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PATENTS, STANDARDS AND BORDERS

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Today's technology product markets are inherently international.[1] Products designed in California may be assembled in Taiwan from parts sourced from Korea, Germany and Malaysia for sale to end consumers in Australia. The global character of technology markets underscores the importance of technical interoperability standards such as those in the areas of wireless networking (Wi-Fi, Bluetooth), wireless telecommunications (4G LTE), digital media storage (DVD, SDRAM) and digital content encoding (MP3/MP4). These standards enable products and components manufactured by different vendors to work together without customization or firm-to-firm interaction. Stakeholders affected by technology interoperability standards span the globe, from product designers to manufacturers to consumers. This paper considers the impact of patents on international technical standardization activities. In particular, it assesses the impact that patents have on individual firm behavior and intra-firm dynamics in the context of international standard-setting, and evaluates available options to reduce disparities between large patent holders and firms from less-developed economies.

I. *Standards and the International Standard-Setting Landscape*

While many health, safety and environmental standards are developed by governmental agencies, the vast majority of interoperability standards originate in the private sector (Ernst 2012, Biddle et al. 2012). In the U.S., there is an express governmental preference for privately-developed over governmental standards,[2] and elsewhere this preference has generally been supported by the market. Some widely adopted interoperability standards (e.g., VHS, PDF) are single-firm proprietary formats (*de facto* standards). Over the past two decades, however, most interoperability standards have been developed by groups of firms that collaborate within voluntary associations known as standards-development organizations or standards-setting organizations (SSOs). The resulting standards are often referred to as "voluntary consensus standards", which will be the principal focus of this paper.

SSOs vary greatly in size and composition. The European Commission (EC 2014) identifies three broad categories of SSO:

> (1) those that are formally recognized by governmental bodies. These include:

[1] The information and communications technology (ICT) sector has dominated the public debate over standardization in the past few decades, and will be the focus of this paper.

[2] Office of Management and Budget (OMB) Circular A-119 (1998).

international groups (e.g., the International Organisiation for Standardisation (ISO) and the International Telecommunications Union (ITU)),

regional groups (e.g., the European Telecommunications Standards Institute (ETSI)), and

national groups (e.g., Germany's Deutsches Institut für Normung (DIN), France's Association Francaise de Normalisation (AFNOR), the British Standards Institution (BSI), the Japanese Standards Association (JSA) and China's National Institute for Standardization (CNIS)).[3]

(2) "quasi-formal" groups that are typically large international organizations that share many of the characteristics of formally recognized groups (e.g., the IEEE Standards Association, ASTM International and the Internet Engineering Task Force (IETF)), and

(3) smaller, privately-organized consortia (also known as special interest groups or fora), including groups such as the Bluetooth SIG, HDMI Forum, USB Forum and hundreds of others.[4]

Table 1 below lists a number of widely-adopted ICT standards and the organizations in which they were developed.

Table 1
Selected ICT Standards and Where they were Developed

Standard	Description	SSO	EC Class
802.11	Wireless networking	IEEE	2
Bluetooth	Short-range wireless networking	Bluetooth SIG	3
CD	Compact disc (digital media)	n/a[5]	n/a
CDMAone/IS-95	2G wireless telecommunications	Qualcomm/ TIA[6]	n/a 2
DVB	Digital video broadcast (Europe)	DVB Forum	1
DVD	Digital media	n/a[7]	n/a
Ethernet	Device networking	IEEE	2
GPS	Global Positioning System	n/a[8]	n/a
GSM	2G wireless telecommunications	ETSI	1
H.264	Audiovideo encoding	ITU	1

[3] The American National Standards Institute (ANSI) presents a somewhat unusual case, inasmuch as it is a private organization which is recognized in certain capacities by the U.S. government. ANSI oversees, accredits and establishes policy for national SSOs that wish to develop American National Standards. Among other things, ANSI-accredited SSOs must adopt due process and intellectual property policies that comply with ANSI's "Essential Requirements".

[4] Updegrove (2015) catalogs more than 1,000 such groups.

[5] The CD specification was developed by Philips and Sony.

[6] CDMA technology was initially developed by Qualcomm, which then submitted it for adoption to the Telecommunications Industry Association (TIA).

[7] The DVD specification was developed by Philips, Sony, Toshiba and Panasonic.

