards. Compounding this challenge is that the Chinese government is picking the standards, as opposed to permitting standards to be developed in a voluntary, international, consensus-based, and market-led manner. As demonstrated, there are a number of hazards to this approach: it risks picking the wrong standard; it risks delays in standards development (often caused by bureaucratic rivalry or inefficiency) that cause both missed market and economic growth opportunities; it encourages belief that Chinese markets alone are of sufficient scale; and even when and if it does succeed in developing indigenous standards, it risks the Galapagos Island effect that isolates China's ICT products and markets from global ones.

Risk of Getting the Standard Wrong

The case study of China's attempts to develop indigenous technology standards for optical storage media platforms—running the gamut from the CVD to the EVD to the CBHD standards—demonstrates the risks of picking the wrong technology standard. In the CVD case, picking an effectively China-only standard produced video compact disc players that could not meet the demands of global markets because they were incapable of playing video discs using the globally prevalent DVD standard, contributing to the collapse of China's video compact disc player industry in the late 1990s as 40 percent of the firms went bankrupt.[122] And while China had protested the industry's unprofitability because it had to pay what it argued were too-high royalty fees for the foreign DVD standard, in reality the economic loss to China was far greater when 40 percent of a heavily state-subsidized industry went bankrupt. Adopting the global standard and an appropriately-sized video compact disc industry manufacturing devices that competed effectively in global markets would have been a better economic choice.

The risk of picking the wrong standard was also apparent in the TD-SCDMA case, where China Mobile was forced to use the TD-SCDMA standard (as it received a license from MIIT that permitted it only to offer 3G services using that standard) while competitors

China Unicom and China Telecom received licenses to use the better-proven and internationally developed WCDMA and CDMA2000 licenses, respectively. The decision led directly to China Mobile struggling to increase subscribership for its 3G mobile services. As Breznitz and Murphree write, "Chinese consumers have noted that the 3G services offered by China Mobile's competitors are less prone to bugs. The perception of weaker technology has hurt adoption of TD-SCDMA."[123] (In other words, China Unicom's and China Telecom's mobile services, using the internationally developed standards, were the ones with the more reliable 3G service.) And, in fact, whereas China Mobile had once commanded 70 percent of China's 2G mobile subscribers, by the end of 2012, it had won just 40 percent of China's 3G mobile subscriptions.[124] As Kennedy, Suttmeier, and Su write in "Standards, Stakeholders, and Innovation: China's Evolving Role in the Global Knowledge Economy," "even though China was successful in having TD-SCDMA accepted as an international standard, its share of the patents in the standard are thought to be only 7.3 percent of the total, and its ability to use that standard as the basis for 3G service in China has been seriously wanting."[125]

An important contributing factor to delays in developing standards has been bureaucratic inefficiency and rivalry in China.

At the same time, "China's greater activism has not yet been matched by widespread international adoption of its standards, or the commercialization of Chinese standards in China or globally."[126] Indeed, many of China's indigenously developed standards—including TD-SCDMA, WAPI, AVS, CVD, EVD, CBHD, and IGRS—have found little uptake outside of China.

Delays in Standards Development Cause Missed Markets and Economic Growth

As noted, China delayed its introduction of 3G mobile services until 2008 as it waited for the TD-SCDMA standard to be ready for market. By then, as *The Economist* wrote in 2007, China found itself the maker of many of the world's 3G phones, "but almost none of the world's 3G phone calls."[127] As Kennedy, Suttmeier, and Su write, "This has been to the detriment of Chinese consumers and Chinese telecom companies."[128]

