UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Industrial Development Report 2005

Background Paper Series

Standards, Technical Change and IPRs: Lessons from Industrialized Countries for Developing Countries

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Industrial Development Report 2005 Background Paper Series

Standards, Technical Change and IPRs: Lessons from Industrialized Countries for Developing Countries

Knut Blind

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For further information on the IDR05, please contact f.sercovich@unido.org.

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The Role of Standards in Technical Change

Introduction

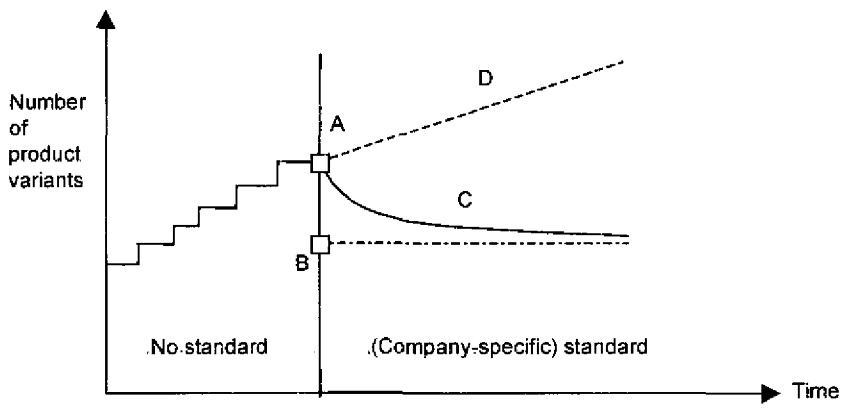
Technical change, or rather the innovations accompanying it, are the guarantee for the economic prosperity of industrialized countries. However it is not enough that our researchers and inventors produce lots of new ideas. In order to trigger off significant, positive economic effects, these product and process innovations must be successfully positioned in the market and diffused. Diffusion can be fostered by a functioning standardization system. Existing standards may present hurdles for new technologies and products, because they compete with existing technologies and products, which are more familiar to the users and in which additional human and physical capital has been invested. This ambivalence will be the focus of the analysis. Furthermore, we will discuss this relationship in the context of developing countries and their link to international standards developed by industrialized countries.

This first section of this background paper is structured as follows: in section B there is a short overview of possible connections between standardization and technical change (this section draws on chapter A in Blind 2004). For the microeconomic analysis of the influence of standardization on technical change, the complex problem of network externalities and the related role of compatibility standards are especially relevant, and they will be dealt with in more depth. Finally, three co-ordination mechanisms are examined for their economic efficiency regarding technical change. The section closes with an analysis of the special role of standards for developing countries, at first independently from the context of international standardization strategies, and then taking into account the strong influence of international standards on national standards and standardization activities.

Overview

Technical standards can exert influence on technical change in various ways. A central aspect is the argument of reducing variety or diversity, i.e. standards limit the diversity of products and thus the consumers' possible choices and exclude special individual preferences. If a standard sets the precise composition of a product regarding quality, form or interface, then alternative (deviating) product designs can only be procured under considerable additional expenditure of cost and time. A basic driving force for technical change is questioned: the existence of variety is a vital pre-condition for the selection possibilities in the market. This selection is possibly brought forward to an earlier point in time by standardization. Standards have a further excluding function: consumers become dependent on the enterprises using specific standards. This applies especially to the use of so-called company-specific standards, which make individual system components offered by one company compatible with each other and thus limit the exchange of single components to the range offered only by the supplier of the system. The phenomenon of variety reduction is represented graphically in Figure 1. Four different cases can be depicted in this figure: A describes the number of product variations available at a given time in an enterprise (e.g. due to product modifications and different specifications). B describes the number of product variations at the point in time when all existing national (respectively European or international) standards have been put in place. The adoption of own, company-specific standards is represented by curve C; the readjustment takes place here successively. D shows the average growth of product variations if no standardization (company-specific or industry-specific) has taken place. This graphic illustrates, albeit in a very simplified fashion, that standardization negatively influences the variety of products. It can similarly be used to illustrate the reduction of product variations in entire sectors or economies. Through this reduction of variety, it also negatively influences technical change by preventing possible product variations which could provide the basis for the development of new products. According to Saviotti (1991), this also has negative impacts on economic growth and thus the economic development of a country.

Figure 1
Development of product variety within a company (source: Blind 2004, p. 26)



This negative effect is counterbalanced by the argument of advantages through specialization, namely, the decrease in the number of system elements because of variety-reducing standards and the increase in the combination possibilities of single elements through interface compatibility. This opens up possibilities for mass production, reduces the costs and thus the prices and enlarges the potential circle of consumers. Then there is the additional advantage of a concentration of research and development (R&D) on a manageable number of product options, which involves a lesser market risk. The costs of searching information are decreased from the perspective of the demand side (Foss 1996). Further, standards which start from quality or processes can also influence the work sequences in R&D; whether the effects are positive or negative on the innovation process depends on the degree of obedience to the standards and the mode of implementation (Senden, Wöckel 1997).

A consequence of inflexible and 'false' standardization can be the 'cementing of the state of technology'. What is meant by this is cutting down on other variations in the interest of standardization and the low incentive to changing to another standard. This incentive is again lessened by the fact that the more broadly a standard is defined, the greater is also the *probability that own products fulfill the requirements of the standard. On introducing a new,* better technology, a so-called cannibalism effect would occur, which means the replacement of the existing standard and the suppression of own products (Heß 1993).

Bauer (1980) points out that technical standards and also their drafts, contain information about the state of the art in technology, and in addition the state of science, and provide – if publicly accessible as formal standards – a good basis, like patent documents, for researchers to generate new ideas. A free transfer of know-how takes place between the authors especially of formal standards and their users. By these means, information flows and cost savings in the innovation process are generated, almost for free. According to Thiard and Pfau (1991), the same advanced effect can also be achieved by collaboration in standardization committees and bodies, in which informal contacts can be established with engineers and other experts who are working in the same technological area.

The problems of variety reduction can be alleviated by standards which do not determine the precise content or design, but only certain characteristics or the performance of a product. In this connection the problem of the subjectivity of the definition of quality can be solved by quality standards, which do not determine the quality of certain products but only define fundamental points of the quality (Liphard 1998). Another positive effect of standards can be derived from this, namely, that product and process innovations which fulfill the minimum requirements of the currently valid formal standards (e.g. quality and safety standards), are in principle facing a lesser market risk, because for the consumers the information asymmetries on the part of the manufacturer are lesser with standardized products and processes as regards product characteristics and quality, and thus their trust and willingness to pay more is greater. This gives the innovator a greater probability of success when introducing his new product to the market.

The argument of reducing transaction costs can be applied in any case. The transaction cost approach applies in institutional economics as the reason for developing the 'institution standard' and corresponds to the target of economic efficiency. Variety-reducing standards allowing economies of scale are almost exclusively founded on this argument. On the other hand, quality, environmental and safety standards meet more societal goals, so for example environmental standards prevent damage to the environment as a socially desirable goal. Common to all standards is that they codify technical knowledge like patents, which may be the base for further technical progress. This differentiation in the kinds of standards reveals the basic problem of a general examination of the impacts of standards on technical change: compatibility standards work differently from variety-reducing standards, these again have another impact than quality, environmental or safety standards. Table 1 sums up the above results in an overview.

Table 1
Overview of the influence of standards on technical change (source: Blind 2004, p. 28)

	Positive Effects	*Negative Effects*
Compatibility/ Interface	More possibilities of combining system elements, forming network bridges	Slowing down the transition from old to new technology
Minimum Quality/Safety	Reducing information asymmetries Greater probability of market acceptance of new products	Risks of lock in of technology status quo
Variety Reduction	Cost reduction, which fosters the accomplishment of critical masses of new products	Reduction of variety
Information Standards	Information about the status of technology; source for new technological innovation (i.e. idea generation)	

Moreover, a differentiation must be made between process and product standards. Willgerodt and Molsberger (1978) examined the influence on product and process innovations and came to the conclusion that basically process standards (e.g. safety standards or environmental standards in manufacturing) do not impede product innovations, and product standards (e.g. compatibility standards or safety standards in consumption) do not hinder process innovations. Product standards however hamper product innovations, as they establish preferences of customers (or reinforce preferences for standardized products with the customers) and these can only be surpassed by a technologically vastly improved innovation. In order to simplify further argumentation, only the relationship between product standards and product innovations will be dealt with in this section, if the other two standardization or innovation types are not explicitly referred to.

The remarks up to now have dealt – using the micro-economic toolbox – with the question of the extent to which formal standards and industry standards exert influence on technical change and which fundamental problems standardization must overcome. No touched upon is the question of how the standards are arrived at and which institutions and other economic actors play a role therein.[1] According to Thum (1994), there are also aspects of the impacts on technical change which can be traced back to different coordination mechanisms in the evolution of a standard. There are three basic possibilities of coordination for standardization: governmental regulation (laws and directives), coordination by voluntary committees (formal standards) and market coordination (industry standards).[2]

The market mechanism can produce an optimal solution, if perfect competition and different product or standardization preferences dominate. Should no standardization take place, this would correspond to the preferences and would thus be efficient. If standardization takes place due to identical or majority preferences, then it must be examined if this has taken place to an optimal extent. The danger of an exaggerated (over-)standardization arises if a certain leeway in setting prices is possible (no perfect competition). A supplier could subsidize his own product, increase its market share and thus lay the foundation for an industry standard which corresponds to the characteristics of his own product (sponsored standards). In this form of industry standardization, technical change would be guided in a direction pre-determined by one enterprise, and only in the rarest cases does this option produce the technologically and economically optimal technical change.

Inadequate (under-)standardization appears if costs from the standardization process are borne exclusively by the standardizers and the positive external effects (e. g. network externalities, but also positive environmental and health impacts) cannot be internalized. The positive effects of standardization – also on technical change – would not be completely realized. Generally, it can be stated that markets with network externalities tend towards inertia and prevent the adoption of new technologies through the lock-in effect. The standardization of new products is impeded by the abovementioned coordination problem, and also by positive network externalities. The problems of network externalities described above speak against a purely market-driven solution. Although it is argued by the school of New Institutional Economics that standards are so efficiency-enhancing by their ability to decrease transaction costs that standardization should not be influenced by external forces, like governmental institutions (Wey 1999).

