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The Impact of Intellectual Property Rights on the Propensity to Standardise at Standardisation Development Organisations: An Empirical International Cross-Section Analysis

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Abstract

This paper investigates the impact of intellectual property rights on the propensity to standardise at standardisation development organisations. First, different strategies to protect intellectual property and their use in the manufacturing sector in Germany are discussed. Secondly, institutional arrangements concerning the problem of intellectual property rights in standardisation processes are presented. In the following part, theoretical hypotheses concerning the impact of patent protection on sector-specific standardisation are derived. On basis of 20 sectors and seven countries, these hypotheses are empirically tested in a pool model. The results show that R&D intensive sectors standardise very actively. However, intellectual property rights play a more important and ambiguous role, because too much patent protection is hindering standardisation processes. After a summary of the results, recommendations for future standardisation practice are given.

Keywords: Standards, patents, R&D

1 Introduction

In January 1998, manufacturers and network operators, together with the Japanese, agreed on a universal mobile telecommunications system UMTS, which in one to two years should complete the present global system for mobile communication standard GSM of the European Telecommunication Standardisation Institute ETSI. However, the new standard was being contested by the U.S. firm Qualcomm, which claimed the basic patents of the integrated technical specifications for itself and also decisively co-developed the rivalry American CDMA 2000 standard. This topical case is an excellent example of the influence of intellectual property rights on standardisation. Standardisation organisations deal with the problem of integrating protected knowledge in standards by requiring that the enterprises and individuals involved in the standardisation process disclose the patents and copyrights which affect the content of the standard. Should patent protected technologies or protected knowledge become established in a committee standard, most standardisation organisations prerequire the copyright owner to make an advance declaration of willingness to sell licenses at reasonable terms.[1]

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[1] A problematical aspect of this procedure, but not further discussed, is naturally – as the example underlines – that it cannot be guaranteed that the enterprises not involved in the standardisation process disclose their industrial property rights before the standardisation process. They can perhaps wait until the committee standard has been decided on, published and already widely applied in industry. In this case, the competitors and potential customers have already made considerable investments in the standardised technique. If an enterprise, like Qualcomm, discloses that parts of the standard are protected by their intellectual property rights after the investment phase, then the further use of the

The ambivalence of industrial property rights and public available standards for technological development is triggered off by the contradiction between static and dynamic efficiency considerations.[2] For the generation of new knowledge, the inventors are awarded exclusive property rights due to dynamic efficiency aspects. The monopolistic effect provides incentives for the production of new knowledge, by enabling the innovators for a limited period of time to sell the innovative products over the marginal cost level and thus to achieve adequate compensation for the outlaid R&D expenditure.[3] As however the economic benefit of new technologies is based on their wide diffusion and parallel developments are macroeconomically undesirable, the exclusive protection ceases after a certain period and the knowledge is at the disposal of imitating competitors for free in order to respond to static efficiency.

In contrast to the property rights, standards are decisive for the diffusion of new technologies.[4] They make information about new technologies available to everyone, for a small fee, and come near to being a classical public good, which is particularly distinguished by non-rivalry in consumption and application.[5] The economic benefit is optimal, if all economic units have free access to the public good.

To sum up, it must be said that the economically optimal, strong property rights in the phase of knowledge generation should be relaxed at the beginning of the stage of wider use of innovative technologies in order to foster their diffusion. From this it can also be derived that in the standardisation process, property rights must be moderated for the promotion of the diffusion, in order to enable standards containing new technologies to be produced.

The effects of intellectual property rights on diffusion of new ideas has already been addressed by a broad amount of economic literature.[6] However, their specific impacts on standardisation have only been discussed so far by Farrell (1989). Besides a lack of formal modelling in economic theory, deficits are perceptible also in the empirical foundation and validation of theoretical hypotheses. If there is an empirical proof of the role of intellectual property rights on standardisation at all, it is mainly restricted to specific case studies. Empirical studies, which rely on a broad sample of standards, concerning the influence of intellectual property rights on standardisation are not available.

