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Publications include *America's Voluntary Standards System—A "Best Practice" Model for Asian Innovation Policies* (2013); *Indigenous Innovation and Globalization: The Challenge for China's Standardization Strategy* (2011) [now published in Chinese]; *China's Innovation Policy Is a Wake-Up Call for America* (2011); *A New Geography of Knowledge in the Electronics Industry? Asia's Role in Global Innovation Networks* (2009); *Can Chinese IT Firms Develop Innovative Capabilities within Global Knowledge Networks?* (2008); *China's Emerging Industrial Economy-Insights from the IT Industry* (with Barry Naughton) 2007; *Innovation Offshoring-Asia's Emerging Role in Global Innovation Networks* (2006); "Complexity and Internationalization of Innovation: Why is Chip Design Moving to Asia?," *International Journal of Innovation Management* (2005); *International Production Networks in Asia: Rivalry or Riches?* (2000); and *Technological Capabilities and Export Success—Lessons from East Asia* (1998).

This paper was first presented at the International Workshop on Asia and Global Standardization, Center for International Standardization, Yonsei University and Korean Agency for Technology and Standards, Seoul, April 19, 2013. A revised version has been submitted to the journal *Telecommunications Policy*.

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Standards, Innovation, and Latecomer Economic Development – A Conceptual Framework[1]

by

Dieter Ernst, East-West Center

Abstract

Little is known about the impact of standards on the economic development of countries which are latecomers to industrial manufacturing and innovation. Standardization is regarded primarily as a technical issue, and hence receives only limited high-level policy support.

However, technical standards contribute at least as much as patents to economic growth. As a key mechanism for the diffusion of technological knowledge, technical standards contribute to productivity growth. Equally important are qualitative impacts for instance of environmental, health, food and work safety standards. A well-functioning standardization system and strategy can work as a catalyst for translating new ideas, inventions and discoveries into productivity-enhancing innovation. Standards thus are the missing link in a growth strategy which seeks to create quality jobs in higher-value added advanced manufacturing and services.

The paper develops a conceptual framework to study how standards are created and used in Asian countries that seek to catch up with the productivity and income levels of the US, the EU and Japan. A stylized model of latecomer standardization tasks, capabilities and strategies is used to demonstrate that the costs of developing and implementing effective standards can be substantial. The paper examines the critical role that patents play for standardization and argues that "strategic patenting" to generate rents from *de facto* industry standards can stifle latecomer economic development. Policy implications conclude the paper.

[1] This paper was first presented at the International Workshop on Asia and Global Standardization, Center for International Standardization, Yonsei University and Korean Agency for Technology and Standards, Seoul, April 19, 2013. A revised version has been submitted to the journal *Telecommunications Policy*.

About the author

Dieter Ernst, East-West Center senior fellow, is an authority on global production networks and R&D internationalization in high-tech industries and on industrial and innovation policies in the US, China, India and other emerging economies, with a focus on standards and intellectual property rights. Dr. Ernst served as a member of the US National Academies' Committee on Global Approaches to Advanced Computing; a senior advisor to the OECD, Paris; research director of the Berkeley Roundtable on the International Economy (BRIE) at the University of California at Berkeley; professor of international business at the Copenhagen Business School; and scientific advisor to governments, private companies and international institutions.

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Introduction

There is an abundance of theoretical and econometric studies of how standards shape market competition, but most of these studies have focused on Western economies, primarily those with Anglo-Saxon institutions. And even for Western economies, fundamental public policy issues of standards setting remain grossly under-researched. According to two leading scholars of standards policy, "… [g]eneral agreement about appropriate public policy toward government standard setting does not exist. The most basic questions remain unaddressed." (Greenstein and Stango 2007: 1–2).

We know even less about the impact of standards on the economic development of countries which are latecomers to industrial manufacturing and innovation. Most of these countries are focused on upgrading their economies through innovation, as measured by patents. Standardization is regarded primarily as a technical issue, and hence receives only limited high-level policy support. However, China as well as Korea and Taiwan are now searching for ways to strengthen and upgrade their standardization systems and strategies.

In fact, standards contribute at least as much as patents to economic growth. As a key mechanism for the diffusion of technological knowledge, technical standards contribute to productivity growth. The macroeconomic benefits of standardization thus exceed the benefits to companies alone. For Germany, a widely quoted study conducted for the German Institute for Standardization (DIN) finds that a 1% increase in the stock of standards is positively associated with a 0.7 to 0.8% change in economic growth[2].

But these econometric studies only scratch the surface. Equally important are qualitative impacts for instance of environmental, health, food and work safety standards. In fact, broad qualitative impacts of standards are essential for latecomer economic development – a well-functioning standardization system and strategy can work as a catalyst for translating new ideas, inventions and discoveries into productivity-enhancing innovation. Standards are the missing link in a growth strategy which seeks to create quality jobs in higher-value added advanced manufacturing and services[3]. This poses an especially demanding challenge for countries which only recently begun to build up their standards systems and strategies.