An optimal solution is possible using a cooperative committee solution if a common interest to agree on a formal standard exists on the part of the actors involved, and these actors adequately represent the demand and supply sides. Further, the standardization committee must be well-balanced regarding power structure, as well as technological, economic and social competence. In bodies such as the standard development organizations (SDOs) an attempt is made to fulfill these requirements by making standardization work in principle always accessible to "interested parties" who unite these competences. Over-standardization emerges when standardization committees are not evaluated by the economic and technological efficiency of their released formal standards, but by quantitative output. An exaggerated propensity towards standardization can lead to a premature or inappropriate technology being established by standards. Moreover, the possibility exists that non-participating suppliers are deliberately disadvantaged by the standardization committee, either through one-sided standardization or when the strong interest congruence of a few powerful participants influences formal standards in a fashion not conducive to technical change.[3]

There is a tendency towards under-standardization if differing standardization preferences on the part of the participating actors emerge, or single suppliers pull out and so nil or insufficient standardization takes place. David and Monroe (1994) examine, on a game theory basis, the probability that an agreement will be reached and come to the conclusion that under certain conditions, depending on the strategies of the participants, the role of the mediator and information asymmetries, the agreement will not take place on time. Economic losses through non-utilization of network effects, rationalization and economies of scale, as well as technologically unsatisfactory standards, can be the result. It can be generally stated that the problem of network externalities can be better solved with this cooperative solution than through the market mechanism, with the danger inherent in the strategic behavior of the participating actors and thus the tendency towards a technical change strongly influenced by interest groups.[4]

Regulation by governmental institutions results in an optimal solution if the standardization succeeds in internalizing external effects. This target can only be aspired to from the government side, as the governmental bodies should represent the interests of all the members of an economy and possesses the necessary authority to issue binding regulations and instigate punitive measures in the case of non-observance. A sub-optimal standardization takes place when the state cannot adequately foresee technological development and a technical regulation is introduced too early or too late.

The economic inefficiencies regarding the timing of the change from old to new technology is also of relevance for governmental regulation. The following failures have to be discussed. First, not every new technology is necessarily better than the old one and is not so mature from the outset that it cannot be improved. A premature change would not only impair technological development, but also economic efficiency, if the utility from an improved old technology is greater, with the same number of participants. A danger exists in the development into a "blind giant", meaning the further development of the actually inferior new technology. Second, if an "old" technology is still relatively young and not all economic units have adopted this technology, a change to a new technology would be likelier to be accepted by latecomers, but not by the adapters of the old technology, as they have to bear the opportunity costs or the costs of joining the "old" technology and therefore their net utility can be negative. They are referred to as "angry orphans". They would remain embedded in the old technology ("stranded") and would lose not only the external network benefit of a large number of participants, but also the net advantage of adoption of a new, better technology. Third, all users shrink from a change, as the opportunity costs are too high, although if behavior is coordinated, the utility exceeds these costs. Society remains a prisoner of the old technology due to the lock-in effect and restricted to the narrow windows, i. e. the possibility of a further technological development is limited to the further development of the inferior old technology.

Also relevant for the actors deciding about governmental regulations is the problem of "narrow windows" and blind giants, i.e. a restriction of future technological development to the further development of existing technologies without the chance of switching to a new technology (blockade by angry orphans), or the further development of a new technology with only small technological potentials.[5]

Table 2
Coordinating mechanisms (source: Blind 2004, p. 40)

	*Over-standardization**	*Under-standardization**
Market (industry standards)	Leeway for price setting, cross-subsidies	Positive externalities via non-internalized costs of standardization
	Result: sponsored standards	Co-ordination problem
		Lock-in effect
Committees (SDOs) (formal standards)	Incentive for participants to produce too many standards	Interests of individuals hinder standardization
	Interests of individuals influence standards	
Governmental institutions (technical regulations)	False estimation of technological development	
	Blind giants	Narrow windows
		Angry orphans

Notes: *Over-standardization should be equated in this connection also with premature or inadequate standardization and under-standardization with too late standardization.

Although coordination against excess inertia or excess momentum may be a welfare-improving activity of the governmental bodies (Adams 1996), it can be said that the governmental solution is the least promising one, as it cannot be assumed that the governmental decision-makers are well informed about the market chances of the technological developments and thus capable of making optimal decisions. As a consequence of this inadequate competence for standardization, governmental institutions are given the responsibility of creating the framework conditions for standardization, but the standardization process itself should by conducted by private committees.[6] Table 2 summarizes the results of this section.

The preceding reflections have shown how ambivalent the effects of standards on technical change can be. As compatibility standards they can make positive network externalities possible, encourage improving innovations and product differentiation, internalize positive and negative external effects from consumption and production and strengthen (innovation) competition. On the other hand, compatibility standards can hinder the radical transition to totally new technologies without interfaces to old technologies and provoke economically and technologically sub-optimal strategic innovation behavior. Quality and safety standards in new technologies, however, tend to have a positive impact by reducing the critical mass to be reached and thus support the change to a new technology in the case of network externalities by the utility increase (by reducing risk). Variety-reducing standards reduce the diversity of system elements and products, which in the first case can lead, in combination with compatibility standards, to a greater number of combination possibilities of elements and thus to an extended product assortment, in the second case to a limited possibility of choice for the consumers.

Strategic behavior and differing interests of the participants in the standardization and innovation process play a not insignificant role in the question of whether standards come into being, and thus in technological development. In the case of network externalities, a new standard can be undermined by latecomers and powerful suppliers, or the excessive enthusiasm for standardization of bureaucrats and competitive politicians can produce sub-optimal standards which lead technical change in the wrong direction or towards a dead end. Standards which lead to the compatibility of various systems can cause strategic innovation and standardization behavior which, on the other hand, can lead to inefficiencies of the economy as a whole. A false standard or one introduced too early or too late lessens the potentially positive effects of the standards on technical change and can even transform them into negative ones.

Lessons for Developing Countries

In general, the impacts of the various types of standards on technical change are identical for industrialized and developing countries.[7] However, two dimensions which cause differences in the impacts have to be considered. First, the development stage of a country has an impact on both the relevance of the various types of standards and their effects. Second, the industrialized countries are the leaders of technical change and therefore also in setting most types of international standards, which have – also via imports of new products – a crucial influence on the national standardization processes and bodies of developing countries. In the following, we discuss the types of standards differentiated according to the two identified discrepancies between industrialized and developing countries.

In comparison to the industrialized countries, the developing countries face the following modified effects of standards on technical change (under the preliminary assumption that interdependencies between industrialized and developing countries do not exist). Compatibility or interface standards have the same effects on technical change in developing countries as in industrialized countries. However, their positive effects in the context of positive direct and indirect network externalities are restricted, especially if we assume that this type of standard is mostly required in markets for high-technology-related products, like information and communication technology. First, the number of potential users of compatibility- or interface-based standards, like information and communication technologies, is restricted at least for complex and expensive high-technology-related products, due to the lower purchasing power of consumers in developing countries. Consequently, the related direct network externalities are lower.

In addition, the indirect network externalities are also lower in developing countries, because the variety of system components is also smaller due to the lower purchasing power.[8] Due to the lower number of product components, the number of variations of "system" products feasible by interface standards is also smaller than in industrialized countries. To sum up, the potential positive effects of compatibility or interface standards are relatively lower in developing countries compared to industrialized countries.

The negative effects of compatibility or interface standards on technical change due to lock-in effects, i.e. the sticking to an old outdated technology because of too high sunk investment and too high costs to change to a new technology, are also less severe in developing countries, because the size of the installed base, the number of users or consumers, is in general lower. Furthermore, the speed of internally generated technical change is reduced in comparison to industrialized countries. In total, we can derive for the developing countries the same causal relationships between compatibility and interface standards and technical change. However, the potential of both positive and negative effects is smaller, especially for expensive high-technology-based products, which face a lower demand in developing countries. Nevertheless, compatibility and interface standards relevant for emerging mass markets in developing companies, e.g. mobile communication, have the potential to trigger the rapid diffusion of related new products and services.

The second type of standards which are closely related to governmental regulations are quality and safety standards. In general, this type of standard structures the relationship between the demand and the supply side, because it reduces the information deficit of the users and consumers regarding product and service characteristics. Technical change regarding new products and services increases the risk and the uncertainty on the user side. Quality and safety standards are especially relevant for new products and services, because other instruments reducing information asymmetry, like the reputation of a company in respect of its products, and experience collected by consumers, become more relevant and reliable the longer new products and services have been distributed among and used by an increasing number of consumers.

This positive effect of quality and safety standards is also relevant for developing countries, especially for new products and services produced domestically. In comparison to industrialized countries, which are characterized by effective and efficient consumer organizations on the one hand, and governmental product approval and surveillance mechanisms, quality and safety standards as instruments of self-regulation have an even more important role in developing countries. However, less complex products with short periods of performance revelation, newly introduced in developing countries, can gain a reliable reputation as high-quality and low-risk, or low-quality and high-risk, in a very short time, whereas more complex products introduced in industrialized countries may need a longer time until users and consumers detect their real performance. Depending on the kind of quality and safety standards, they may foster a lock-in of the technological status quo, if they are defined as design standards requiring a narrowly defined product specification. The lock-in effect is less crucial in the case of performance standards, which just specify some minimum requirements.

The third effect of standards to be discussed is its variety-reducing impact. Technical change is characterized by the variety of technologies and products. However, there is a trade-off between variety and production cost. Therefore, variety has to be restricted in order to be able to offer new products at reasonable prices. The selection of a particular specification via a standard allows, on the one hand, the realization of economies of scale, which will allow the provision of products at lower prices, and on the other hand the generation of critical masses of users allowing positive network externalities on the demand side. Standards allow the success of a few selected new specifications and related products, but the scope for the non-selected specifications to become innovative products will be reduced. This effect of standards is also relevant for developing countries. However, the variety of new technologies and specifications is lower in developing countries compared to the stronger and broader technical change in the industrialized countries. Therefore, this positive effect of variety-reducing standards is the same in developing countries, but they have a lower leverage effect compared to the industrialized countries. Consequently, the negative variety-reducing effect of standards for technical change is also lower in the developing countries, because their internal technology and product varieties are lower. In summary, we observe also for variety-reducing standards lower positive, but also lower negative effects for technical change, especially if we argue in the purely domestic context.

The last type of information standards, which codify technical information about the status quo of technology and provide a source of information for new products and services, is also relevant for developing countries. If we argue in the domestic context, the basis of technological capacity is lower in developing countries than in industrialized ones. Consequently, the impact of standards codifying technological know-how is higher in industrialized countries and provides a broader basis for the development of further technologies.

In summary, the impacts of the four types of standards on technical change implemented in developing countries are rather similar to the effects to be observed in industrialized countries. However, we have also concluded that the strength of both positive and negative effects of all types of standards is lower in developing countries than in industrialized countries.