The lack of broad empirical studies on the impact of intellectual property rights on standardisation lies in the data problems. These do not concern important intellectual property rights like patents, but are due to the different kinds of standards. A taxonomy of four different kinds of technical standards exists, depending on how they

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standard is dependent on paying licence fees and the patent holder can appropriate a part of the economic rents connected with competitors' and customers' investments.

[2] See the discussion of Ordover (1991) about possible solutions of this dilemma.

[3] Cf. Scherer (1990), p. 621ff.

[4] Property rights can contribute towards the distribution of new technologies, because for example new technological knowledge is codified in patents and thus represents at least a source of information for competitors and potential users in order to create alternative or improved technical solutions.

[5] In contrast, Antonelli (1994) defines standards as non-pure private goods because they are excludable to some extent, because outsiders of the standardisation process have greater distances to their products and processes.

[6] See the surveys of Besen and Raskin (1991) and Ordover (1991).

are created.[7] First, a firm has property rights or patents on a specific technical specification or a product and is able to promote it as a widely accepted and used industrial standard. Here, identity of intellectual property and standard exists and conflicts arise with other patent holders. In the second case, a group of companies are negotiating in an informal way about the specification of a component of a system or of a whole system, which is necessary for the effective diffusion of their products or services. The agreement about a common specification is also an industrial standard, which can either be protected by property rights by a common patent application and a patent pool or is reproducible for free by everybody. When these companies go to national or international standardisation organisations (SDOs), then all interested groups, also consumers, are allowed to join in the standardisation process. Furthermore, the standardisation process will only be successfully completed when all participants or the majority agree on the set of characteristics for the standard. The obstacles and costs of this process are outweighed by the fact that the standard is regarded as an official document with almost legal status[8], especially because public procurement regulations, liability laws and insurance companies rely on it. Finally, the government itself is setting up technical standards, mostly as minimum quality or safety standards, which are legally binding for the corresponding suppliers of goods and services. This standardisation process is originally driven by the public needs as perceived by government institutions, and not by private firms. However, the latter may benefit from these legal standards because they can improve the consumer acceptance of new products and services with a low transparency of their characteristics.

In our analysis, we will focus on the standard documents generated by the national or international standardisation organisations (SDOs), for the following reasons. First, the industrial standards generated by one or more firms are mostly protected by some sort of property rights and therefore the addressed conflict does not exist. Furthermore, there is no database which contains these standards.[9] Legal regulations in general are also excluded, because they are not generated by private company initiatives, but by government decision processes and cannot be protected by intellectual property rights. Consequently, the empirical analysis of the influence of intellectual property rights on standardisation is concentrated on the standards which underwent the SDO standardisation process.

The scope of this paper is to bridge the gap between the theoretical insights about the impact of intellectual property rights on standardisation and the lack of empirical results of an aggregated international cross-section level. Based on theoretical hypotheses concerning the impact of intellectual property rights on standardisation, this paper examines empirically, for a set of seven countries and 20 sectors, the impact of R&D expenditures and patent protection on the standardisation of processes

[7] Compare the taxonomy of standards by David and Greenstein (1990) or Toth (1997). Another taxonomy categorises standards by their function, e.g. compatibility, variety-reducing and quality or safety standards. This distinction is not essential for the analysis in this paper, although both taxonomies are not totally independent.

[8] Under the so-called New Approach of the European Commission, many directives regulate am issue on a very broad level and refer concerning details to European standards, which give them consequently a legal status.

[9] In Germany, the DIN (Deutsches Institut für Normung) has been offering companies the opportunity to publish their industrial standards as publicly available specifications (PAS) only since 1997. Therefore there is no adequate sample size available yet.

and products at official national standardisation bodies. The paper is structured as follows. First, the different protection strategies concerning innovations are discussed and their use in the German manufacturing industries are presented. After the institutional regulations concerning the role of intellectual property rights in the standardisation processes in section 3, theoretical hypotheses are derived (section 4), and some remarks on the data are made (section 5). The results of the regression analyses are presented in section 6. A summary and general recommendations for the standardisation policy of SDOs are presented in section 7.