[8] The GPS standard was developed by the U.S. Department of Defense

Standard	Description	SSO	EC Class
HDMI	High-definition multimedia interface	HDMI Forum	3
HDTV	High-definition broadcast tv (US)	ATSC	3
HTTP	Hypertext transfer protocol	W3C	2
IP	Internet protocol	IETF	2
LTE	4G wireless telecommunications	ETSI	1
MP3/MP4	Audio and video compression	MPEG (ISO/IEC)	1/2
PDF	Portable Document Format	n/a[9]	n/a
SDRAM	Semiconductor memory	JEDEC	2
UMTS	3G wireless telecommunications	ETSI/3GPP	1
USB	Device networking	USB Forum	3
V.90	56k modem	ITU	1
VHS	Video cassette media	n/a[10]	n/a
WWW	Worldwide web	W3C	2
XML	Extensible markup language	W3C	2

II. *Firm-Level Participation in Standard-Setting*

Firm-level participation in SSOs varies according to the type and nature of the SSO. ISO, probably the most prominent Category 1 SSO, allows participation solely on a national basis, so that each member state has a delegation that represents its interests at the SSO. Criteria for participation in a national delegation are determined at the national level. The U.S. representative to ISO, for example, is ANSI. Other Category 1 SSOs may limit participation to firms and institutions engaged in business in a particular geographic area. For example, the members of the European Committee for Electrotechnical Standardization (CENELEC) comprise the national electrical standardization committees of each European state. Other Category 1 SSOs, such as ETSI, open membership to all interested parties, but offer different membership categories and benefits to those within a preferred region (Europe, in the case of ETSI).

In contrast, Category 2 SSOs are generally open to all interested parties on an equal basis. Participation depends on firms' interest in the relevant area of standardization, as well as its ability to bear personnel, travel and technology costs associated with SSO participation. It is no surprise that large global technology firms participate in upwards of fifty or more different SSOs, with the largest involved in more than one hundred SSOs each (Baron & Spulber 2015). Participation in large, international SSOs in the ICT sector has traditionally been international in character, with representation from firms and institutions based in North America, Europe, Oceana, Japan, Korea and Taiwan. Over the last decade, Chinese firms have dramatically increased their participation in international SSOs, in some sectors surpassing participation from all countries other than the U.S. (Ernst 2011, Contreras 2014). Despite recent gains by China, SSO participation by firms in less-developed countries, particularly in Latin America and Africa, has remained at low levels.

[9] PDF is a proprietary format developed by Adobe.
[10] The VHS format was developed by Matsushita/JVC.

Category 3 SSOs or consortia are usually formed by small groups of firms interested in developing a specific technology or standard. Often these "founder" or "sponsor" firms hold patents relevant to the technology in question (Biddle et al. 2012). Such founders are often large multinationals with substantial patent portfolios, but may also include smaller, specialized firms focusing on the target technology area.

III. *Patents and Standards*

A. *Patenting Standards*.

Standards are sets of protocols and technical descriptions of product features enabling interoperability. While standards themselves are not patentable, products manufactured in accordance with the instructions provided by standards (often referred to as standards-compliant products) generally satisfy the statutory requirements for patent protection. The owners of patents covering these standardized technologies (referred to as standard-essential patents or "SEPs") are typically the firms and institutions that employ individuals who make particular inventive contributions to standards. Some of these contributions may be made jointly and owned by multiple firms, but in most cases firms individually submit technical contributions to the standard-setting process and own the resulting SEPs.

Because standards documents are often quite lengthy and complex, sometimes running to hundreds or thousands of pages, multiple inventive concepts are frequently embodied in the same standard, leading to the possibility of multiple patents covering any given standard. For example, Blind et al. (2011) report large numbers of patent families[11] declared to be essential to various standards including WCDMA (1000 patent families), 4G LTE (1000 patent families), MPEG-2 and MPEG-4 (160 patent families), optical disc drive standards (2200 patent families), and DVB-H (30 patent families)).