So far we have argued in a framework which assumes that there is no link between the stocks of standards in the industrialized and developing countries. However, we have to acknowledge that the set of international standards is initiated and specified by the industrialized countries. This has crucial implications for the standards bodies in developing countries, i.e. we observe spillovers from the standardization activities of standards bodies of industrialized countries towards the developing countries via the integration of international standards into the body of national standards (see Annex). In the following section, we discuss the implications of these spillovers on the technical change in the developing countries.

To the extent that standards incorporate information about a particular technology, they create a means of diffusing know-how internationally. While a technology that has now become a standard may not be on the technological frontier, one can imagine a situation where technological know-how differs between firms in developed and developing countries. So a mature technology which is adopted as a standard in developed countries may still represent an advance for firms in developing countries. The existence of such standards that can be adopted by firms in developing countries can represent an important mechanism for diffusing technology from industrialized to developing countries. In the following section, we discuss the effects of this kind of technology spillovers via standards on technical change in developing countries, differentiated by the type of standard.

To the extent that international compatibility and interface standards allow network externalities to be exploited by large installed bases of users and consumers, they are likely to enhance exports from industrialized into developing countries. The development of large user groups applying the same standards, which are then transferred into international standards, allow companies located in industrialized countries both to realize economies of scale and to strategically exploit network externalities among users, which create competitive advantages for their products in developing countries (Gandal, Shy 2001). Domestic companies in developing countries will have problems to compete with these foreign companies from industrialized countries referring to larger user bases and exploiting economies of scale and learning effects, and there is little chance that an installed base of users in developing countries would create a strong enough bandwagon effect to convince foreign suppliers to switch to the national firm's standard. The technological capacity of developing companies depends therefore in the short run on imported technology. In the long run, the domestic technological capacity of the developing countries may benefit from the standard-based technology import from industrialized countries, due to the imitation possibilities of domestic producers, especially in case of open standards, and also to domestic users learning from applying foreign technologies.

Minimum quality and safety standards defined in industrialized countries are likely to be more rigorous than in developing countries, since the higher the income level of the population, the higher will be the preference for quality and safety. Therefore, the spillovers from the quality and safety standards from the industrialized countries create a tension in developing countries, because the realized quality and safety level is higher than the optimal degree according to the domestic income per capita. This inefficiency in the developing countries is only justified in the short run if negative externalities for other countries are reduced, and in the long run, if we observe a convergence of the income levels. However, the impacts of the spillovers from quality and safety standards which originated in industrialized countries can be positive for technical progress in developing countries, because they at least reduce information asymmetries between users and suppliers of new innovative products, and consequently are able to increase the acceptance of new products among lead users. Nevertheless, these effects are restricted if the income levels in developing countries are so low by comparison with industrialized countries that only a small group of users prefer the high-technology products. The negative impacts of safety and quality standards on technical change by creating lock-ins are also less relevant for developing countries, because the standards driven by the industrialized countries are always ahead of the technical capacities of developing countries, which reduces the danger of lock-ins in outdated technologies.

Summarizing the discussion on the effects of standards with different economic effects in developing countries in comparison to the situation in industrialized countries, we come to the following conclusions. Although the effects of the different types of standards on technical change do not diverge from those in industrialized countries, we observe that the extent of positive impacts may be lower, due to the lower usage of high-technology products and systems relying on numerous and complex standards. More important for the effects of standards in developing countries are the spillovers from international standards developed by industrialized countries. On the one hand, the knowledge and technology transfer from industrialized countries to developing countries is fostered by the stock of international standards. In the short run, this channel of technology transfer has only a limited positive impact on the knowledge and technology capacity of the developing countries, because this stock of international standards influenced by industrialized countries strengthens the imports by their companies and increases the pressure on domestic suppliers (compare the empirical evidence provided by Maskus et al. 2004). However, this kind of high-technology imports and the facilitation of multinationals to outsource at least production capacities to developing companies at least foster imitation and, in the long run, also the innovation capacities in developing countries. If the discrepancy in the preference for quality and safety between industrialized and developing companies becomes too large, developing countries should react to the high levels specified in international standards by creating own quality and safety standards. This strategy may serve domestic preferences, but hinders export possibilities. Finally, the fostering of areas with potential domestic competitive advantage in the international context should be accompanied by domestic standardization activities driven by innovative R&D-intensive companies, which have both the capacity to define standards reflecting the state of the art in science and technology and the interest to define specifications encouraging exports.

Regarding the question of whether and how developing countries should participate in international standardization processes, the following have to be taken into account: The immediate involvement of standardization experts from developing countries enriches the tacit knowledge of these participants (Blind 2006), but there is no significant chance to influence immediately the specifications towards the preferences of the developing countries due to the distribution of power in the international standardization processes. Nevertheless, the active involvement in international standardization processes increases the awareness of the preferences of the developing countries among the developed countries dominating the standardization processes. Since standards are not only shaped according to the technological requirements, but also according the needs of the markets and the preferences of the users, the consideration of the user preferences of the developing countries in the final specification of international standards will have positive welfare effects on developing countries, because imported goods will better reflect the preferences of the users and consumers in developing countries and in the long run it may even be likely that domestic companies will be able to provide goods for the world market in a competitive manner.

The efficient participation in international standardization processes requires a solid education and training of the experts from the developing countries. The most effective and efficient way to train these experts would be to do so in the top technical universities of the developed countries. However, this is not sufficient. As argued, it is necessary to for these experts to have an in-depth understanding of the preferences of domestic users and consumers in the developing countries.

The second step of an effective and efficient implementation of international standards in domestic countries is their timely integration in the body of national standards, which is in the responsibility of the national SDOs. More important is the "absorptive" capacity in the domestic companies to implement the international standards. Again, there is a strong need to hire adequately trained and educated personnel, who are likely to be trained – at least partly – by the universities in the developed countries.

In summary, an effective and efficient participation in international standardization processes requires adequately trained personnel. The same is true for the implementation of international standards in domestic companies. Consequently, the transfer of codified technological know-how from developed countries into developing countries has to be accompanied by a respective transfer of tacit knowledge embodied in human capital trained in the developed countries, at least in the short run. In the long run, the developing countries have to train the required personnel domestically. Furthermore, institutions responsible for certification procedures have to be built up and respective personnel has to be trained and hired.

Finally, the role of developing standards for emergence or the closing of technological gaps has to be discussed. Industrialized countries can indeed increase their technological lead by starting standardization processes in an early phase of a technology's life, as in the case of the mobile telecommunication standard GSM in Europe. The diffusion-fostering effect of standards increases the installed base of users, which are able to give a broader and more qualified feedback to the technology and service providers. This in turns creates new suggestions for improving the technology and for extending the range of possible applications. In the long run, formal standards are an instrument to close technology gaps between countries, since the laggards have the option to adopt and implement the standard.

For developing countries, which are in general laggards in the development of technology, standardization alone cannot raise them to a position of technological leadership. However, the timely adoption of standards from the advanced countries may be an instrument for closing the technology gap, at least temporarily, before a new technological life-cycle begins. In the long run, developing countries can raise themselves into a position of technological leadership in some niches when a timely adoption of standards from the industrialized countries has closed a former technology gap. Currently, China is moving into a leadership position in standardizing nanotechnological products. However, it is not yet clear whether this strategic move in standardization will also result in technological leadership in this area, since the research activities in the US and Europe are much stronger, as confirmed by impressive developments of the output indicators, publications and patents.

So, standardization processes can indeed reduce the technology gaps for developing countries. However, technological leadership can only be extended via standardization if a potential technological leading position already exists, a constellation which is not very prevalent in developing countries. This holds certainly for standards protected by IPR, but also for non-proprietary formal standards, because their implementation requires complementary assets and services which are more likely to evolve in industrialized countries. Besides the process of developing standards, it is essential to have highly qualified people to produce and implement these standards. Consequently, developing countries have to complement and coordinate their standardization activities with special education and training activities in order to make participation in standardization and standards strategic instruments to close technological gaps with the advanced industrialized countries.

IPRs and Standardization

Introduction

IPR regimes and formal standardization are key institutions in the changing frame of the innovation system. However, the role of intellectual property rights is not strongly emphasized in the literature on innovation systems. Pittaway et al (2004) briefly address the relevance of property rights. Although their roles are inherently complementary, we know that the relationship between them has become increasingly tense as the use — and the conditions of use — of each has changed over the past two decades. The "co-evolution" of these and other factors has brought patenting in particular onto a collision course with formal standardization activities. This has led to an increasing number of conflicts and to new attempts to resolve them at different levels: institutional (IPR policies), policy (areas of competition, IPR, and standardization policy), and other multilateral contexts (patent pooling and other licensing schemes).

This situation represents an emerging area of dis-coordination at a key juncture of the innovation system. However, the treatment of this important issue has by and large been limited in scope and perspective. The literature has first and foremost described and analyzed the patent-based conflicts that have emerged in the area of information and communication technologies either in general theoretical terms (legal or economic) or empirically, mostly on a case-by-case basis. The issues are however not necessarily limited to the ICT field, although this is obviously an area where the drives towards patenting and standardization are particularly strong. Nor is it necessarily confined to patents, although this is the most obvious front for conflict as regards technological standardization. Nor does it only involve the areas of standardization, IPR, and competition policy, but may extend to research policy more generally.

This chapter works from the premise that the interaction between IPRs and standardization involves a more general strain on the innovation system, and that this strain potentially has implications that extend well beyond a single industry. This in turn suggests the need to broaden the frame of analysis and to direct increased policy attention to the complicated set of issues. In this context, the paper extends and broadens the existing analysis of this relationship in several fundamental ways.[9] This section of the background paper is structured in the following way. It first takes stock of the issues, extending the exploration of the economic questions to further investigate the implications for public funding of research. Based on various empirical evidences, it then discusses policy implications and a broad set of policy approaches, and concludes considering possible diverging implications for developing countries.

Issues in the Interaction of IPRs and Formal Standardization

The interaction between formal standardization (particularly in standards-development organizations) and IPRs (particularly the patent regime) involves fundamental issues in the economics of technological change. This section introduces the relationship in terms of the distinct roles they play in the "innovation infrastructure", presenting the case that a co-evolutionary process is bringing into increased confrontation what are initially complementary functions in the innovation process.

Innovation is a complex evolutionary process involving the sustainable generation, distribution and utilization of new economically-relevant knowledge. This knowledge continuously accumulates and is recombined in the economy[10], contributing significantly to economic growth. The evolutionary economics literature[11] points, in this setting, to the importance of two complementary processes, namely, the generation of technological variety and the selection process. The interaction between technological diversification and a complementary selection process lays the basis for technological development. The process of diversification drives evolution. In the case of technology, this involves a purposeful search by economic actors to adapt new technologies with performance attributes that are intended to distinguish them from rivals. "Fitness" entails success in this venture, not in terms of survival of the fittest or of the "best technology", but in terms of success in navigating the selection environment.