While some have argued that China's development of the 3G TD-SCDMA standard produced some benefits—including enhancing China's experience at developing technology standards and lowering royalty payments for foreign technologies—the reality is that by unnecessarily delaying the introduction of high-speed wireless telecommunications networks by at least six years, China needlessly sacrificed untold billions as the innovation-enabling and productivity-enhancing potential of mobile applications that leverage advanced mobile network technologies went missing. And, in fact, it was the development of those value-added mobile applications that was later an important factor in making Apple's iPhone so popular. In other words, by delaying the emergence of the mobile applications ecosystem, China unwittingly hurt its own mobile phone manufacturers, as Apple developed a more innovative smartphone that captured a much larger share of global markets. Moreover, it's no surprise that America significantly outpaced China in the development of the mobile app economy starting in the mid- to late-2000s, as America's mobile apps developers got a head start developing applications that could leverage a superior wireless network. Put simply, by favoring TD-SCDMA, China significantly delayed the advent of its "mobile economy."

An important contributing factor to delays in developing standards has been bureaucratic inefficiency and rivalry. As Murphree and Breznitz explain, "in many cases Chinese representatives act on behalf of their various ministries' interests rather than advancing a national agenda."[129] Indeed, technical difficulties, bureaucratic conflicts, and inertia significantly delayed the implementation of the TD-SCDMA standard. As Kennedy, Suttmeier, and Su write, "the prolonged delay in licensing 3G technology [was] in part due to failures of coordination and bureaucratic competition, as are problems in reconciling bureaucratic interests in order to move forward on digital media and other forms of ICT convergence."[130] This was also apparent in China's development of the AVS standard as a competitor to the MPEG-4 standard, as the Chinese State Administration of Radio, Film, and Television (in choosing the MPEG-4 standard for China's mobile telephony operators) worked against MIIT's efforts to develop the AVS standard. As Kennedy, Suttmeier, and Su note with regard to that case, "one implication is that although it is rare for China's government to remain technology neutral on any one ICT standard, it is not uncommon for different standards to be supported by different parts of the bureaucracy."[131]

As large as China's markets for ICT products are, they aren't large enough to support globally competitive Chinese ICT enterprises whose viability rests on catering only to Chinese markets.

The related issue of bureaucratic inefficiency was also apparent in China's efforts to develop the Intelligent Grouping and Resource Sharing (IGRS) as a standardized set of technologies for goods which could constitute a home-based Internet of Things.[132] MIIT had organized the formal working group developing the IGRS standard, but its rules required members to make full technology and IP disclosure. Consequently, "Chinese firms involved in IGRS such as Great Wall, Konka, TCL, Hisense and TCL balked at sharing their technology with Lenovo, fearing that they would be giving away secrets to a major competitor."[133] As Kennedy, Suttmeier, and Su conclude, "the strong role of the state in technological development can, and does, result in perverse policy outcomes."[134] And this has certainly been the case in several Chinese efforts to craft indigenous technology standards.

Misconception that Chinese Markets Alone Are of Sufficient Scale

The comment made by Lu Da, the director of OMNERC at Tsinghua University, that "China is a large potential market with more than one billion consumers, which is enough to support its own standard" is revealing, for it unmasks a core, mistaken conception among many Chinese policymakers that Chinese markets alone are of sufficient scale to support markets for ICT products developed with China-unique technology standards. As the second largest economy at the time, Japanese officials thought the same about the adequacy of the size of its market. But as large as China's markets for ICT products are, they aren't large enough to support globally competitive Chinese ICT enterprises whose viability rests on catering only to Chinese markets. Indeed, the reality, as Figure 4 shows, is that in 2014 China claims just 10.8 of the global ICT marketplace, compared to a 27 percent share for the United States, 20.7 percent share for the European Union, 7.7 share for Japan, and 33.8 share for the rest of the world.[135]