2 The Most Important Property Rights and the Intensity of their Utilisation in the German Manufacturing Sector

A number of legal possibilities can be deployed to protect the results of companies' in-house R&D processes. In the following, the most important legal bases in this study for the protection of intellectual property, as well as the legal possibilities to protect industrial secrets – such as patent law, utility or petty patent law or copyright law – will be shortly characterised, [10] before the intensity of their use in Germany is gone into.

2.1 Patent Law

Recourse can be taken to patent law when an invention results from new knowledge. An invention must have the following characteristics, according to § 1 para. 1 of the German Patent Law (PatG), in order to achieve patentability:

- The invention must be new.
- The invention must be based on an inventive activity.
- The invention must be suitable for industrial/commercial application.

The here obviously central concept invention is however not specified more closely in the law. The Federal Supreme Court has defined the patent law requirements of an invention as follows: an invention is "lesson for systematic action using controllable natural forces – outside the reach of human understanding – for the direct cause of a causally assessable success."
The recourse to natural forces thus limits the applicability of patent law directly to technical innovations.

The granting of a patent is handled differently in different states. Whereas in some countries the date of the invention is all-important, in other states the date of patent application is the basis.[11] All the various forms of patent law have one thing in common, that this right is awarded for a limited period of time. In some states the patent will be renewed only on payment of an increased fee, in order to remove worthless inventions for the inventor from the patent pool, or to internalise the increasing costs of a too small diffusion.

[10] Cf. Kleinemeyer (1998), p. 193ff.
[11] See Kaufer (1989), p. 11.

2.2 Utility Patents

The utility patent law is, like patent law, geared to technical innovations and is often characterised as "little patent" or "petty patent". It is much quicker to achieve protection by means of an industrial or utility patent, but this lasts for a maximum of ten years (three years initial duration, with a maximum extension possible of a further three years - once – and two years – twice (§ 23 Utility Patent Law)). The fundamental difference to patent law is that the registration of the utility patent is made without further examination. It is a considerably faster form of protection.

2.3 Copyright Law

Copyright law concentrates on the protection of the expression of creative performances, the so-called *works*, which exist in words, images or sound. The creator of a work is awarded the copyright protection for the period of 70 years after his death. By the "Second Law to Amend the Copyright Law" of 9 June 1993, the call for a form of protection for computer programmes, as raised in the European Directive 91/250, was included in German law. From this date computer programmes can be protected under § 69 of the Copyright Law.[12]

The Copyright Law tries to differentiate between the "expression" and the "idea". Thus in principle the expression of an idea can be protected, but not the idea itself. This procedure is unproblematic, as long as an idea can be expressed by more than one possibility. This is certainly the case for a great number of creations – especially in those areas which were the original target of the Law of Copyright, such as literature and music. In copyright a further distinction can be made between personal and non-personal rights. The former apply for example to the right of acknowledging authorship or the right of invariation of the work. The latter deals with the commercial utilisation of the works; they are therefore called the exploitation rights. Whereas there is no possibility, for example, to sell the right of authorship, every creator is entitled to sell the exploitation rights to his work.

2.4 Industrial Secrets and the Law against Unfair Competition

Besides patent and copyright law which directly protect innovation, there is the further possibility to classify information about the standard as industrial or company secrets in the sense of §§ 17 and 18 of the Law against Unfair Competition (UWG), and thus render it inaccessible to the general public. In § 20 of the UWG, not only the divulging of company secrets but also the incitement to divulge secrets is a punishable offence. Company secrets are understood not only to be information that has been exclusively generated in the company, but which are in principle also generally available, but whose determination and collection is linked with costs.