Furthermore, rapid and disruptive technical change (such as the transition to the *Internet of Everything*[4]) creates new challenges for standardization. Of critical importance are *interoperability* standards that are necessary to transfer and render useful data and other information across geographically dispersed systems, organizations, applications, or components. (Gasser and Palfrey, 2013) Rising complexity and increasing uncertainty are two defining characteristics of the new world of ubiquitous globalization. Technology-based competition is intensifying, and competitive success critically depends on control over intellectual property rights and on "a capacity to control open but owned architectural and interface standards" (Ernst, 2002a: 330). This process has increased the economic importance of standardization, but

[2] Blind, Jungmittag, Mangelsdorf, 2011. Similar findings are reported for Australia, New Zealand, the UK, France, and Canada in Standards Australia, 2012.

[3] On the American standards systems, see Ernst, 2013. China's standards system is examined in Wang, 2013; Ernst, 2011; and Suttmeier, Kennedy and Suh, 2008.

[4] "The Internet of Everything" brings together people, process, data and things to enhance the relevance and productivity of networked connections - turning information into actions that create new capabilities, richer experiences and unprecedented economic opportunity for countries, businesses, communities and individuals.

especially so for countries (like China and Korea) which are deeply integrated into international trade and global corporate networks of production and innovation[5].

In short, we need a conceptual framework that allows us to study how standards are created and used in countries with economic institutions that differ from those in Western economies. We need to place standardization in the larger context of latecomer economic development in countries that seek to catch up with the productivity and income levels of the US, the EU and Japan.

This paper is a very first step toward developing such a framework, with a focus on practical policy-oriented research. Part One reviews the evolving tasks of standardization and explores why standards are the lifeblood of innovation in the global knowledge economy. Part Two uses a stylized model of standardization tasks, capabilities and strategies to demonstrate that the costs of developing and implementing effective standards can be substantial, especially for latecomer countries.

Part Three describes the challenge faced by latecomer economies in their quest for economic and technology development and explores what this implies for standardization. Part Four asks what standardization research can learn from recent work on the role of intellectual property rights for economic development. Part Five highlights the tension between standards and innovation, examines the critical role that patents play for standardization and argues that "strategic patenting" to generate rents from *de facto* industry standards can stifle latecomer economic development.

The paper concludes with reflections on what constitutes success or failure of standardization for latecomer economic development and presents generic policy implications.

1. Evolving tasks of standardization

There is an almost infinite number of standards that differ in their form and purpose. To shed light on the evolving tasks of standardization, we first need to open the black box of standards and introduce an operational definition. A state-of-the-art definition that serves our purpose well is provided by the National Institute of Standards and Technology (NIST) as part of its Smart Grid Interoperability Standards project (NIST, 2010: pages 19 and 20): Standards are

"…[s]pecifications that establish the fitness of a product for a particular use or that define the function and performance of a device or system. Standards are key facilitators of compatibility and interoperability. … Interoperability…[is].. *the capability of two or more networks, systems, devices, applications, or components to exchange and readily use … meaningful, actionable information - securely, effectively, and with little or no inconvenience to the user. …* [Specifically, standards] *define specifications for languages, communication protocols, data formats, linkages within and across systems, interfaces between software applications and between hardware devices, and much more. Standards must be robust so that they can be extended to accommodate future applications and technologies."*

In the literature, standards are normally categorized as 'proprietary' versus 'open', and as '*de facto* versus' '*de jure*' (Stango, 2004). Proprietary standards are owned by a company that

[5] On Korea's global network integration, see Ernst and Kim, 2002, and Ernst, 1994. An economic analysis of integration into global corporate networks of production and innovation, see Ernst, 2009.

may license them to others, while open standards "are available to all potential users, usually without fee" (Steinfield, 2007: p. 163). *De facto* standards achieve adoption through standards competition among rival standards consortia. Finally, *de jure* standards are adopted through consensus, which is sometimes formally expressed through industry committees or formal standards organizations.

At the most fundamental level, standards help to ensure the quality and safety of products, services and production processes, and to prevent negative impacts on health and the environment. Hence, an important function of standards is to reduce "risks for makers of compliant products and users of these products." (Alderman, 2009: pages 2 and 3)

In addition, standards enable companies to reap the growth and productivity benefits of increasing specialization, analyzed long ago in chapter III ("That the Division of Labor is Limited by the Extent of the Market") of Adam Smith's "The Wealth of Nations" (Smith, 1776/1970, Book One, chapter III). According to economic historian Charles Kindleberger (1983: p.378, 379), "… [f]or the most part, standardization was originally undertaken by merchants" to facilitate a progressive specialization through trade."