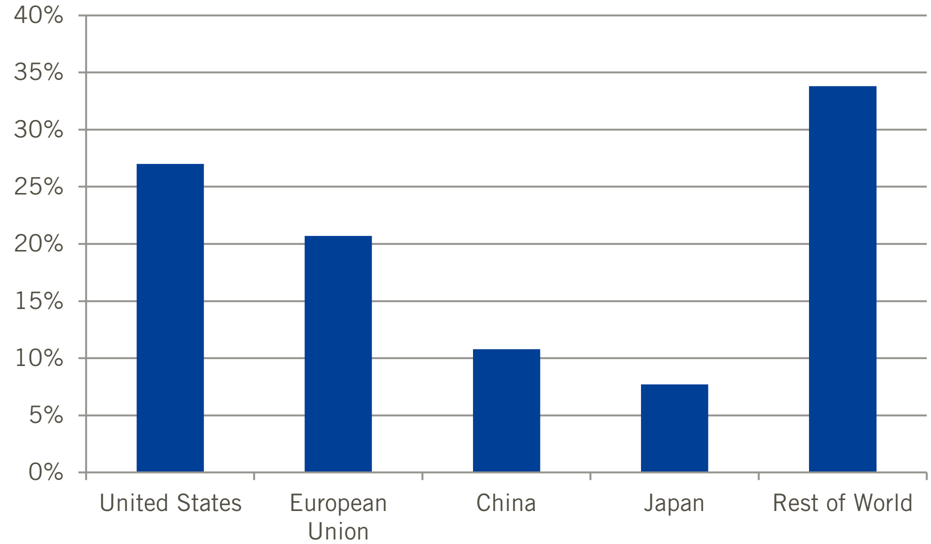

Figure 4: Country Share of Global ICT Market, 2014[136]

In other words, 90 percent of global ICT markets lie outside of China. Of course, China has benefited tremendously from this, leading the world with a 30 percent share of global ICT exports (valued at $554 billion) in 2012, as ITIF writes in "How ITA Expansion Benefits the Chinese and Global Economies."[137] But as the case of the China Video Disc (CVD) standard in the video compact disc player industry so clearly demonstrated, to have viable manufacturing industries for ICT products, industries need to leverage technology standards that support their sale at scale in global markets. The TD-SCDMA case also evinces this, as, even with the world's largest base of mobile phone users, China Mobile experienced declining market share and share price as a result of adopting the underperforming TD-SCDMA standard.[138]

China would need to have a much larger internal market and command a much larger share of global ICT consumption than it currently does to have any chance at fielding a large enough technology market that could enable China-only standards to gain the scale needed to produce globally competitive players. And even if China does receive some benefit from its development of indigenous technology standards, such as reducing foreign royalty payments or marginally protecting domestic competitors, the downside of not enabling its ICT enterprises to achieve scale in global ICT markets is much larger than the margins saved on royalty payments.

Risking the Galapagos Island Effect

Conversely, even supposing China succeeds in establishing a range of its own China-unique ICT standards, this runs its own set of risks—particularly that it accelerates the development of technology markets (of insufficient scale) isolated from global norms, as Japan experienced with the Galapagos Island Syndrome. And even if China's greater than one billion consumer marketplace is larger than Japan's and is able to support a China-distinctive ICT product for a short time, China's isolation from global technology markets would still catch up to it. In other words, China would still experience the Galapagos effect; it would just see this effect later than the Japanese did because China's domestic market is relatively larger than Japan's.

Yet even when standards issues aren't directly at play, the broader push toward "indigenization"—i.e., toward advancing a China-centric ICT technology or market—can lead to isolation from the global community. For example, as Kai Lukoff, the editor of *TechRice*, a China-focused technology blog based in Beijing, writes, "the Chinese Internet market is so set apart from other countries that we inside the industry refer to it as the Galapagos Island syndrome." As he continues, "domestic Internet products are extremely well adapted to the Chinese market, but they are way out of place for global users."[139] The point is that integration into global ICT markets, instead of isolating ICT applications to China-only markets, is the most sustainable course for China in the long run if it ever wants to succeed with its government supported "going out" strategy.

TOWARD A MORE SUSTAINABLE STANDARDS DEVELOPMENT APPROACH

Even supposing China succeeds in establishing a range of its own China-unique ICT standards, this runs its own set of risks—particularly that it accelerates the development of technology markets isolated from global norms, as Japan experienced with the Galapagos Island Syndrome.