To a degree the process of selection can then be said to steer evolution. However, selection and diversity do not happen in isolation from one another, but rather in close interaction. The ultimate selection mechanism in market economies is the market, where the fitness of an individual technology comes down to the choice of consumers. In an ideal situation, a technological design may fit differentiated niches of heterogeneous users.[12] However, many other factors may affect choices in the selection environment — for example, network externalities will shape preferences and affect the diffusion of new technologies. The case of launching a large technological system, like a cellular telecoms system, provides a special challenge in successfully navigating the selection environment. Coordination in developing and selection is especially needed here to concurrently design and select the large set of design dimensions involved, which interact in complex ways.

This brief evolutionary explanation highlights the processes of search and of choice, both of which are unpredictable, especially when one accepts that they interact. This distinction between search and selection processes is useful for appreciating the roles of IPRs and SDOs, since each is a social institution in what can be described as the industrial infrastructure for innovation,[13] that affects the search and selection processes. In the following, intellectual property rights regimes will be most closely associated with influencing the search process and fostering diversification of new technologies, while institutional standardization will be most closely associated with the selection environment. The roles, however, overlap, apparently increasingly so. The point is that the two central institutions play complementary roles in perpetuating such a balances

Understanding the Role of IPRs

In this context, the term IPR means the technologically oriented rights used in the context of industrial innovation. This definition primarily includes patents and trade secrets, but in view of the importance of software, also certain applications of copyright protection. The rationale of patenting is the most relevant and most illustrative for standardization. A patent on an invention is in effect a public contract that grants certain rights to the applicant for the use of a technical invention. The patent system caters to the assignee's basic desire to appropriate profits accruing to the invention, while catering to the public interest in having the details of the invention spread to others so that the system can build on new knowledge.[14] In this view, the motives of the state involve (i) creating an incentive for actors in the economy to undertake inventive activities and (ii) to disseminate detailed information about inventive activities so that future generations can build upon them.[15] The motive usually ascribed to the patent-applicant is, on the other hand, to use the protection from competition to realize profits from the invention, either through developing it and commercializing it himself or through selling the rights to others who do the marketing of the innovation.

Copyright has also become a large issue in standardization due to its uneasy association with software.[16] The question about how software should best be protected against imitation, by copyright[17] or by patent protection[18], has recently arisen again in the European context. This question suggests one aspect of the changing environment that increasingly brings IPR into conflict with standards-development organizations (SDOs) in new ways.

In general, IPRs have a role to play in organizing knowledge production, in promoting new R&D, in promoting further utilization as well as coordinating use of new knowledge, while avoiding underutilization losses. [19] In terms of the economy as a whole, the way IPRs do this implies both costs and benefits. On the one hand, IPR protection brings with it social costs in the form of higher prices (monopoly pricing); on the other, IPRs provide the economy with an *incentive to innovate* (based exactly on the prospects for the innovative firm to engage in monopoly pricing). The monopoly profits provided by IPRs may have the added advantage for the economy as a whole if it is ploughed back into higher levels of production and innovation. David (1993) emphasizes the following dimensions of this role:

a. The importance of full disclosure of information in patent applications. This allows for dissemination, verification, and application by others engaged in intellectual pursuits;

b. The importance of "allocative efficiency". The provision of efficient focusing of research effort entails, among other things, the avoidance of over-focusing effort on the same research; the avoidance of the "deadweight burden" of monopoly. This is the case where rights become too strong, bar close substitutes and raise royalties, while lowering the benefit to society in general and consumers in particular. It also involves the importance of achieving good coordination of R&D activities. This is significant in facilitating common standardization activities.

c. The importance of avoiding "unproductive competition for monopoly profit" (Kitch 1977; Beck 1983) including wastage of resources on premature invention, duplicative R&D, substitute inventions, and excessively rapid spending on research. The non-disclosure of patents in standardization activities represents a poignant example where patenting contributes to unproductive competition for monopoly profits.[20]

Understanding the Role of Standardization

IPRs tend to be seen predominantly in terms of their contribution to the 'incentive structure' and less for their role in distributing information about innovation throughout the economy. There are two characteristics we want to mark here:

1) IPR are most often identified as a promoter of a diversity of technological ideas; and,

2) *IPRs lay the basis for proprietary technologies.*

In contrast, the role played by standardization, especially in standards-development organizations (SDOs) in innovation[21] can be associated with a selection process to reduce variety, and with the creation of non-proprietary goods; ideally, they work in the collective interest of all actors.

Standardization is a process with a surprisingly large range of associations. There are different ways in which to classify standards and the standards process Standards can be differentiated as to *what* is standardized and as to *how* the standard is produced. As for the object dimension, there are product standards, control standards or process standards. As for the way standards are produced, there are again three categories: standards that are set through the market, on a de facto basis, standards that are set by government, through the regulatory process (mandatory standards) and standards that are negotiated through a voluntary consensus process.

In general the economics literature tends to associate the role of formal standardization with the idea of the 'failure' or inefficiency of markets. Schmidt and Werle (1998) indicate that the focus tends either to be on the reduction of transaction costs, especially related to information, or associated with network externalities. Standards are associated with, among other things, reducing uncertainty by controlling variety; enhancing competition by clearly defining what is required to serve a market (information); constituting markets by defining the relevant aspects of products (Tirole 1989); facilitating scale economies for suppliers, or influencing the distribution of cost and benefits of building and operating large complex technical systems (Mansell 1995). Ideally, they work in the collective interest of all actors. Thus, they provide a type of public good. (Berg 1989; Kindleberger 1983).

Standards play a particularly important role as a 'selection mechanism', especially in the case of network technologies, where the importance of narrowing the diversity of network technologies, in order that the industry may take advantage of network externalities, is highlighted.[22] In short, network technologies are vulnerable to the generation of 'too much diversity'. These technologies rely on connectivity, and their worth therefore rises in proportion to their user bases. As a result, the unbounded proliferation of different, incompatible versions of an emerging radical technology may lead to a damaging Tower of Babel situation. The contest between individual alternatives to establish dominance in such a situation can be costly for manufacturers, service providers and customers. In the end, a protracted fight for dominance might undermine the potential market for that emerging technology altogether, and remove it from the technology race. Sustainable networks will simply not be created, and the value of the component for the consumer will not be realized. Failing to reach a 'critical mass' of users, technology risks missing its fabled window of opportunity. There are many examples of this situation, of the type of Betamax (Liebowitz, Margolis 1999) or more recently the CT-2/ Telepoint system (Grindley, Toker 1993).

Central Aspects of the Interrelationship

In general, one complex set of factors induces and promotes the creation of diversity and another affects the complementary and intertwined selection process. The important thing is that there is a complex interrelationship that keeps the virtuous circle of the differentiation and the selection processes in swing. Intellectual property rights regimes and institutional standardization are closely associated with these processes, although they are not tied to one or the other. A stylized division of labor indicates that IPRs, especially patents, are most closely related as incentive mechanisms to the continuous generation of technical variety while formal standards bodies, especially voluntary SDOs, are most closely related to selection from among the ripening variety of technological solutions. In reality, the roles are not this clear cut.

The way IPRs and SDOs are used mixes their roles with regard to the creation of variety and the promotion of selection. On the one hand, the standardization process has moved further and further in front of the market, in such fashion that standards activities contribute to creating new solutions not provided by the market; the semantic web standards are one example. On the other, the increasing strategic use of IPRs to create defensive bulwarks against competing technologies can serve to mimic a selection mechanism; such strategies can limit the scope for competing technologies to emerge and therefore reduce the gene pool from which new combinations of emerging technologies can develop and recombine.

A further phenomenon, which underlines the changing relationship between IPR and standardization, is the new one of open-source software (OSS). By OSS is meant that the source code of an application has to be made available (via the Internet) and not only in a compiled form such as software. Moreover the right of exclusive exploitation of a work is denied to anyone. This offers the opportunity to develop the program further and adapt it to own needs. According to the widely spread Gnu Public License (GPL), OSS is to be provided free of charge and along with the complete source code of the application, even though a reproduction cost or service cost may be charged. Despite strong copyrights under the GPL regime, it realizes the open software standards. A virtuous circle between IPRs and open standards can be observed in the context of open-source software, because the incentive to contribute to open-source software is triggered by building up reputation in the labor market for software development and by the exploitation of the IPRs via providing complementary services (Lerner, Tirole 2000).

Indeed the interaction between variety and selection — and the roles of IPRs and SDOs in it — are much messier. The schematic division of labor does however point to an essential trade-off in the innovation process. It indicates the complementary roles of IPRs and SDOs, and it suggests the essential tension that underlies that relationship. Here it appears that the tension between these mechanisms issues from their opposition: opposition between the private interest of the inventor and the collective interest of the industry and, more fundamentally, opposition between a role in promoting technological variety against that of facilitating a certain uniformity.

In this setting, maintaining balance is important. Too much variety may be bad, since "variety conveys efficiencies in specialization and customization that are offset by the failure to achieve network externalities and other economies of scale" (Steinmueller 1995). Likewise, the opposite may also be the case since, "in reducing diversity, standardization curtails the potentialities for the formation of new combinations and the regeneration of variety from which further selection will be possible" (David, Foray 1995). Therefore, in the ongoing interaction between the generation of technological variety and its selection, "effective long-term adaptation requires that these two processes be kept in balance" (Carlsson, Stankiewicz 1999).

One implicit side-effect of incorporating the institutional framework systemically with the innovation process is that the different components — technologies, institutions, etc — will tend to 'co-evolve' (Nelson 1994). That is, the rapid change of technologies will also be reflected through a two-way relationship with the institutional framework. Institutions will be forced to change and their changing will also reflect the way technology evolves. The reason that this phenomenon of co-evolution is important here is that both IPR regimes and SDOs are undergoing changes. The OECD report on ICT standardization in the new global context discusses some of the relevant changes standardization is facing, including the IPR concern. It appears that it is this changing environment that is translating the inherent tension between these two institutions into conflict (Iversen 2000).

Central Aspects of the Emerging Conflict

Since the mid-1990s, it has been observed (Iversen 1996) that a set of forces has served to amplify the tension and has begun to threaten the balance. The prospect that the role of IPRs should come into conflict with the complementary role of formal standardization suggests that the way these institutions are each evolving is translating the inherent tension into conflict (Iversen 2000).