Today however, specialization extends well beyond trade into manufacturing and services, including engineering, product development and research. Equally important is the international dimension. As globalization has been extended beyond markets for goods and finance into markets for technology and knowledge workers, standards are no longer restricted to national boundaries. Standards have become a critical enabler of international trade and investment – they facilitate data exchange as well as knowledge sharing among geographically dispersed participants within global corporate networks of production and innovation (Ernst, 2005a and 2005b). As network sociologists emphasize, the "creation and diffusion of standards underlying new technologies is a driving element of contemporary globalization." (Grewal, 2008: p.194)

In short, standards are the lifeblood of innovation in the global knowledge economy. Today, standards are necessary not only to reap economies of scale and scope, but also to reduce transaction costs and to prevent a duplication of efforts. In addition, standards are required to enable data transfer and knowledge exchange and to facilitate interoperability of components and software within increasingly complex technology systems (e.g., a smart phone or a switching system). Without interoperability standards, it would be impossible to achieve 'network externalities' which shape competition in markets for products and services that use information and communication technologies (Katz and Shapiro, 1985). In these markets, "…[a]s the set of users expands, each user benefits from being able to communicate with more persons (who have become users of the product or service)."(Rohlfs, 2001: page 8) 'Network externalities' imply that a company succeeds "when customers expect that the installed base of … [the company's] … technology [will] become larger than any other," with the result that the customers "adopt that technology to the virtual exclusion of others" (Sheremata, 2004: p.359).

Developing these interoperability standards is a moving target. The challenge is to allow for a continuous adjustment to cope with technical progress. Take the example of the rapidly evolving processor technology that drives the world's computers. The central processing units (CPUs) made by Intel and AMD under Intel's "x86" designs are now rivaled in importance by graphic processing units (GPUs) as PCs are used for multimedia tasks. For a computer company to use the GPU technology, it needs at least three things: "a license … [from Intel] … to the "x86" design of the CPU, a clear agreement about interoperability between the GPU and the

CPU, and finally a strong enforcement mechanism—with clear standards and a timetable for prompt resolution of disputes." [6]

To cope with these critical challenges, standardization has become a complex and multi-layered activity that involves multiple stakeholders who differ in their objectives, strategies, resources and capabilities. Most importantly, standardization is a highly knowledge-intensive activity that requires well educated and experienced engineers and other professionals. While engineers originally created this discipline, key concepts are now shaped by legal counselors as well as corporate executives and government officials.

A dynamic analysis is required to capture the continuous changes and adjustments in the processes of standardization. A fundamental insight of Schumpeter's "creative destruction" theory is that economic institutions incessantly need to adjust to changes in markets and technology. (Schumpeter, 1950) This implies that there is no one best way of organizing standardization. According to the American Engineering Standards Committee Yearbook of 1925, "… [s]tandardization is dynamic, not static. It means, not to stand still, but to move forward together."[7]

This fundamental insight still holds today, but unfortunately there is a tendency in current debates about standardization to neglect this dynamic aspect. Standardization systems are in constant flux, and one needs to apply this fundamental insight to the study of contemporary standards systems, and this is true for an advanced economy like the US and a latecomer economy like Korea or China.

2. A stylized model of standardization costs

Equally important is that considerable financial resources are required to develop and implement effective standards. A rough estimate of such costs can be gained from a stylized model that distinguishes important tasks of standardization and that highlights differences in capability sets and in standardization strategies[8].

Standardization tasks

Based on the author's interviews with leading standards experts in the United States, the European Union and China, we use a taxonomy of standardization that involves, but is not restricted to, the following tasks (Table 1).

Table 1: *A Taxonomy of Standardization Tasks*

1. Develop the technology to support the standard
2. Cost-benefit analysis of whether to adopt existing international standard or whether to create a new standard

[6] David Balto, a former antitrust attorney at the Federal Trade Commission, quoted in "Intel Nears Settlement in Market Abuse Probe," *Financial Times*, July 21, 2010, 15.

[7] Quoted in Russell 2005: 1.

[8] For details, see Ernst, 2011, chapter 3, pages 49 ff.

3. Licensing fees for essential patents (both for existing standards and for newly created standards)
4. Pass testing, conformity assessment, and certification
5. Membership fees for formal and informal standard development organizations
6. Logistics (travel etc.)
7. Cost/risk of including one's own patents into a standard
8. Patent pool management
9. Back-end support
10. Legal (litigation)
11. Lobbying

Source: Interviews with leading standards experts in the US, the EU, and China

Typically, tasks 1, 3 and 4 are the most costly, but in case of litigation, legal costs in the United States can easily run into the hundreds of millions of U.S. dollars. In China, however, while costs of patent litigation are rising, they still remain significantly lower than in the United States[9].

Capability sets

As for capability sets, the model distinguishes two countries. Country A (the "innovator") has a long history of standardization, a proven ability to operate successfully within standardization bodies and to shape international standards, a fairly diversified production and innovation system, and a broad base of accumulated knowledge and intellectual property rights (IPR) that helps to generate product and process innovations. Country A thus is able to ""control much of the technological input necessary to meet the standards." (Pai, 2013: p. 5) As a result, a primary concern of law and policies in country A is the protection of IPR, and the "openness" of standards is subordinated to IPR protection.

Country C (the "global factory"), on the other hand, is a relative latecomer to standardization. Country C is a standard taker, manufacturing products that are developed and standardized by Country A. Country C still has to learn how to operate successfully within standardization bodies. Most importantly, country C still has a long way to go to establish a fairly diversified production and innovation system and a broad base of accumulated knowledge and IPR that would allow it to shape or at least co-shape international standards. In country C, laws and policies are focused on economic development and the diffusion of knowledge inherent in IPR. Standardization is viewed as an enabling platform for innovation and latecomer economic development.