Ordinarily, if the vendor of a product that infringes a patent is unable, or does not wish, to obtain a license on the terms offered by the patent holder, that vendor has three choices: to stop selling the infringing product, to design around the patent, or do neither and risk liability as an infringer. With standards-compliant products, however, the decision is different as designing around the patent may be impossible or may make the product non-compliant with the standard. Moreover, once a standard is approved and released by an SDO, market participants may make significant investments on the basis of the standard (a situation often referred to as lock-in). Such investments may include contractual commitments, purchases of durable goods and capital equipment, employee training, development or procurement of information technology, identification and outfitting of suppliers, and built-up customer loyalty (Shapiro & Varian, 2001). In such cases, the cost of switching from the standardized technology to an alternative technology may be prohibitive, thereby increasing the patent holder's leverage in any ensuing negotiation. This phenomenon has been termed patent "hold-up" and is discussed extensively in the literature ((Lemley & Shapiro 2007, Contreras 2016).

[11] A patent "family" consists of all individual patents deriving from a single, initial patent application. These may include individual patents in multiple countries, as well as multiple patents in the same country derived from the same initial application (e.g., continuations, continuations-in-part and divisionals in the U.S.).

As noted above, complex technological products may implement dozens, if not hundreds, of standards each of which may be covered by hundreds or thousands of patents. As such, the aggregation of royalty demands by multiple patent holders could lead to cost-prohibitive burdens on implementing standards-compliant products. This situation is sometimes referred to as "royalty stacking" (Lemley & Shapiro 2007, Contreras 2016).

B. SSO Patent Policies

Over the past two decades, SSOs have responded to the increasing number of patents covering standardized technologies and the perceived threats of patent hold-up and stacking by adopting a series of policy measures intended to address these concerns. SSO patent policies today fall into two general categories: disclosure policies and licensing policies, and often include elements of both. Disclosure policies typically require participants in the standards development process to disclose SEPs they hold. Licensing policies typically require that participants grant implementers licenses under their SEPs on terms that are "fair, reasonable and nondiscriminatory" (FRAND) or royalty-free (RF).

These commitments purport to assure manufacturers that they will be able to obtain licenses (which may sometimes involve a payment) to sell standards-compliant products covered by SEPs. Perhaps, in part, because FRAND commitments require relatively little administrative overhead to enact, their use has become widespread among SSOs.[12] Nevertheless, a consistent, practical, and readily enforceable definition of FRAND has proven difficult to achieve. Virtually no SSO defines what this phrase means, and many SSOs affirmatively disclaim any role in establishing, interpreting, or adjudicating the reasonableness of FRAND licensing terms. This lack of certainty has contributed to recent litigation over FRAND commitments (Contreras 2013), and leaves most of the details of licensing arrangements to bilateral negotiations among patent holders and potential licensees.

IV. Impact of Patents on International Participation in Standard-Setting

A. Patenting by SSO Participants

Over the past two decades there has been a sharp increase in patenting within certain technology standardization sectors, particularly wireless telecommunications (Bekkers & West 2009). In addition, a core group of firms in the telecommunications sector accounts for the large majority of patent filings covering ICT standards. These firms include Qualcomm, InterDigital, LG Electronics, Nokia, Samsung, Ericsson and Motorola (Blind et al. 2011, Baron & Pohlman 2015). In addition, Contreras (2014) observes a rapid increase in patenting activity by Huawei in the area of Internet standardization. These statistics suggest that patenting behavior is not concentrated among firms of any one country, but is distributed at least among firms based in the major developed economies (U.S. (Qualcomm, InterDigital and Motorola), Korea (LG and Samsung), Europe (Nokia and Ericsson), and China (Huawei)).[13]

[12] FRAND commitments (or similar commitments to license patents on a royalty-free basis) are required of all SDOs accredited by ANSI.

[13] Though Japanese firms such as Sony, Toshiba, Sharp and Panasonic have played major roles in many areas of ICT standardization, particularly consumer electronics and digital media, they are comparatively underrepresented in telecommunications and networking SSOs, due largely to early policies adopted by the Japanese government (Contreras 2014).

When considering levels of patent acquisition, it is important to note that a firm's home jurisdiction is relatively immaterial to the jurisdictions in which it seeks and obtains patents. That is, a large firm with a global market is likely to seek patents in all major markets, no matter where it is based. Thus, in 2014, the ten firms to which the greatest number of U.S. patents were awarded were: IBM (US), Samsung (Korea), Canon (Japan), Sony (Japan), Microsoft (US), Toshiba (Japan), Qualcomm (US), Google (US), LG (Korea) and Panasonic (Japan) (USPTO 2015). It is likely that a comparable distribution exists in most other jurisdictions, with only a modest "head start" advantage for local firms. Thus, in India, preliminary research being conducted by the author suggests that many patents in the telecommunications sector are held by the same large international technology firms that are active elsewhere, with a smattering of grants to domestic firms.