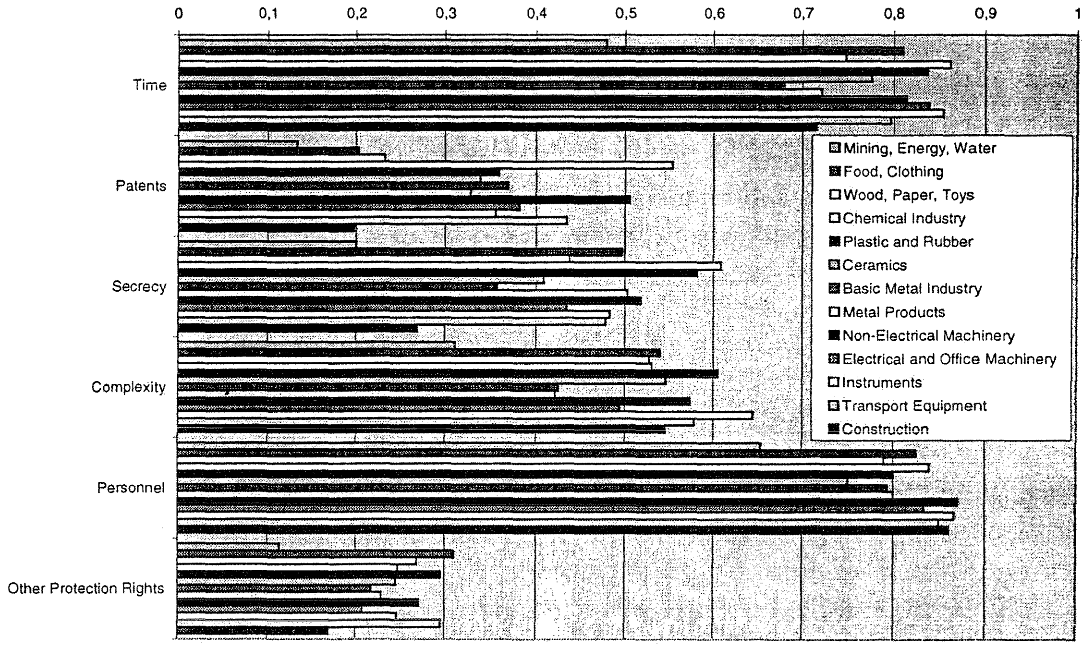
Besides these legal instruments to protect product or process innovations, other strategies exist. First of all, it is possible to try to score a time advantage over your competitors in the marketing of the products or in the using of innovative processes. Secondly, the complexity of products and process may also be a strategy to hinder competitors from imitating own innovations. Finally, because important information

[12] Currently, the European Commission and the responsible national ministries and bodies are discussing the possibility to award patents for computer programmes. In the United States, this option has been allowed in the 80ies and it is meanwhile also reality in several patent offices in Europe.

concerning innovative ideas is tacit knowledge of the employees, companies attempt to make long-term contracts with their innovative labour force.

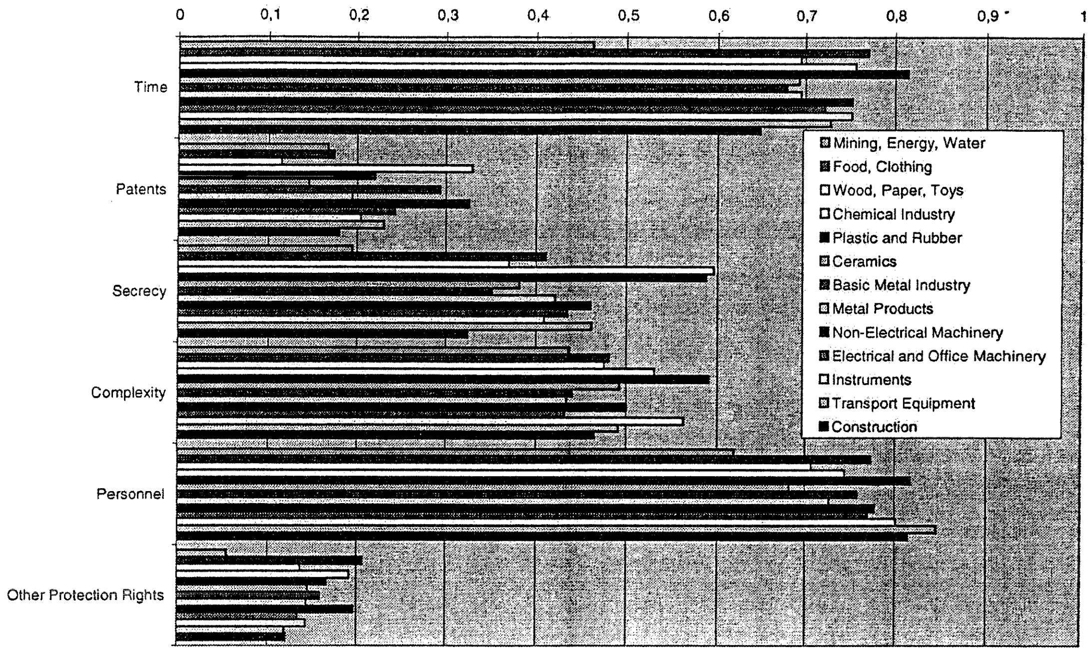
The following figures show the intensity of the use of these different legal and informal strategies in thirteen German industries. In general, the time advantage and the long-term involvement of the staff are the most favoured strategies, both for product and for process innovations.[13] The secrecy and the complexity of products and processes follow. Patents and other protection rights are less important. However, they have – as expected - a higher importance for product innovations than for processes. Between the sectors, they are widely used in the chemical industry and in the non-electrical machinery branch. In the less innovative sectors, like mining, construction and food, the use of patents to protect innovations is under-represented.