Standardization strategies

In principle, countries and companies can choose one of the following standardization strategies described in Table 2 (or a combination of them).

Table 2: *Standardization Strategies*

[9]Top judgments (or settlements) range from RMB 30 million to RMB 157 million. Top cases include domestic firms litigating against foreign firms, with only one top case of a foreign firm litigating against a domestic one. (Interview with Zhang Yan, IBM senior counsel international property law, April 8, 2010.)

Free rider: Let others develop standards and save costs

Fast follower: Get existing standard fast so that products with the standard's technology can be deployed quickly

Co-shaper: Adjust existing international standards to suit a country's specific needs, and deploy these adjusted standards in current and future products

Leader: Create new standards and embed own essential patents in the standard

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Country A and its leading firms are likely to pursue standards leader or co-shaper strategies, while country C and its leading firms will initially focus on free rider or fast follower standardization strategies.

The diversity of standardization capabilities and strategies explains why there are significant differences in the organization and governance of standardization processes. These differences reflect differences across industrial sectors in technology, demand patterns and competitive dynamics. But standardization processes also differ across countries, reflecting the underlying conditions of population, resources, technological capabilities, products and tastes. Standardization processes reflect peculiar characteristics of a country's economic institutions, its level of development, its economic growth model, as well as its culture and history (Kindleberger, 1983: p.383).

Unfortunately, an important weakness of the standardization literature is that we still lack systematic research that compares different national standards systems and their divergent development trajectories[10]. Existing comparative studies are focused on the American, the European and the Japanese standardization systems, neglecting important developments in latecomer countries like Korea, India, Brazil, and, most importantly, China[11].

3. Latecomer Economic and Technology Development – A Dual Challenge

A central proposition of this paper is that the study of standardization needs to be "nested" in the larger context of latecomer economic and technology development. The essence of latecomer economic development is narrowing the gap in productivity and income relative to a leading country like the US.

Latecomers to industrial manufacturing and innovation, such as Korea and China, are facing a dual challenge. They need to overcome very substantial barriers to entry ("latecomer disadvantages") that result from being backward in market size and sophistication and in the level of technology. At the same time, however, latecomers need to exploit new opportunities as

[10] There are of course many specialized data bases for engineers that compare technical standards for particular technologies. But very little research exists that compares institutional arrangements and strategies that shape different national standards systems.

[11] An example of this outdated view of the global map of national standards systems can be found in Mattli and Buethe, 2003. See however Lee and Huh (2012), and a new project by the *National Academy of Sciences* that seeks to compare different national systems of managing intellectual property in standard development organizations (http://sites.nationalacademies.org/PGA/step/IPManagement/index.htm)

they are facing fewer legacy constraints to technology development, strategy and organization ("latecomer advantages").

The distinction between "latecomers" and incumbent "leaders" who have accumulated "first-mover advantages" goes back to debates among economic historians on how "relative economic backwardness" in the 19th century has shaped the patterns and strategies of industrialization of countries such as the US, Germany, Japan and Russia (Gerschenkron, 1962; Nelson and Wright, 1992; Landes, 1965). It was argued that, under certain conditions, economic advantages are conferred on countries which are latecomers to industrial development. The basic idea is that those who are behind have the potential to make a larger leap. According to a classical study, "the larger the technological and, therefore, the productivity gap between leader and follower, the stronger the follower's potential for growth in productivity: and, other things being equal, the faster one expects the follower's growth rate to be. Followers tend to catch up faster if they are initially more backward." (Abramovitz, 1989: p.221) In one of its more sophisticated versions, this argument contents that, since the cost of changing to each more advanced level of technology progressively increases, latecomers do have a chance of bypassing industrial early starters. (Ames and Rosenberg, 1963)

Case studies of latecomer industrialization however have identified a great variety of entry barriers for countries that are late adopters of a technology[12]. Such entry barriers include but are not restricted to

- Production-related scale economies, including learning economies, threshold barriers and economies of scope;
- Barriers related to intangible investments required for developing the knowledge and competence base as much as complementary support services;
- Barriers to entry and exit of network transactions, particularly in the context of sourcing arrangements for core components;
- Barriers related to customer relations, including market intelligence, sales channels, and maintenance and repair;
- And the growing number of regulatory barriers (including standards) which, directly or indirectly, affect the costs of entry.

None of these entry barriers however are absolute – they can be reduced under certain conditions. Take *economies of scale* which can constrain the entry of latecomers for at least three reasons: the existence of learning economies, the lumpiness of investment and the need to reduce the cost of increasing product variety[13]. In principle, this could be avoided, if the market expanded rapidly. In that case, market leaders might even welcome the entry of at least some new competitors, as the leaders' production capacity could fall well short of existing demand. With demand booming, new entrants might be willing and able to sustain at least some initial losses, given the prospects for future profits.