These findings suggest that in terms of standard-essential patents (and, most likely, all patents), firms can be classified as either "Haves" or "Have-nots". The Haves are generally large multinational technology-focused firms based in North America, Europe and the developed Asian economies. The "Have-Nots" are all others. It is important to note that not all firms based in these key jurisdictions are Haves. Smaller firms and new market entrants in developed economies may also be Have-Nots. Likewise, not all firms based in developing nations are, or must remain, Have-Nots. A key example is China-based Huawei which, in the span of just a few years, rose from insignificance to prominence in the area of Internet standardization and related patent holdings. Other large firms in China, India, Brazil and other emerging economies may also be situated to invest the resources necessary to increase their patent portfolios in this manner. However, it appears that most firms in these jurisdictions are still likely to be classified as Have-Nots.

B. Patent Licensing Dynamics

As noted above, most SSOs require that their participants license standards-essential patents to product manufacturers on terms that are either FRAND or royalty-free (RF). Thus, at least as to standardized technologies, patent acquisition and enforcement is unlikely to result in outright exclusion of competitors from a market. However, in markets characterized by FRAND (as opposed to RF) licensing, transactions are not always smooth or equitable, particularly in relation to transactions between Have and Have-Not firms.

The situation often plays out as follows: a standard is developed at an international SSO. Firms that participate in the SSO obtain patents covering the standard throughout the world. The standard then becomes implemented in products that are sold globally. By the time firms in less-developed countries become aware of the potential for sales of such products in their own countries (possibly with locally-attractive features, lower costs or domestically-sourced components), the basic product technologies have already been patented by foreign Have firms. Local Have-Nots must thus seek licenses from foreign Haves in order to manufacture standardized products in their domestic markets. The royalties sought by foreign patent-holding firms, while arguably reasonable on an international basis, may be viewed as excessive in local markets. The royalty burden owed to foreign firms is thus often viewed as inequitable by local firms and governments, particularly if foreign Have firms enter the market and compete with the local Have-Nots.[14]

[14] In addition, the royalty burden on local Have-Not firms is often greater than the burden on other foreign Have firms that hold patents that may be used as bargaining chips in cross-licenses with other Have firms. The result is that

The perception of unfairness is exacerbated when foreign firms actively enforce their patents against local market participants in their domestic markets, as has recently occurred in India.[15]

V. *Potential Responses*

There are several potential responses, both public and private, to the perceived inequity implicit in foreign Have firms' practices relating to the patenting and licensing of technical interoperability standards in less-developed countries. In many cases, these responses are not mutually exclusive and may co-exist within a country or region. The principal categories of such responses are considered below:

A. Embrace the Status Quo

Action is required to address a situation only if a problem exists. There are many who would argue that the current patent imbalance between Have and Have-Not firms in the area of interoperability standards is the natural result of a market-based global trading economy. The situation is no different than it is in many other industries including pharmaceuticals, automotive, aviation and others. As such, Have-Not firms have the potential to succeed based on superior innovation and technical skill. This is particularly true in the area of technical standardization, in which participation is, in many cases, open to all interested organizations irrespective of national origin. The success of firms from small countries (e.g., Philips (Netherlands), Nokia (Finland) and Ericsson (Sweden)), and from developing economies (e.g., Huawei and ZTE (China)) demonstrates that the "club" is not limited to firms from the largest developed economies. Thus, special measures designed to create a greater balance between the interests of Haves and Have-Nots could be misguided and counterproductive.

B. Enact Protectionist Regulation and Enforcement

When a government perceives that its domestic producers are being disadvantaged by foreign interests, a natural reaction is to implement regulations, and undertake enforcement actions, intended to protect the local industry. Of course, expressly protectionist regulation generally flies in the face of widely-adopted international treaty obligations such as the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (the TRIPS Agreement),[16] as well as more recent bilateral and multilateral trade agreements such as the Trans-Pacific Partnership (TPP).[17] Nevertheless, protectionist measures that target the actions of foreign patent holders may be disguised as prohibitions of unfair business practices and anticompetitive behavior, and may remain on the books for years before they are successfully challenged.

Have firms that have entered into cross-licensing networks generally have a low monetary royalty burden as compared to Have-Not firms that lack patents essential to relevant standards.