Chinese policymakers should rethink their approach to technology standards development, particularly since the current mindset is largely geared toward "overcoming" foreign technologies. As Murphree quotes one Chinese interviewee in "Building Markets: The Political Economy of Technology Standards":

> In a given technology, there are dominant foreign technologies which China must overcome. The state is necessary to give the time and space to develop a technology sufficiently and get it into the market. If a technology can be given the space and the time to develop, Chinese technology has at times been even more advanced than technologies overseas. However, foreign firms have the advantage of name recognition, brand and technology trajectory in their favor. Hence the state must lead the local market to even give Chinese technology a chance.[140]

But who picks those technologies? Which agency decides? How does the government make the choices? When the government gets too interventionist and picks the wrong standard (e.g., the CVD standard) before the market is ready, it leads to the "tragedy" of the CVD industry. The strong government involvement in standards development fundamentally misses the mark. A better approach, as ITIF writes in *Innovation Economics: Race for Global Advantage*, is for governments to focus their efforts on supporting factor (or "framework") conditions, such as investing in the basic building blocks of innovation—e.g., basic scientific research, skills, and education—and supporting key broad technologies and industries, as depicted in the Innovation Policy Continuum in Figure 5.[141] This means identifying industries and technologies broadly where a country needs to be more innovative and productive and then developing and implementing policies to work with the private sector to ensure that result. But this role is distinct from an overt "industrial policy" in which governments select specific national champion enterprises, nationalize industries, choose extremely narrow technologies or specific standards, or impede beneficial market forces.[142] In other words, it's about building Chinese enterprises' technology base and competence in sectors such as the Internet of Things, electric vehicles, or mobile networks, but not by trying to articulate specific technology standards that benefit domestic enterprises at the expense of foreign competitors.

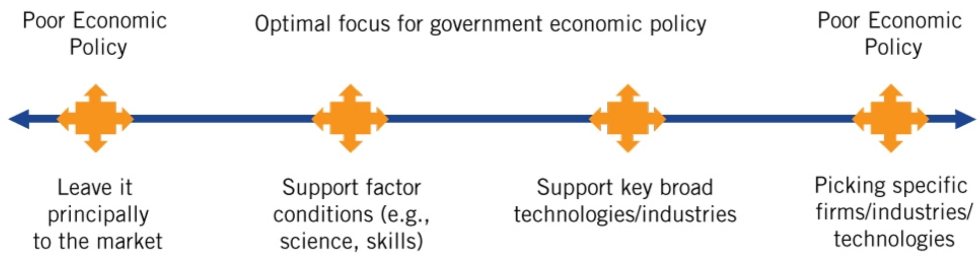

Figure 5: The Innovation Policy Continuum

Chinese policymakers—and enterprises—should also recognize that it is normal to pay royalty payments for technologies. In fact, the goal should be for China to field globally strong ICT enterprises that participate in international-standards-setting bodies and earn revenues from standards development; but that won't happen if China is developing Galapagos standards, or trying to follow a model where it largely develops the standard inside China and then tries to take it to the rest of the world.

As noted previously, there are three basic choices before China in its standards development strategy:

1. It can pursue a "Galapagos Island" path of isolated, indigenous technology standards development;

2. It can participate in the global standards development process, but with an aim toward coopting or manipulating this processes to the advantage of Chinese domestic enterprises; or

3. It can engage as an equal participant in the development of voluntary, transparent, consensus-based, market-led standards.

Selecting the third path will be most likely to prove beneficial, successful, and sustainable in the long run for Chinese ICT enterprises, the global ICT industry, and indeed the global economy. ITIF offers the following policy recommendations as China pursues that third path and improves its approach toward technology standards development:

POLICY RECOMMENDATIONS

- China should adopt an "open participation model" in standards development processes and frameworks that is transparent, open, and non-discriminatory for all stakeholders.