For quite some time, the information technology (IT) industry was the archetypical growth industry. Today, however, new entrants are confronted with a situation where rapid demand growth is no longer assured. It is due to this market growth constraint that economies of scale have become an important barrier to market entry (Ernst, 2002b). In such a situation a latecomer

[12] The following sections draw on Ernst, and O'Connor, 1992.
[13] See for instance Bain, 1959, and Scherer, 1980.

faces a major challenge. He must expand the market through non-price means, i.e. through product differentiation and the creation of new markets and distribution channels, and through the development of strong and sophisticated standards systems.

The problem of course is that economies of scale for such activities may even be higher than economies of scale in manufacturing. For instance, a latecomer may be disadvantaged relative to a large incumbent market leader who can spread her budget for standards development over a large output and who can purchase international standards at negotiated discounted prices if it has sufficient negotiation power in the market.

Latecomer strategies for standardization are even more constrained by the "first mover advantages" which market leaders have been able to establish relative to latecomers in terms of cost, quality and speed-to-market of standards development. Such "first mover advantages" usually result from accumulated experience in managing standard development organizations, and privileged access to the best sources of knowledge. At the same time, first movers have been able to amass a vast amount of market intelligence, technological capabilities and organizational competence which, in principle at least, allows them to calibrate and quickly adapt standards to changes in demand, technology and production economics.

As a consequence, latecomers, "… face higher unit costs in providing the good and service involved – and therefore earn a lower rate of return." (Ergas, 1988) This, in turn, constrains their capacity to finance standards development. It also limits funds available for the purchase of international standards and for the intangible investment that is essential for organizational upgrading and for more active participation in international standards development organizations and private consortia – all of which are necessary preconditions for catching-up with industry leaders. Latecomer disadvantages thus have a built-in tendency of mutual reinforcement.

However, the new world of ubiquitous globalization also provides new opportunities for latecomer economic development. Countries like Korea and China have been able to catch up and to forge ahead, even in complex technologies like advanced information and communications technology. New entry possibilities may open up for instance, as technological change erodes established market structures and leadership positions. In addition, "first mover advantages" are sometimes constrained by weak intellectual property protection that facilitates copying and knowledge leakage. Also, incumbent market leaders may become complacent and neglect to fight against latecomer attacks.

Furthermore, latecomers are fast followers of established technology roadmaps. Hence, they have the great advantage of being able to set clear targets for product development and related research. Finally, latecomers can compare and learn from the experience of incumbent leaders, particularly their failures in reducing costs and in adapting products and the distribution system to changing customer needs. Through judicious strategies of lower-cost innovation, latecomers can avoid being trapped into huge R&D cost burdens. By acting as suppliers for OEMs, whether as EMSs or ODMs, latecomers can also avoid the huge investment outlays required for distribution networks and marketing.

Industrial latecomers however face fundamental trade-offs in their attempts to catch up with industry leaders. New technologies figure prominently in shaping success or failure. Latecomers can either use these technologies to upgrade traditional industries or they can seize new market opportunities spawned by those technologies in high-tech industries. In the former, latecomers may already be well established and cost-competitive, whereas in the latter they are newcomers and are trying to catch up technologically in intensely competitive markets.

Another trade-off latecomers must address is that between timely access to new technologies and the ability to develop such technologies indigenously. Given the sizeable technology gap, especially in high-tech industries, that separates latecomers from technology leaders in the US, Japan and the EU, relying principally on their own R&D capabilities might well condemn the latter to using obsolete technologies. Importing the technologies would provide readier access to the latest vintages but at the expense of perpetuating technological dependence.

In short, conscious efforts are required in latecomer economies, both by firms and governments, to invest in R&D infrastructure and Higher Education. Most importantly, latecomer economic development requires a careful coordination of innovation and standards policies that combine the protection of intellectual property rights and the development of a broad portfolio of high-quality intellectual property rights, with a focus on patents that are widely quoted and essential for the definition of important standards.

4. Intellectual Property Rights and Economic Development: Lessons for Standardization Research

To calibrate standardization research to the needs of latecomer economies, important lessons can be drawn from recent work on the role of intellectual property rights (IPR) for economic development.[14]

Learning advanced technologies is critical for successful catching-up. The protection of intellectual property rights is a necessary, but by no means sufficient, condition. Detailed case studies of earlier historical experience in the United States, the Scandinavian countries, Japan, Korea, and Taiwan demonstrate that IPR protection can only contribute to economic development if it takes place as part of a multi-faceted innovation strategy that seeks to strengthen absorptive and innovative capabilities of firms, and to develop a broad-based innovation infrastructure (including standards).[15]

The relationship between intellectual property protection and innovation is complex - "although stronger IPR protection directly increases the incentive to innovate, it also discourages innovation in the long run by suppressing the process of 'learning by doing.' … This implies that both very strong and very weak IPR policies decrease innovation, so a moderate approach is preferable" (Furukawa 2010).

Of particular interest for the study of standardization is that IPR regimes significantly vary across industries and across countries of different economic size or different technological capacity. Case studies "document again and again the very great differences across industries in the extent to which IPR regimes, indigenous or foreign, affect the catch-up process….[Hence], it makes no sense to talk about the influence of IP on development in general. One has to specify the sector one is concerned with" (Odagiri et al. 2010: 423).