[15] In a highly-publicized case, Ericsson sought to enforce its patents against local Indian phone manufacturers, allegedly to stymie efforts by Chinese manufacturer Xiaomi to expand into the Indian market (Ernst, 2015). The case prompted an investigation and action by the Indian competition authority.

[16] World Trade Organization, Agreement on Trade-Related Aspects of Intellectual Property Rights, Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, 15 April 1994, in World Trade Organization, The Legal Texts: The Results of The Uruguay Round of Multilateral Trade Negotiations 321 (1999), *available at* http://www.wto.org/english/docs_e/legal_e/27-trips.pdf.

[17] *See, e.g.*, Chapter 8 (Technical Barriers to Trade).

For example, in the early 2000s, after realizing that foreign firms had dominated the market for 2G wireless telephony devices, the governments of both Korea and China sought to assist their domestic industries in the area of 3G standardization. Korea supported Qualcomm's CDMAOne wireless telecommunications technology in exchange for presumably favorable terms for Korean vendors. China, in contrast, embarked on a go-it-alone approach to 3G standardization, producing a competing TD-SCDMA technology that was not heavily patented by Western interests (Ernst 2011). Neither of these approaches proved to be successful, and the telecommunications markets in both Korea and China have now gravitated toward international interoperability standards, with Korean and Chinese firms playing significant roles in the relevant international SSOs (Contreras 2014).

Closely related to the enactment of new regulations disfavoring foreign patent holders is the enforcement of existing regulations against such entities. There has been a spate of recent competition law investigations and enforcement actions against large Western holders of standards-essential patents in China, Korea and India.[18] For example, in February 2015, China's National Development and Reform Commission ("NDRC") fined Qualcomm approximately US$975 million for a host of alleged violations of China's Antimonopoly Law in connection with its licensing of standards-essential patents. The Korean Fair Trade Commission is also reportedly investigating Qualcomm.

A final way that governments can seek to reduce the dominance of foreign patent holders in domestic markets is through the imposition of compulsory licensing for particular patents or products. This power, which is permitted under TRIPS in special circumstances, has to-date been exercised primarily in pharmaceutical markets in developing economies. Nevertheless, the possibility of compulsory licensing exists in other industries that have a significant impact on health, safety and welfare of local populations (Contreras & McManis 2014).

C. Increase Patenting By Local Firms

As the competitive advantage possessed by Have firms derives principally from patents on standardized technology, some have suggested that it would benefit local firms to increase their own patenting activity (Ramel & Blind 2015). Increased patenting by local firms would, it is argued, give such firms greater bargaining power in licensing negotiations with existing Have firms. While this conclusion is correct on a theoretical level, it may oversimplify the issue. The acquisition of patents is not itself a productive activity, but a by-product of technological innovation. Thus, unless one seeks to encourage speculative patenting divorced from technical development (a goal that most would agree is undesirable), the ability to seek patents must be coupled with technological development. To the extent that patents cover technical standards, that technical development usually occurs in connection with participation in an SSO. Thus, to enhance their bargaining position Have-Not firms should seek not to increase their patenting activity, but their participation in international standardization activities (see VI.D below). If they do so, then their ability to obtain patents covering their technical contributions should follow.

It is, of course, a separate matter whether local governments should facilitate patenting by domestic providers. Doing so in a manner that discriminates against foreign

[18] To some degree, these investigations echo similar investigations by U.S. and European competition law authorities.

firms would generally run afoul of TRIPS and other treaty obligations. However, governments can help their domestic industry by funding additional R&D and SSO participation.

D. Incentivize Increased SSO Participation by Local Firms

The potential benefits that Have-Not firms can obtain from increased SSO participation in international SSOs are numerous. First, such firms may be able to influence the direction of standardized technologies in a manner that favors, or at least takes into consideration, local markets or local technology/patent positions. Involvement in charting the future direction of technology standards can also give firms insight into and advance notice of product development and evolution opportunities. It may also offer local firms opportunities to export interoperable products beyond the domestic market. It may also afford increased opportunities for patenting in domestic markets and abroad, and will inform foreign firms of the technology and patent assets that such firms have available for licensing.

From a policy standpoint, increased involvement in SSOs would give Have-Not firms opportunities to influence SSO policies and practices, particularly in ways that might facilitate licensing and technology dissemination in developing markets. For example, SSO policies could clarify that offering lower royalty rates for deployment of standards-compliant products in developing markets would *not* violate the SSO's requirement of non-discriminatory treatment. Likewise, SSOs could mandate reduced-royalty or royalty-free licensing in certain markets or under certain conditions.