- China should remove policies that inappropriately withhold access to standards-development organizations or other Chinese standards-making forums based on where a company or organization is headquartered.

- China should align its standards (including national, industrial, and provincial standards) with international standards and use international standards as the basis of Chinese standards and regulations wherever practical. China should not make minor alterations to existing international standards with the intent of developing a China-only standard. Rather, it should modify international standards only in cases where it is permitted to do so by the WTO Technical Barriers to Trade agreement, such as to achieve legitimate objectives including environmental, health, safety, or national security protections.[143]

- China should broaden its recognition of international standards to include any standard that meets the principles for the development of international standards identified by the WTO TBT agreement. In particular, China tends to define international standards too narrowly, to include only those standards developed by treaty- and non-treaty organizations such as the ITU, the International Organization for Standardization, or the International Electrochemical Association. This definition excludes other significant SDOs, such as IEEE and ASTM International, and is not consistent with the development of international standards identified by the WTO's TBT rules. China's policies also do not recognize the importance of standards from organizations such as the World Wide Web Consortia or the Internet Engineering Taskforce.[144]

Just as Japan experienced, China won't be able to support ICT industries of global scale if they fail to incorporate global technology standards in their products.

- China's standards notification policies should adhere more closely to the WTO TBT Committee's *2000 Decision on Principles for the Development of International Standards* and to the TBT Code of Good Conduct policy. In particular, the latter calls for China to abide by a 60-day comment period for any newly proposed standards and calls for mandatory reply to all comments received by domestic and international stakeholders.

- Technology that is not developed or registered in China should still be considered for inclusion in Chinese standards. Currently, it is difficult for individuals, universities, or enterprises to get their technology considered for inclusion in Chinese standards if the technology is not developed or registered in China.

- China's funding of university or research institution R&D activity should not be contingent upon nor reward the development of China-unique standards, but should support the development of workable technology solutions in general. This would change a policy in which the provision of research funding in China may take into consideration whether the institution intends to develop a China-unique standard as a result of the funding. Such policies ultimately limit needed engagement of Chinese academics with the global academic community.

- Wherever the majority of the rest of a global industry sector has developed a voluntary consensus standardization forum as the preferred venue for the development of certain ICT standards, Chinese industry should join the rest of the sector in the development of those standards.

CONCLUSION

Countries' strategies to develop unique technology standards are often inherently illogical; in the event that the unique standard succeeds in building a successful domestic market, the countries' enterprises are often unable to export successfully to global markets. And even the largest countries, including China, lack sufficient market power either to compel the rest of the world to adhere to their standards or to support markets for ICT industries developing products large enough to enable the needed scale when they rely on country-specific standards designed to cater solely to domestic markets. Scale isn't all when it comes to ICT, but over the long run it is a lot. Just as Japan experienced, China won't be able to support ICT industries of global scale if it fails to incorporate global technology standards in its products. While China's approach to indigenous ICT standards development may yield some temporary gains, the long-term risks of this approach are far greater and the downside much higher than a strategy that permits Chinese industries and enterprises to participate in a global standards development process that leverages a voluntary, transparent, consensus-based, market-led approach.

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ABOUT THE AUTHORS

Stephen Ezell is a Senior Analyst at the Information Technology and Innovation Foundation, with a focus on science, technology, and innovation policy issues. Mr. Ezell holds a B.S. from the School of Foreign Service at Georgetown University, with an Honors Certificate from Georgetown's Landegger International Business Diplomacy program. He is the co-author of *Innovation Economics: The Race for Global Advantage* (Yale University Press, September 2012).

Dr. Robert Atkinson is the president of the Information Technology and Innovation Foundation. He is also the author of the books *Innovation Economics: The Race for Global Advantage* (Yale University Press, September 2012) and *The Past and Future of America's Economy: Long Waves of Innovation that Power Cycles of Growth* (Edward Elgar, 2005). Dr. Atkinson received his Ph.D. in City and Regional Planning from the University of North Carolina at Chapel Hill in 1989.

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