Latecomer countries face a fundamental dilemma: A weak IPR regime may stimulate imitation (without patent holder consent), while discouraging the development of advanced technology through licensing or inward FDI, or through domestic innovation efforts. In a developing country, "utilization of knowledge invented abroad should be given priority over

[14]See, for example, Goldstein and Straus 2009; and An, 2009

[15]. See case study chapters 2–6 in Odagiri et al. 2010.

incentive for invention and, hence, a weaker patent regime that targets diffusion … [rather]…than creation should be adopted" (Odagiri et al. 2010: 11).

Hence, a country's IPR regime needs to evolve with the development of its domestic innovative capacity. "… [T]he relative merits of different IPR regimes change over the stages of economic development…. [Typically], countries try to alter their IPR regime in response to changing needs. In consequence, a country's IPR regime likely coevolves with its economy" (ibid.: 12). As long as a country's innovative capacity is weak, it benefits from a relatively loose IPR regime. Once the country's innovative capacity begins to improve, its IPR regime needs to be gradually strengthened.

In addition, there is an important international dimension. In-depth research on Asia's export-oriented economies finds that, while their own IPR regimes matter, of at least equal importance for their economic growth have been the IPR regimes of their main export markets in the United States, the European Union and Japan. That research also shows that a sophisticated domestic IPR regime is important, as it forces Asian firms to learn about IPR legal issues and to accumulate capabilities for IPR management.

5. The Tension between Standards, Patents and Innovation

The relationship between standards, patents and innovation is much more complex than acknowledged thus far in innovation theory. Policy-oriented research needs to highlight a fundamental tension that sets standards apart from innovation.

By freezing a given technology, standards are supposed to provide stability for industry and customers, as well as for international trade and investment. Yet, at the same time, innovations continuously upset this stability by introducing new products based on new standards. J. A. Schumpeter's theory of "creative destruction" provides a useful analytical framework. For Schumpeter, capitalism

"is by nature a form or method of economic change and not only never is but never can be stationary. And this evolutionary character of the capitalist process … [is driven by innovation] …, the fundamental impulse that sets and keeps the capitalist engine in motion.… [Innovation] … incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. The process of Creative Destruction is the essential fact about capitalism. … In other words, the problem that is usually being visualized … [by economic and legal theories] … is how capitalism administers existing structures, whereas the relevant problem is how it creates and destroys them".(Schumpeter 1950: 83, 84)

On the positive side, there is no doubt that standards can be a critical enabler of innovation. There is no automatic link, of course, but standards can foster economic growth by reducing transaction costs and achieving economies of scale through interchangeability (Kindleberger 1983). Economic standardization theory has shown that "… [s]tandards affect the R&D, production, and market penetration stages of economic activity and therefore have a significant collective effect on innovation, productivity, and market structure" (Tassey 2000: 587).

That does not imply that standardization per se is good under all conditions. For instance, standards that fail to address critical societal concerns with regard to climate change, health, or product safety may actually give rise to wasteful and even destructive innovation. Standards may

also effectively limit innovation and economic growth when they are used as a weapon to block competition (e.g., Lemley 2002).

Patents provide the missing link to such anti-competitive conduct. Their role for standards has increased with rising technological complexity. Increasingly, standards include technologies that are protected by IPR. In theory, a neat distinction is possible between standards that are a "public good" (free, collective good) and patents that are a "private good" (for private, exclusive use by patent owners).[16] But in reality, tensions are rising between patents and standards: "… (w)hile technical standardization is meant to transform ideas into a public good, patent protection transforms them into a private good" (European Patent Office 2007: 93).

As globalization has increased technology-based competition, the key to competitive success is a broad portfolio of "essential patents," which are necessary to produce any product that meets the specifications defined in the standard.[17] In fact, each of the major interoperability standards in the IT industry is protected by multiple patent families, giving rise to patent thickets. With increasing complexity of technologies, these patent thickets become denser. For instance, for the GSM standard (for second-generation mobile telecommunications systems), 140 essential patents were claimed by their respective patent holders (Bekkers et al. 2002).

For the third-generation mobile standards, the number of essential patents has substantially increased. For example, W-CDMA (one of the three competing 3G standards) is protected by more than 2,000 patent families comprising more than 6,000 individual patents from some 50 companies and consortia (Davey 2006). At the same time, the number of standards required for a single mobile device has grown exponentially. Today's typical smart phone combines hundreds of standards coming from dozens of standard-setting organizations, for camera, video, web browser, PDA, WiFi, Bluetooth, Linux, USB, and so on. As a result, smart phones have become the latest patent battleground. In 2010, nearly 8,000 patents held by 41 companies apply only to the 3G wireless communications capabilities of a typical smart phone.[18]

The use of "essential patents" as a strategic weapon to prohibit, delay or obstruct standardization processes is well documented in the literature[19]. This is the case for instance when incumbent market leaders pursue so-called 'platform leadership' strategies through allegedly open but de facto proprietary standards[20]. While nominally 'open', these standards are designed to block competitors and to deter new entrants.