The potential for conflict between intellectual property rights and standardization arises when the implementation of a standard, by its essence, necessitates the application of proprietary technology. The case of 'essential intellectual property rights'[23] is implicit to the tension between the two institutions. The risk that may emerge during the standardization process is that the codification of the specifications will infringe the proprietary rights described in the IPRs of one or more such agents. The IPR will be considered 'essential' if the standard, by its depth and detail, necessitates the use of the proprietary technical solutions described in it. Should it do so, the collective interest in the standard confronts the private interests of the IPR holder.[24]

A court is ultimately needed to establish whether or not the IPR (patent or software-copyright for example) is really 'essential'. At the same time, a court case would require considerable time and resources[25], and could jeopardize the collective standardization enterprise. So the difference between an IPR that is in reality essential and one that is potentially essential is not that great after all: both cases threaten to tie up the standardization process. Essential intellectual property rights in this sense should be further differentiated from 'Blocking IPRs' which definitively obstruct the process.

However, the interaction between business and standards increasingly raises the situation of the essential or blocking IPR. Essential IPRs in the context of standards are for example patents which cover a technology that is essential to the specification of a standard. These essential IPRs are consequently also able to block related standardization processes. A blocking IPR can be a result of two main situations for companies. In the first general set, the IPR holder refuses to license at all or refuses to license on a basis that is considered fair, reasonable and non-discriminatory. The threat to withhold IPR in this situation may be used as a bargaining chip. A flat refusal would be regarded with extreme suspicion. The existence of essential intellectual property rights among individual rights holders outside the standardization work is much less predictable. Absent the necessary search processes, such rights may appear at any time during the life of the standard. The willingness of the rights-holder to license at agreeable terms is likewise not a bygone conclusion, especially if added to already agreed royalty schemes.

The second set of cases involves a plurality of rights holders. The relevance of this case — that more than one right held by more than one rights holder — is itself testimony to the fact that intellectual property rights and the work of standards development organizations have become much more inter-tangled. A variety of rights holders complicates the licensing process which is supposed to be fair for both the licensee and the licensor. What happens when the *cumulative royalty costs*, while fair to the individual rights holder, become too high for the potential licensee? The short answer is that the standard would die. This raises the question of different ways to address cases of conflict, which are becoming more and more common. Finding solutions to new challenges in the interaction however does not happen by itself.

Summing up

IPRs involve a more proprietary aspect and standards more of a public domain one. This difference entails a certain tension in their relationship, which may create a broad scope for conflict and therefore a need for policy attention. Besides this, there has been a rising propensity to use patents, together with a growing reliance on standards activities. Since standardization has moved more towards the coordination of technologies, it has also taken on a more active role in knowledge-creation process. On the other hand, the pooling of IPRs has become an issue pertinent to standardization. This phenomenon is exacerbated by the increasing intensity of patenting in particular areas, e.g. in mobile telecommunication and semiconductors. The effect on how IPRs and standards are being used, combined with some other changing framework conditions (like the internationalization of markets, the convergence of technologies, and the increasing pace of technological change) has led to a growing tendency towards conflict. Consequently, the dynamic balancing of private and public knowledge becomes a constant consideration both for SDOs and for government agencies.

Three constellations illustrate how IPRs and standards interrelate:

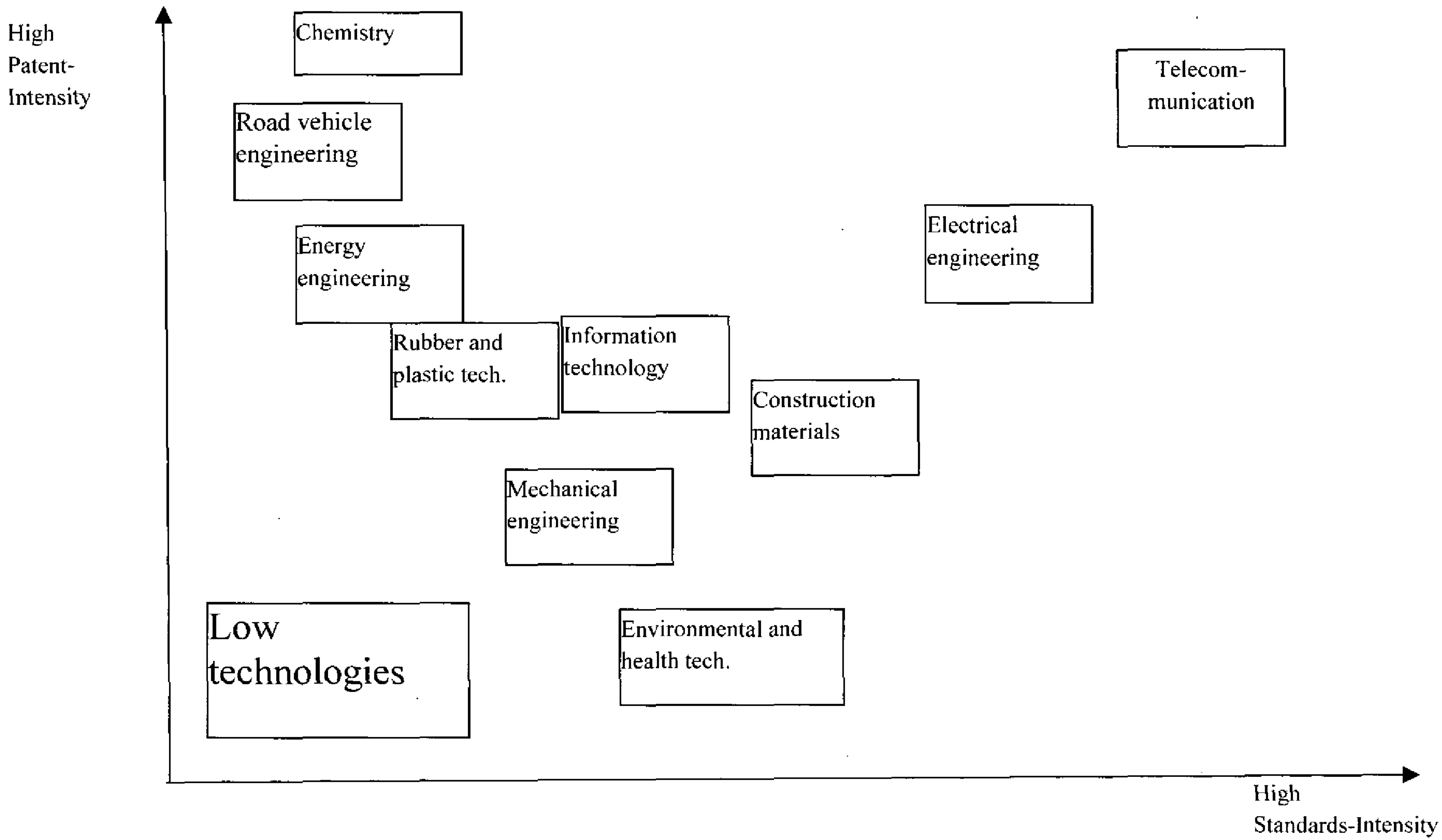
a) the two are designed to complement each other, which promotes a 'virtuous circle' of creation and diffusion of new knowledge

b) in a worst case, IPRs, especially patents, can be exercised to block standards, with considerable negative welfare impacts (Blind 2002)

c) however, in a growing number of cases there is a need to ensure more efficient licensing mechanisms, for example through equitable patent-pool schemes, which do not endanger the IPR regime, but allow their controlled diffusion into standardization processes.

The following Figure 1 illustrates various technologies in the patent-standard-space based on the number of German patent applications at the European Patent Office and the stock of German standards in the year 1999. Telecommunication technology is characterized by a high patent- and standards-intensity, which increases the likelihood of conflicts, which is not the case for chemistry, which displays high and low patent intensity. However, the tendency to a higher patent intensity in all technologies increases the likelihood of conflicts between IPRs and standardization activities. Therefore, the need to develop new institutional innovations, like patent pools or intelligent licensing schemes, increases.

Figure 1
Technologies in the Patent-Standards-Space



Policy Recommendations

Also notable for the policy dimension is the fact that it has become evident that the interface between IPR and standardization can be located either closer to the research and development area or already in the marketing phase of products. Consequently, the policy approaches have to cover both research and development, the IPR regime, the standardization regime and competitive issues. In the following final section, policy recommendations concerning the relationship between IPRs and standardization are spelled out which relate to all four policy areas. Sometimes, a recommendation concerning one policy area may contradict a proposal made from another policy perspective. A final decision can only be made by taking into account the specific framework conditions of the respective technology or market. Therefore, a comprehensive shaping of the interrelationship between IPRs and standardization has to take into account all the policy dimensions. However, since different institutions, like R&D funding organizations, patent offices, standardization bodies, and institutions regulating competition are addressed by the policy recommendations, there are many difficulties in finding a consensus among their interests and developing coordinated actions.

Research Policy Recommendations

Although research policies are not directly linked to standardization, the origin of new standardization projects can often be found in publicly funded research projects. Furthermore, the direction of research activities can be more easily influenced by the design of public policy than by standardization activities, which are mostly driven by private interests. The evidence from the empirical material collected allows us to derive the following recommendations concerning future research policies.

- Since the awareness is rather limited among researchers about the relevance and the implications of standards and standardization processes, training or even exchange of personnel should be made available to increase their understanding. This training should also include a broad knowledge about IPRs, which is also rather limited among researchers.

- Publicly funded research should make a clear provision for support that may be needed in order to transfer results generated by research projects to develop standards of benefit to the whole economy. The need may not be evident at the beginning of the project and hence the potential for a standard must be reviewed at regular project meetings and seriously considered by the funding institutions. Therefore, after the completion of research projects, the research consortia should be flexible enough to undertake additional work related to the development of standards.

- By designing research programs especially dedicated to solving social or environmental problems, it should already be taken into account that the costs for the development of respective standards should be – at least partially – eligible for funding.

- All research projects containing a clear aim to develop test and measurement methods should establish the scope for the development of a new standard at the beginning. Direct links with the standards organizations and the relevant committees should be established early in the life of the project.

- Promoters who are part of the research team as well as a member of relevant standardization committees should be identified, since they may be able to support the transfer of research results into standards more effectively and efficiently.

- The information flows between the public research institutes and the standardization bodies have to be improved. Setting incentives for the researchers in these institutions can do this. Because direct financial incentives for researchers are often incompatible with the remuneration in the public sector, the scientific evaluation of these institutions and possible consequences for their public funding should not only be based on their scientific output, i.e. publications and patents, but also on their scientific and technological contribution to standardization processes.

- Researchers should be more aware of the freedom to use IPRs in standards and particularly to understand that IPRs and standards are not mutually exclusive. There are also positive advantages in sharing IPRs in a pre-competitive environment by developing common guidelines, as pre-stages of future standards, in order to provide the confidence within the supply chain for investment in new technologies. Related successful case studies of the co-existence of IPRs and standards, like the standards underlying the MP3 technology, and also the standard for mobile communication in Europe GSM, should be identified and promoted amongst the research community.