Despite these potential advantages, with a few exceptions, Have-Not firms have not yet made meaningful and sustained contributions to major international SSOs. This absence is rendered the more notable by express policies intended to ensure broad participation in such SSOs. For example, participation in international Category I SSOs such as ISO and ITU is often determined on a national basis.[19] The national delegations to bodies such as these present good opportunities for involvement by firms from less-developed countries. Some Category I SSOs such as ETSI, and most Category II SSOs, such as IEEE, ASTM and IETF are, by their own policies, open to participation by all interested organizations. Accordingly, the only barriers to participation in these SSOs, which represent a significant portion of global standardization activity,[20] arise from a lack of technical skill, financial resources and interest among Have-Not firms. These deficiencies are, of course, very real and very serious. However, they can be overcome, at least in part, through national and philanthropic programs that provide resources for technical training and participation in international SSOs.[21] The example of Chinese firms such as Huawei and ZTE (Contreras 2014), illustrate that it is possible for local firms, with sufficient determination, governmental support and expenditure of resources, to become significant forces in international standardization activities.[22]

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[19] See Part I, above.

[20] Because Category 3 SSOs (consortia) are typically formed by small groups of firms with an existing technology and patent position, it is not realistic to hope that they will be fruitful avenues for greater Have-Not firm participation.

[21] For example, the Internet Society, a US/Switzerland-based NGO, regularly sponsors a number of Fellows from developing countries to participate in meetings and other activities of the IETF. http://www.internetsociety.org/what-we-do/education-and-leadership-programmes/ietf-and-ois-programmes/internet-society-fellowship.

[22] Of course, China recently underwent a phase during which it concentrated significant resources on the development of local standards without heavy foreign patent coverage (see Part V.B, above, discussing initiatives such

Trade agreements, despite their potential to facilitate the involvement of local firms in international SSOs, have, to date, done little in this regard. Though the TPP includes an entire chapter devoted to standards, its goal is ensuring that locally-developed standards, generally those relating to health and safety, are open and transparent and do not discriminate against foreign producers.[23] The standards focus of the TPP is thus inbound with respect to Have-Not firms and countries, ensuring that they allow international firms to enter without standards-based barriers, rather than outbound, or helping them to participate in the broader global standardization community.

Future trade agreements, however, could level the playing field for Have-Nots. Among other things, they could encourage greater openness to Have-Not participation in nationally-based SSOs, require that nationally-adopted standards originate from open SSOs, and establish international bodies designed to support Have-Not participation in international SSOs. This last approach could be coupled with a variety of mechanisms to subsidize the participation of Have-Not firms in international SSOs. Potential sources of such subsidies include local governments, non-governmental organizations (NGOs),[24] and multi-governmental organizations (e.g., the World Intellectual Property Organization (WIPO)). SSOs themselves could also offer financial support to Have-Not firms wishing to participate, underwritten by the membership dues paid by their existing multinational firm members. With such subsidy programs in place, the steep costs of international SSO participation could be defrayed for Have-Not firms, thus broadening overall participation and promoting broader representation in these critical global organizations.

Conclusion

Patents on standardized technologies are being issued with increasing frequency, and the majority of these patents are held by large multinational firms based in developed economies. As a result, firms from less-developed economies with sparse patent holdings are disadvantaged in both domestic and foreign markets. While protectionist governmental policies can address these disparities, such measures are potentially contrary to international treaty obligations and generally unsuccessful in the long term. An alternative approach involves greater participation in international SSOs by firms from less-developed economies. This increased participation is likely to benefit such firms both in terms of technology development, strengthening of patent positions, and influence over SSO policies. To facilitate increased participation, subsidies may be required from local governments, NGOs, multinational organizations or SSOs themselves.

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as China's TD-SCDMA 3G mobile telephony effort, as well as Ernst (2011), which details several such efforts). While many would argue that these efforts were ultimately of limited success, it is possible that they did serve the unexpected purpose of preparing Chinese firms to participate in international standardization efforts.

[23] See Trans-Pacific Partnership, Chapter 8 (Technical Barriers to Trade).

[24] For example, the IETF fellows program sponsored by the Internet Society (see note 21 above).

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