Two highly influential studies on the licensing and disclosure of private standard-setting organizations by M.Lemley document the difficulties of finding fair and reasonable non-

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[16]. Economists typically define "public goods" by two qualities: "non-rivalry in consumption (i.e. they are not depleted by an additional user) and non-excludability (i.e. it is generally difficult or impossible to exclude people from its benefits, even if they are unwilling to pay for them)" (Baumol and Blinder 1991: 617).

[17] Patents are "essential" to a standard when it is not possible to comply with the standard without infringing that intellectual property right.

[18] Confidential interview with smart phone company.

[19] See the seminal article by Lemley and Shapiro, 2007. For an analysis of implications for standard development organizations and policy makers, see Weiss and Spring, 2000.

[20] The overriding purpose of "platform leadership" strategies is to leverage the existing market power of industry leaders into the control of "systemic architectural innovations." (See Gawer and Cusumano, 2002). For example, Intel has attempted to extend its control over microprocessors by creating widely accepted architectural designs that increase the processing requirements of electronic systems and, hence, the market for Intel's microprocessors (Gawer and Henderson, 2007).

discriminatory (FRAND) compromises in private standard-setting organizations to reduce the negative impact of strategic patenting[21].

This is especially difficult for industries, like the information and communications technology sector, where interoperability standards are required to make products or services compatible with each other in order to maximize the benefits of network externalities. The emergence of a "winner-takes-all" competition model, described by Intel's Andy Grove, implies that companies need to combine economies of scale and scope with flexibility and speed-to-market (Grove, 1996). Only those companies thrive that succeed in bringing new products to the relevant markets ahead of their competitors. Of critical importance is that a firm can build specialized capabilities quicker and at less cost than its competitors (Kogut and Zander, 1993). Hence, competitive success critically depends on "a capacity to control open-but owned architectural and interface standards." (Ernst, 2002) It is hardly surprising that, under such conditions, as John Alic puts it, "firms may be tempted to seek profits through collusion rather than technological innovation. And when innovations do result, the costs may be high."(Alic, 2009: p.3)

According to a recent study by the Federal Reserve Bank of Philadelphia, finding fair and non-discriminatory compromises is made even more difficult by "the potential for opportunistic behavior by participants who own patents on a technology essential to the standard. There is a risk that without sufficient transparency and sufficiently strong mutual interests, network participants could make large investments to implement a standard only to be held up by a firm threatening to withhold a key piece of technology" (Hunt et al. 2007). The study argues that "… in all likelihood some kind of agreement would be reached, but on terms substantially worse than the participants initially expected. Indeed, the risk of such an outcome may discourage firms from adopting a standard or even participating in the standard-setting process. In other instances, awareness of a key blocking patent might lead to the adoption of a standard that poses less risk to participants but which is also technologically inferior." (ibid.: 3).

In short, the use of "strategic patenting" to generate rents from de facto industry standards has transformed the dynamics of the international standards system, with potentially very negative implications for latecomer economic development. Within the WTO framework of TRIPS (trade-related aspects of intellectual property rights) and TBT (technical barriers to trade) agreements, only very few remedies are available to address the fundamental tension between patents and technical standards.

This enables patent holders to engage in anticompetitive conduct within national and international standard-development organizations and from outside. The weapons at their disposal include patent hold ups, patent ambush, royalty staking, strategic injunctive reliefs, unilateral refusal to license, and violation of FRAND (Fair, Reasonable and Non-discriminatory) contracts. In short, patent holders can increase their market power "when they demand 'unreasonable' royalties for their patents that are embedded in standards. *Thus, standards generate a market power far beyond the power of exclusion and the freedom of contract granted by patent law* [italics added, DE]." Pai, 2013: p.5)

By stifling innovation and knowledge diffusion, this type of "strategic patenting" is likely to have a quite negative impact on latecomer economic development.

[21] Lemley, 2002; and Lemley, 2007. See also the recent systematic study by Jorge Contreras who lays out an alternative approach focused on a reform of standard-setting organizations (Contreras, 2012)

Conclusions and Policy Implications

This paper has explored how standards and innovation interact in countries that are latecomers to industrial manufacturing and innovation. These countries seek to catch up with the productivity and income levels of the US, the EU and Japan, but they have only recently begun to build up their innovation and standards systems and strategies.

A central proposition is that latecomer economies like Korea and China face opportunities and challenges in their standards and innovation policies that differ quite considerably from the opportunities and challenges faced in today's advanced economies. Latecomers typically are standards takers, and have a long way to go in their efforts to shape or at least co-shape international standards. Latecomers also typically are more vulnerable to the impact of "strategic patenting" strategies that large patent holders use to generate rents from controlling *de facto* industry standards.