- The early planning of the IPR distribution and future involvement in standardization activity, as successfully realized in the MP3 standards, can be very beneficial to avoid conflicts and to achieve best returns from research projects.

- The collaboration between industry and research institutes can be very successful when IPR issues are taken care of even before the beginning of the research project. A general agreement is meanwhile required for the performance of European research projects within the Framework programs.

IPR Policy Recommendations

We have seen in the review of the literature and in empirical studies that characteristics of the IPR regime have major impacts on the effectiveness and efficiency of standardization processes. Therefore, a separate section is devoted to suggestions for practices in patent offices and IPR-related institutions.[26] Patents clearly dominate the relationship between IPRs and standardization. In addition, patents claim the broadest protection of a technical invention, whereas trademarks are more important for visibility in the market than for the protection of a specific technology, and copyrights can be more easily circumvented. Therefore, the following recommendations are focused on changes in the patenting regime or practice:

- In general, the implication is that the potential for conflict can be reduced in an environment where the IPR system as a whole works efficiently. The potential for conflict is reduced in cases where the examination process assures a high level of quality of issued patents, thus reducing the risk of conflicts arising from weak patents.

- Since cross-border application of technical standards will be further promoted, but IPR regimes differ between countries' national legal systems, inconsistencies and conflicts between technical standards and intellectual property rights are likely. Therefore, a world-wide harmonization of national IPR regimes would decrease the likelihood of such conflicts.

- Since conflicts arise very often due to unclear IPR constellations, the ability to identify relevant patents and other IPRs is of paramount importance: meaning that transparency and accessibility of IPR material makes monitoring activities of the IPR minefield easier.

- There should be a last resort in the court system, allowing for compulsory licensing provisions, although there are major concerns that a widespread use of this instrument may deter IPR holders from participating in standardization processes, because it is already observable that the R&D-intensive companies at the leading edge are not very interested in bringing their knowledge into standardization processes.[27]

- IPR Helpdesks should also provide services concerning the role of IPRs in standards. This way it can contribute to increase the awareness about conflicts between IPRs and standardization.

Standardization Policy Recommendations

The following recommendations are addressed to the standards-development organizations, which may modify their guidelines according to the suggestions made. The existing ISO/IEC directives related to patents, which are implemented by most standard-development organizations, have proved to be effective and efficient in most circumstances. Nevertheless, the proposals are mostly directed to general strategic standardization policies, including licensing and disclosure rules.[28]

- In the very early pre-competitive stage of technology life-cycles characterized by high risks, the main actors are aware that they need to form alliances with their customers and suppliers, but also with their competitors. This constellation already causes some pressure on the actors to make their interests converge. With progress in the technology life-cycle, this pressure on the companies will decrease and the likelihood of single actions will increase. Therefore, standardization-development organizations are encouraged to identify promising new technologies in their very early stages, where basic research activities dominate, and to start new standardization processes instead of waiting for them to mature, when single companies are already in the development process of first pilot products and therefore less inclined to share their knowledge in standardization processes.

- The participants of standardization processes should be made aware of possible inputs from science, especially in technologies at the very beginning of their development.

- Concerning the immediate relationship between IPRs and standardization, standards should be preferred which do not specify the design of components but their performance, in order to avoid conflicts with patents protecting these components. This aspect is especially relevant for the development of measurement and testing standards.

- From the famous GSM referring to mobile communication case it can be learned that the duration, the scope of an entire system and the level of detail of a standardization process should be limited, since extending these dimensions increases the probability for IPR conflicts, and their seriousness. Guidelines have to be developed for the treatment of IPRs, which come up during (long) standardization processes.

- Since the empirical evidence shows a reluctance of innovative R&D-intensive companies to join standardization processes, the framework conditions of standardization have to be changed in such a way that their incentives to participate increase (e. g. attractive licensing schemes, see below).

- In general, standardization development organizations have to improve their performance by being faster, by reducing the costs for participants, especially working time, and by being more flexible in order to increase their attractiveness for researchers and therefore to allow more easily the transfer of research results into standards.

Disclosure Rules

Disclosure rules enable the SDOs to obtain information about whether technologies under consideration for inclusion in the standard are proprietary and subject to licensing. They thereby reduce the potential for a technology to be included in a standard without the knowledge that a technology owner, with intellectual property rights that impinge on the standard, may try to extract royalties for the use of the technology.

- Because of differences across industries in the reward afforded by patent protection and in the needs for compatibility and standardization, no rule would be optimal for all situations. Because of this heterogeneity across industries, the best policy choice may be the one that leaves the disclosure rule and the rigor of enforcement up to the respective technical committees themselves. They themselves may be the best suited to optimize the trade-off between the benefits and costs of disclosure that these rules entail.

- Consequently, the shifting of responsibilities concerning the identification of relevant IPRs from the members of the standardization committee to the IPR holders – a rule to the detriment of IPRs – is not assessed as being an adequate solution. However, the current attribution of responsibilities seems to be too much to the detriment of standardization. Therefore, the identification and disclosure problem has to be tackled, since false decisions at a very early stage of the standardization process which have to be withdrawn later may cause massive misinvestments.

- In order to increase the transparency of IPRs pertinent to standards, the standard-development organizations, following ETSI's example, should build up publicly available databases with IPRs that are potentially 'essential' for their standards.

Licensing Policy

Having learned through disclosure which elements of the standardized technology may be proprietary and subject to royalties, the SDOs are still left with the problem of setting guidelines for the determination of licensing fees the technology owner should charge after the standard is determined. The typical policy mandating that a royalty be "fair, reasonable and non-discriminatory" gives little guidance for royalty determination because "reasonable" can mean different things to a technology owner and a technology buyer.

- The extent to which a royalty is 'reasonable' may be assessed in terms of the division of gains from licensing between licensor and licensees. While there is no single right answer, it is possible to rule out as unreasonable royalties that leave the patent owner worse than he would have been had he not joined the standardization process, and royalties that absorb all of the gains from standardization. The threshold for what is reasonable will depend on the nature of the invention that is chosen as the standard. In order to avoid too high licensing fees, reasonable should mean the royalties that the IPR holder could obtain in open, up-front competition with other technologies, and not the royalties that he can extract once other participants are effectively locked into the technology covered by the patent.

- Besides this general consideration, databases should be made available which contain the relevant details of exemplary cases. This increased transparency provides guidelines for the negotiations between the IPR holders and potential licensees, which make the negotiation process faster and more effective.

- If alternatives between technologies are available, the IPR holders' pre-selection negotiation and conclusion of licenses with individual licensees should be a positive factor of some weight in the standard selection process.

- Since the empirical evidence has made obvious that conflicts often cannot be solved because of large discrepancies between license fees demanded by the licensor and the willingness to pay of the licensees, SDOs might set up some means of dispute resolution within the organization to help resolve royalty disagreements.[29] Resolving reasonable royalty disputes within the organization will almost certainly be quicker and cheaper than resorting to the courts.

Patent Pools

Since usually it is not only a single patent that has to be considered for integration into a standard, patent pools may represent a solution for some IPR conflicts in standardization processes. Since patent pools can serve the following several key functions, like the identification of essential patents both inside and outside the standardization group, and the differentiation between patents essential to the core standard and those essential to peripheral dimensions. In addition, they are an organizational model to save transaction costs regarding both disclosure and licensing of IPRs, compared to multilateral negotiations. They are also able to resolve conflicts both among IPR holders themselves and between IPR holders and standards users. In general, patent pools may support the diffusion the standards as broadly as possible, while promoting third-party licenses on a fair, reasonable, non-discriminatory basis.

Nevertheless, to establish and run patent pools efficiently and to promote their general welfare advantages, some conflict potentials and potential disadvantages, like their misuse as a price-fixing mechanism, have to be taken into account, and the following recommendations should be considered.

- The pooling of patents and consequently of interests should not take place too late, in order to avoid a constellation with two or more pools driven by different interests and even technologies which cannot be integrated in a hybrid standard.

- Public non-profit research institutions may act as key gravitational force for creating patent pools, since they can more easily balance the often controversial interest of the companies involved, compared to a company trying to promote its commercial interests at the cost of other participants.

- Despite the attractiveness of a pool solution, it has to be considered that the standardization of a technology which is based on a pool of patents does not automatically mean that the technologically and even economically superior solution will succeed. Because of the strong common interests and the economic power of the patent-pool members, the technologically superior solution of an outsider who is either unable or unwilling to join the patent pool may not be considered as a standard specification and may therefore cause the development of products and process of inferior quality or at higher costs. Hence, even if comprehensive patent pools may solve conflicts between IPR holders, they have to be watched carefully because they may rule out better solutions of individuals or smaller consortia with weaker IPRs or economic power.

- The involvement of companies in patent pools which are successful in distributing new products and technologies guarantee the successful acceptance of a new standard, which is economically more beneficial than the failure of a technologically superior standard.

Competition Policy Recommendations

Both the outcome of the IPR regime, like granting a temporary monopoly via patents, and the results of standardization processes, like the specifications of a standard causing heterogeneous implementation costs at the user side, may have negative impacts on competition. However, standardization may also foster competition by leveling the playing field.

In general, competition policymakers have to develop a better understanding of the scope of conflict between IPRs and standardization and its impact on competition policy issues. In general, a more intensive dialogue between all parties involved can be a first step to this better understanding.

The following proposals focus less on different consequences of the IPR regime for standardization and competition, and more on the consequences of the interaction of IPRs and standards on competition.

- If IPR-protected technologies are integrated in a standard, one has to be very careful about possible negative impacts on competition as in the case of Microsoft, since this constellation may increase the monopoly power of the IPR holder. A remedy could be the prescription of compulsory licenses, although this instrument should be used very restrictively because of its negative incentive signal to innovative companies interested in standardization.

- In the case that standards become mandatory via reference in other regulations, solutions have to be found to deal with IPR holders who refuse to give licenses away for nil or very low fees.

- Standardization should also be considered as an instrument to solve antitrust problems, since it allows all interested parties to both influence the specifications of a standard and implement it, leading to a common level in the playing field of competition. Therefore, standardization may also substitute the regulation of competition by governmental institutions.

- Standards are able to devalue the brand loyalty, which is built up during the terms of patents, after the protection comes to an end, since standards may speed up the substitution process after the termination of the patent protection period.

- In general, policies to increase the pro-competitive aspects of patent pools have to be encouraged while avoiding their anti-competitive effects. This can include the involvement of competition regulating authorities in laying out allowable licensing arrangements. The promotion of a patent pool notification scheme may also increase their awareness for the scope of conflict between IPRs and standardization and alleviates their decision-making process.

Conclusion

Since the rationales and objectives of the four policy areas differ in general, there are tensions between the recommendations proposed. In addition, the recommendations address different institutions. Consequently, there is a need for coordinated action in order to improve the relationship between standardization and IPRs, also taking research and competition policy aspects into account. A first step towards comprehensive action is to convoke the responsible authorities and encourage an intensive exchange of ideas. Based on a better understanding, further steps towards an integrated policy approach can be undertaken.

Lessons for Developing Countries

The set of various policy recommendations derived for industrialized countries are in general also valid for developing countries. However, we focus in the following paragraphs on those policy aspects which are either of high relevance for developing countries or which have to be adapted to the specific conditions in these countries. Furthermore, all policy dimensions are only focusing on those aspects relevant to their link with standardization.

Research Policy Recommendations

In contrast to the high budgets spent on publicly funded R&D programs, developing countries have far less resources available for fostering R&D activities. These scarce resources should be targeted on areas where there is a potential for emerging domestic R&D capacities, e.g. by enhancing available human resources. Furthermore, it should they should be focused on fields of technology which could provide the basis for products that could be internationally competitive. However, all the issues raised above for industrialized countries for designing R&D programs in a way that they support and integrate standardization are also valid for the R&D policies of developing countries. Nevertheless, the limited financial resources, but even more the few highly educated human resources, require that the integration between R&D and standardization activities should be incorporated at the project, program, institutional and personal level. Here, developing countries building up new research and standardization capacities have the window of opportunity to create more integrated programs and even institutions. This represents an advantage in comparison to the often strongly separated systems in industrialized countries, which are only now again start to initiate integrating efforts.

IPR Policy Recommendations

It is argued that countries at different levels of industrial and technological development face very different economic costs and benefits from stronger IPRs (Lall 2003). However, we focus in this paragraph on the link between IPR policy and standardization, especially relevant for developing countries. Since developing countries do not yet face numerous IPRs, especially patents, owned by domestic inventors, research organizations or companies, there is less conflict between national standardization activities and these domestic stakeholders. However, national standardization activities in developing countries are confronted with the massive accumulation of patents in industrialized countries. In order to gain international acceptance, national standards released by the domestic institutions in developing countries should obey the IPRs owned by holders located in industrialized countries. Furthermore, the domestic institutions responsible for IPRs, especially patents, should ensure that their IPRs are of high quality and should serve also as information providers about both national and international IPRs. Furthermore, domestic companies should be encouraged to build up patent portfolios of high quality in order to meet in the long run the precondition to influence the specification of international standards.

Standardization Policy Recommendations

Since most of the developing countries are members of or have links to the international standardization organization (ISO), they are aware of their various guidelines, including IPR rules. These should also be followed in the domestic standardization system. Regarding developing countries, a stronger integration between R&D and standardization, by setting up more integrated structures and institutions, will reduce some of the potential conflicts addressed above, which are relevant to industrialized countries.

Disclosing IPRs relevant to standardization processes in developing countries addresses especially the rights of foreign owners. Therefore, the standardization bodies in developing countries should have access to the databases of the most important IPR offices, like the World Intellectual Property Organization (WIPO), the United States Patent and Trademark Office (USTPO), the European Patent Office (EPO) and the Japan Patent Office (JPO).

Tougher than securing the transparency of IPRs relevant to standardization is the question of decide about licensing fees. As already stated above, the typical policy mandating that a royalty should be "fair, reasonable and non-discriminatory" (FRAND) gives little guidance for the determination of the final price. If we consider the relation between an IPR holder in an industrialized country and a standardization body or better companies potentially using a standard including the IPR of the former, there may be large discrepancies over the meaning of "reasonable". Even if the negotiation processes may be difficult, the infringement of foreign IPRs by integrating it into a domestic standard without permission should be avoided. In order to facilitate and fasten the negotiation process in the future, it is recommended to collect previous experiences in all developing countries in a central database available both to potential technology users in developing countries and technology owners in industrialized countries. If conflicts between the stakeholders in developing and industrialized countries cannot be solved, installing some kind of clearing house should be considered.

Patent pools may be an instrument which enables companies in developing countries to gain influence in international standardization processes. If they are able to build up IPR portfolios relevant to specific international standardization, then they may serve as entry tickets into pools of international companies trying to coordinate their technological capacities and find a common consensus within a standardization process. Besides their patent portfolio, their know-how about the specific user and consumer preferences in developing countries makes them attractive to the consortia of companies from industrialized countries. This latter expertise increases also the likelihood of an international standard being successful world-wide.

Competition Policy Recommendations

The competition pool recommendations derived from industrialized countries focus on the interplay of domestic companies within a national market. The markets in developing countries also may be threatened by large companies dominating the specification of a standard often accompanied by relevant IPRs. However, the more severe problem is the overwhelming market power of foreign multinationals, which have also a strong influence on the specification of international standards. In this case, the playing-field-leveling effect of standards does not work – at least not in the short run, because they are determined by foreign companies with rather high technological capacities. If the domestic competitors possess the absorptive capacity to implement the international standards in their products, then they may be able to compete successfully both on their domestic markets and, in the very long run, on international ones.

Since self-regulation via standardization is less prevalent in developing countries, the transfer of international standards from industrialized countries can compensate for this weakness and reduce the need to rely on governmental regulations which, especially in the context of technical change, have the weakness of selecting suboptimal technological specifications (see Table 2).

Finally, the role of standards in devaluing the brand loyalty which is built up during the terms of patents, after the protection period comes to an end, is especially important for the diffusion of formerly patent-protected products in developing countries. Although this function of standards facilitates or shortens only the imitation and diffusion phases, it has also an impact on the speed of technical change in developing countries. The options of this strategy have to be investigated further.

Conclusion

As in industrialized countries, the responsible authorities and the concerned stakeholders in the four policy areas discussed are both numerous and heterogeneous regarding their rationales and objectives. Consequently, in developing countries there is also a need for coordinated action in order to improve the relationship between standardization and R&D regarding IPR policies, also taking competition policy into account. In contrast to the highly fragmented situation in the industrialized countries, which have therefore also severe problems to realize a coordinated policy, developing countries may have the chance, by creating appropriate institutions, to take these various interlinkages into account and to provide the necessary interfaces in the institutional settings.

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Notes

[1] Cf. Farrell and Saloner (1988), Kleinemeyer (1998) and recently Belleflamme (2002) on this general issue.

[2] This section refers basically to the work by Fredebeul-Krein (1997)

[3] Böhm et al. (1998, p. 42ff), suggest, in contrast to current practice, restricting the duration and number of the memberships, as well as appointing representative actors to the committees.

[4] Cf. also Steffensen (1997), and Böhm et al. (1998) on this subject. Lim (2002) describes in an abstract manner pre-standardization in ICT as a negotiation process, whereas Chiesa et al. (2002) highlight the important role of standard development organization in the mediation process between different interests illustrated by two case studies.

[5] Cf. Thum (1994 p. 487ff)

[6] Cf. Helbig and Volkert (1998, p. 5)

[7] The discussion of various co-ordination mechanisms will not be applied to developing countries, since there are very little differences to industrialised countries with the exception that public governmental regulation is stronger in developing countries because private industry has not yet developed a sophisticated system of self-regulation. However, due the spillovers from the standardisation activities performed by the industrialised countries to the body of standards in the developing countries, the weakness of the industry in developing countries regarding their self-regulating activities will be compensated and the need of a more intensive governmental regulation will be diminished.

[8] With increasing income levels, the demand for product variety also expands.

[9] The chapter is relying on information collected within a project funded by DG Research (EC Contract No G6MA-CT-2000-02001) (Blind et al. 2004) and summarised in Blind and Iversen (2004).

[10] See David and Foray (1995).

[11] For a presentation of the issues and their genealogy see Saviotti (1991)

[12] For an evolutionary explanation of such processes see for example Frenken and Nuvolari (2003).

[13] By "industrial infrastructure for innovation", Van de Ven (1993) understands: "institutional arrangements legitimate, regulate and standardise a new technology, public resource endowments of basic scientific knowledge, financing mechanisms and a pool of competent labour, as well as proprietary R&D, manufacturing, marketing, and distribution functions that are required to develop and commercialise an innovation." (Van de Ven 1993).

[14] For a seminal discussion of patents as an appropriation/distribution regime, see Arrow (1962). Note that a basic premise of the incentive aspect is based on assuring the inventor a chance to recoup the cost of his R&D investment. For a recent empirical and theoretical contribution, see Cohen et al. (2000).

[15] See Scotchmer (1991).

[16] On copyrights on software, see Besen and Raskind (1991, pp. 11-14.)

[17] Cf. Common Position concerning the draft of a copyright directive. Official Journal of the EU, no. C 344 of December 1, 2000.

[18] Cf for example Blind et al. (2003).

[19] For a short presentation of the role of IPRs in the innovation process, see e.g. Iversen (2002) on which this section draws.

[20] See cases such as in Stambler v Diebold, Inc (1988), involving the standards related to ATM cards, an early case of conflict in which a patent holder attempted to assert his patent for what manufacturers believed to be an open and available standard.

[21] See Iversen (2000).

[22] See Katz and Shapiro (1985), Farrell and Saloner (1985), David (1987).

[23] For a description of the possible outcomes, see Lea and Shurmer (1995). See Iversen (1999) for the way ETSI IPR Policy addressed such outcomes.

[24] See Miselbach and Nicholson (1994) for a description of essential IPRs.

[25] Witness the current Rambus case. *Rambus v. Infineon and FTC v. Rambus, Inc., FTC (No. 9302).*

[26] The Federal Trade Commission in the US conducted a public hearing on Competition and Intellectual Property Law and Policy in the Knowledge-Based Economy in 2001 and 2002, where the role of IPR in standardisation activities was also explicitly addressed. (http://www.ftc.gov/opp/intellect/index.htm; (3-07-2002)).

[27] Cf. the empirical evidence for Germany Blind (2006).

[28] Some of the suggestions can be found in Rapp and Stiroh (2002).

[29] Cf. Lemley (2002).