Furthermore, latecomers lag behind advanced economies in the sophistication of their standardization capabilities and strategies, and hence are likely to face higher costs of developing and disseminating effective standards. At the same time, ubiquitous globalization and rapid and disruptive technical change (such as the rising complexity of digital networks) create new challenges for standardization. No Korean or Chinese company can succeed in international trade without mastering interoperability standards that are necessary to transfer and render useful data and other information across geographically dispersed systems, organizations, applications, or components. This process has increased the economic importance of standardization, but especially so for latecomer countries which, like China and Korea, are deeply integrated into international trade and global corporate networks of production and innovation.

Given all of these challenges for standards development in latecomer economies - some of them quite new and little understood - is it really sufficient to reduce the debate to a static assessment of the compliance of latecomer standards institutions and strategies with existing approaches to IPR management in standards? In light of the different institutions and weaker standardization capabilities in latecomer countries, couldn't one argue that standards and innovation policies that worked well for advanced economies may not necessarily be the optimal choice for fostering latecomer economic and technological development? And, specifically, what constitutes success or failure of standardization for latecomer economic development?

In the US, where standards are developed primarily by private firms, success is typically defined by commercial criteria, like market share, return on investment, and rents that innovators can reap from a particular technology. In latecomer societies, we need a definition of success that links standardization to the broader challenges of innovation and economic development[22]. In essence, a standards project will be considered a success if it:

- maximizes learning effects and standardization capabilities;
- avoids strategic patenting by owners of essential patents that could block innovation;
- reduces licensing costs to avoid getting caught in the so-called patent trap;

[22] The following definition of success draws on Ernst, 2011

- broadens the scope for innovation to avoid technology lock-in by not blocking foreign standards;[23]
- protects confidentiality, integrity, and availability of data through information security industry standards;
- facilitates and broadens the diffusion of best-practice productivity-enhancing generic technologies;
- initiates open and transparent standardization processes that are in line with WTO and other international regulations;
- helps to adjust the governance mechanisms and institutional architecture of international standards-setting bodies;
- and develops a capacity for flexible and fast adjustments, in cases where policies do not produce the expected results.

This broader definition of success has important *policy implications*. The international community should acknowledge that the challenges faced by latecomers are significant and that one should not always apply the same criteria in judging performance of latecomers as one would to the advanced industrial economies. In light of very different political and economic institutions, it is unrealistic to argue that latecomers should converge to a U.S.–style, market-led system of voluntary standards. Countries like Korea and China will need to find their own institutional and legal approaches to develop a standards system that can both foster innovation and cope with the challenges of globalization and rising technological complexity.

Latecomers, in turn, would benefit from studying inherent advantages of the deeply-rooted U.S. tradition of decentralized, market-led approaches to standardization. This may lead to new ways of blending elements of a U.S.–style voluntary system through independent standards development organizations and consortia with a government-led coordination of standards, innovation, and competition policies.

For instance, a hybrid of the best elements of the U.S. and Chinese standards systems could help latecomers to foster indigenous innovation while maintaining open markets. The Chinese model of an integrated government-coordinated innovation and standardization strategy can help to generate the massive investments needed to upgrade a country's innovation system and its standardization capabilities. At the same time, elements of a US-style decentralized market-led standardization system can help to increase the flexibility of policy tools and institutions in order to cope with sometimes disruptive effects of unexpected changes in technology, markets, and business strategies.

In a world of rising complexity and uncertainty, it is always preferable to have built-in redundancy and freedom to choose among alternatives rather than seeking to impose from the top the "one best way" of doing things. First, rising complexity drastically reduces the time available for standards development and implementation, which makes it practically impossible

[23] Brian Arthur (1989) provides the classic analysis of "technology lock-in." He shows that the economy, over time, can become locked in by "random" historical events to a technological path that is not necessarily efficient, not possible to predict from usual knowledge of supply and demand functions, and not easy to change by standard tax or subsidy policies.

to get solutions right the first time. There may have to be many policy iterations, based on trial and error, and an extended dialogue with all stakeholders to find out what works and what doesn't.

Second, rising complexity makes it difficult to predict possible outcomes of any particular policy measure, especially unexpected negative side effects, of which there is an almost endless variety. In fact, a small change in one policy variable that describes a particular procedure for achieving compliance with a particular standard can have far-reaching and often quite unexpected disruptive effects on many other policy variables and outcomes.

And, third, it is next to impossible to predict the full consequence of interactions among an increasingly diverse population of both domestic and international standardization stakeholders. Given the diversity of competing stakeholders in standardization, the results of a particular national standards policy depends much more on negotiations, gaming, and compromises than on the logical clarity and technical elegance of that policy.

To conclude, countries like Korea and China today provide an experimentation field for new approaches to standardization that seek to combine the advantages of a bottom-up, market-led approach with a unified strategy designed and implemented in close cooperation between industry and government. These new approaches to standardization may also influence debates about international trade agreements. This is true especially for Asia where US-led efforts to create a Trans-Pacific Partnership trade agreement compete with a China-backed Regional Comprehensive Economic Partnership (RCEP) and CJK, i.e. negotiations between China, Japan and Korea to strengthen trade integration between these three Northeast Asian countries.

In short, policy-makers and corporate executives in the United States, as well as in the European Union and Japan, would be well advised to study these new hybrid institutional approaches to standardization for latecomer economic development, and to learn from them.

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