Annex

Country	*ISO status*	*Staff directly employed by ISO member*	*Annual budget 2002 (Thousands of Swiss francs)*	*Number of organizations to which standards development work is delegated*	*Govern-ment subsidy in % of total revenue*	*Total number of standards published at 31/12/2002*	*Voluntary standards in % of total number of standards*	*Number of International Standards adopted as national standard 31/12/2002*
Africa								
Algeria	Member	75	602	130	71.5	6177	98	5360
Angola	Correspondent		341		100			
Benin	Subscriber	10	300	120	60	4	50	
Botswana	Member	66	4503		77	181	93	64
Burundi	Subscriber		44		100			
Cameroon	Correspondent	7	90		80	204	95	170
Congo,	Correspondent	141	7375			2	100	
Democratic Rep. of Côte d'Ivoire	Member	23	483		12	560	60	186
Egypt	Member	825	7269		100	4183	91	959
Eritrea	Subscriber	34	495	17		334	0	
Ethiopia	Member	328				389	0	
Ghana	Member	367	2744		73.25	226	0	370
Kenya	Member	657			56.5	3021	35	1243
Lesotho	Subscriber	11	100		100			
Libya	Member	40			90	479	0	
Madagascar	Correspondent		175		53	67	90	
Malawi (1999)	Correspondent	145	2100		52	450	70	155
Mali	Subscriber	45	250		100		75	
Mauritius	Member	71	1600		63	149	92	38
Morocco	Member	25	600	8	100	3707	98.4	1221
Mozambique	Correspondent	15	97		82.4	16	93.7	5
Namibia	Correspondent	6			100			
Niger	Subscriber	7	48953		100			
Nigeria	Member	164	331	10	77	578	96	9
Rwanda	Correspondent		639		100	6	50	6
Senegal								
Seychelles	Correspondent		1500		73	67	88	8
South Africa	Member	1032	45000		26	4966	99	1430
Sudan	Correspondent	720	3500	4		628	0	1100
Swaziland	Correspondent	3			100			
Tanzania	Member	123	1884		39	738	68	328
Tunisia	Member	104	2154			5401	85	4320

Country	*ISO status*	*Staff directly employed by ISO member*	*Annual budget 2002 (Thousands of Swiss francs)*	*Number of organizations to which standards development work is delegated*	*Govern-ment subsidy in % of total revenue*	*Total number of standards published at 31/12/2002*	*Voluntary standards in % of total number of standards*	*Number of International Standards adopted as national standard 31/12/2002*
Uganda	Correspondent	85	1696		75	467	70	121
Zambia	Correspondent		216	1	85	400	97	12
Zimbabwe	Member	72	2565		50	1195	96	195
Asia								
Australia	Member	478	68573	2	2.5	6664	75	1877
Bangladesh	Member	478	2347		10.9	1729	91.73	115
Brunei								
Darussalam	Correspondent				100	25	100	14
Cambodia	Subscriber			25	100	10	80	3
China	Member	60	16580		100	20206	86.2	8931
Taiwan Prov of China								
Fiji	Subscriber	5	54		100	17	65	4
Hong Kong SAR								
China	Correspondent	214	26700		100			
India	Member	1996	23844			17764	99	1070
Indonesia	Member	123	2077	14	100	5868	96.8	1100
Japan	Member	108	26500	588	100	9009	100	
Korea, Dem People's Rep. of	Member	187	100	204	100	11100	0	752
Korea, Rep. of	Member	244	32732		100	15176	100	7054
Macao, China	Correspondent	60	5000		92	10	0	
Malaysia	Member	40	2500	1	100	3702	98	1064
Mongolia	Member		587	102		3776	21	1057
Nepal	Correspondent	104	387		100	654	99	30
New Zealand	Member	48	5800	2		2371	95	911
Pakistan (1999)	Member	152	630	2000		4602	99	1902
Papua New Guinea	Correspondent	13	286		23	1400	86	1400
Philippines	Member	87	679	25	100	1941	95	1167
Singapore	Member	544	28910		82	824	76	273
Sri Lanka	Member	304	1774		20.8	1627	98.3	448
Thailand	Member	485	11997		100	2347	97	272
Viet Nam	Member	964			60	5370	94	1400
Central and Eastern Europe, Baltic States, CIS								
Albania	Correspondent	25	250	70	95	7038	100	3479

Country	*ISO status*	*Staff directly employed by ISO member*	*Annual budget 2002 (Thousands of Swiss francs)*	*Number of organizations to which standards development work is delegated*	*Government subsidy in % of total revenue*	*Total number of standards published at 31/12/2002*	*Voluntary standards in % of total number of standards*	*Number of International Standards adopted as national standard 31/12/2002*
Armenia (1999)	Member	420	1055	20	4	272	70	8
Azerbaijan	Member		1440	8	70	567	10	6
Belarus	Member	46	1000	39	100	20593	50	2319
Bulgaria	Member	1174	300	75	43	17194	100	929
Czech Rep.	Member	176	6790		36	26082	100	5379
Estonia	Correspondent	20	621	22	50.9	10266	100	1978
Georgia								
Hungary	Member	120	6715		26	22283	100	1488
Kazakhstan	Member	28	3867	48	100	400	0	22
Kyrgyzstan	Correspondent	136	296	3	100	515	50	6000
Latvia	Correspondent	29	466	40	70	10739	100	4207
Lithuania	Correspondent	58	1415	745	80	11743	100	708
Moldova, Rep of	Correspondent	185	299		100	574		110
Poland	Member	294	8738	8	75.23	25613	97.57	6843
Romania	Member	86	885			22710	100	5718
Russia	Member	190	9440	28	82	22219	60	560
Slovakia	Member	108	2948	420	57.1	26295	100	2031
Turkmenistan (1999)	Correspondent	22	4010	8	2	600	0	12
Ukraine	Member	132	1242	1	100	23585	75	3010
Uzbekistan (1999)	Member	925			15	2679	0	
Latin America								
Antigua & Barbuda	Subscriber		139		89.68	1	0	
Argentina	Member	170	6261			7710	91	101
Barbados	Member	20	1200		89.8	200	77.5	70
Bolivia	Correspondent	43	1200	11		1300	65	200
Brazil	Member	73	5771		17	9271	100	340
Chile	Member	50	1738		11	2583	60	651
Colombia	Member	170	7200	5	2	5000	100	1370
Costa Rica	Member	16	885		2	344	100	80
Cuba	Member	1068	6		60	4278	94	2353
Dominica	Subscriber	6	250		100			
Dominican Rep. (1999)	Subscriber	60	503		62	523	77	24
Ecuador	Member	87	1399		3.6	2318	75	27

Country	*ISO status*	*Staff directly employed by ISO member*	*Annual budget 2002 (Thousands of Swiss francs)*	*Number of organizations to which standards development work is delegated*	*Government subsidy in % of total revenue*	*Total number of standards published at 31/12/2002*	*Voluntary standards in % of total number of standards*	*Number of International Standards adopted as national standard 31/12/2002*
El Salvador	Correspondent		375	2		904	92	835
Grenada	Subscriber	9	267		65	117	89	21
Guatemala	Correspondent	7	88	5	100	706	9	16
Guyana (1999)	Subscriber	42	28		98	172		94
Honduras	Subscriber					12	80	12
Jamaica	Member	149	8412		20	343	56	45
Mexico	Member	104		7	100	5570	85.5	
Nicaragua	Correspondent		204		100		10	
Panama	Member	8	167		100	522	85	10
Paraguay	Correspondent	173	2532		70	529	99	17
Peru	Correspondent	273	15270		10.8	3800	99	202
Saint Lucia	Correspondent	11	333	25	100	57	63	10
Saint Vincent & the Grenadines								
Trinidad & Tobago	Member	200	4225		39	505	70	255
Uruguay	Member	35	1500			1561	91	254
Venezuela	Member	67	2435	17		3804	90	454
Middle East								
Bahrain	Member	21	977	2	95	1685	75	245
Iran	Member	1322	33551	1	29	6400	93	4800
Iraq	Member							
Israel	Member	730	59700		3	2475	76	906
Jordan	Member	165	6502		100	1607	65	326
Kuwait	Member		2250	5	88	1247	72	62
Lebanon	Correspondent	6	1000	2	100	655	85	86
Oman	Member	70		4	100	1780	93.88	137
Palestine	Subscriber	91	730		100	621	42.7	55
Qatar	Correspondent	123	6112	2	100	1071	79	222
Saudi Arabia	Member	522	27000		88.88	2136	11.17	268
Syrian Arab Rep.	Member	110	300		100	2250	18	
United Arab Emirates	Member	18	3750	10	100	1062	75	
Yemen	Correspondent	134	965		84.84			
North America								
Canada	Member	88	11000	4	56.1	2143	100	1053

Country	*ISO status*	*Staff directly employed by ISO member*	*Annual budget 2002 (Thousands of Swiss francs)*	*Number of organizations to which standards development work is delegated*	*Govern-ment subsidy in % of total revenue*	*Total number of standards published at 31/12/2002*	*Voluntary standards in % of total number of standards*	*Number of International Standards adopted as national standard 31/12/2002*
USA	Member	77	24426	194	3		100	836
Western Europe								
Austria	Member	120	18000	1	11	14106	74	2219
Belgium	Member	42	6570	2	29.4	17170	99	11000
Bosnia & Herzegovina	Member	23	423	194	60	13626	40	2158
Croatia	Member	149	4925		49	6057	100	2699
Cyprus	Member	13	1087	3	85	10000	97	10000
Denmark	Member	176	27235		29	17496	95	
Finland	Member	60	9000	15	28	16532	99	2698
France	Member	630	119500	28		26544	99	9911
Germany	Member	727	140000	15	11	27179	100	8860
Greece	Member	89	7140		36	12384		1897
Iceland	Member	9	1296	1	63	13106	100	4754
Ireland	Member	167			24	272	100	12619
Italy	Member	120	21905	14	24	15561	95	1197
Luxembourg	Member	7	1106	52	100	14197	100	5560
Macedonia, the former Yugoslav	Member		70		100	11657	100	2
Rep. of Malta	Member	25	1000	8	90	12000	100	113
Netherlands	Member	220	32200		1	22053	100	10092
Norway	Member	14	2760	4	33.1	11775	89	2650
Portugal	Member	11	12710	48	19	5241	100	732
Serbia & Montenegro	Member	105	1133		100	13933	39	1533
Slovenia	Member	31	2828		75.4	15055	100	1776
Spain	Member	430	66797		5	19735	80	3611
Sweden	Member	160	31400		10	21800	100	4675
Switzerland	Member	30	8000	5		13950	100	3500
Turkey	Member	1408	76252			26572	100	6550
United Kingdom	Member	5175	500626	38	1.5	22589	100	10145

Source: ISO Members Directory 2003 cited in the WTO Annual Report 2005.

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About the cover illustration:
The graph on the cover, generated by means of fractal geometry model, simulates a pattern formed by three ring vortices playing catch up with one another (also called 'chaotic leapfrogging').

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Telephone: (+43-1) 26026-0, Fax: (+43-1) 26926-69
E-mail: unido@unido.org, Internet: http://www.unido.org