Figure 1: The share of companies which use different protection strategies for product innovations in 13 industries [14]



[13] Cf. Harhoff (1997), p. 348ff. Levin et al. (1987) find similar results for the United States.
[14] Source: Mannheimer Innovation Survey 1993, own calculations. The scale reaches from 0 (= 0%) until 1.0 (= 100%) and represents the share of companies for which the respective strategy is import or very important in 5-point Likert-scale.

Figure 2: The share of companies which use different protection strategies for product innovations in 13 industries



Despite the fact that other protection strategies are more important, the focus of the further analysis will be on patenting, because the other strategies have no legal impact on standardisation processes.

3 The Role of Intellectual Property Rights in the Institutional Framework of National and International Standardisation Bodies

In principle, the application of patented solutions is possible in the development of standards in standardisation development organisations. However, procedures which are practically identical in all standardisation organisations must be utilised, in order to guarantee that fair conditions apply for both sides, that is, the owner of the patent and the user of the standard.[15] The question arises, how can the protection of an invention by a granted patent be made to agree with the standardisation process which is acknowledged as beneficial for all.[16]

The following remarks roughly reflect the Directives Part 2, 1. edition 1989, Annex A edited by the international standardisation organisation ISO and the international electromechanical commission IEC. The same applies more or less for all European and national standardisation projects.

If, in exceptional cases, technical reasons justify the utilisation of a patented solution in the elaboration of an international standard, there is no objection in principle to this

[15] Valid standards are also valuable aids in defining the "state of the art" in technology and can serve to judge the technical progress represented by an invention. Cf. on this topic and the following Thiard and Pfau (1989) pp. 16ff.

[16] In addition, it is important to know what the significance of technical standards could be for the inventor in other ways. However, the implications of standards for innovations are not discussed here.

step, even if the circumstances are such that no alternative possibility of agreement exists. In such a case, the following procedures have to be followed.

a.) The ISO and IEC cannot give definitive or detailed information about proof, validity and extent of a patent or similar property rights. It is, however, desirable that all obtainable information is disclosed. For this reason, the originator of a standardisation proposal of this kind should draw the attention of the standardisation committee to all known patents or similar property rights, whereby the situation world-wide and known applications for patents must be included. The ISO and IEC, however, are not in a position to guarantee the correctness of such information.
b.) If the suggestion is accepted on technical grounds, the originator should demand a declaration from each known patent holder, that he is willing to grant a license for patents or similar property rights for users in the whole world at reasonable terms and conditions. A copy of this declaration of the patent holder will be filed in the archives of the ISO Central Secretariat or the IEC Central Office. This declaration will be referred to in the relevant international standard. If the patent holder does not submit such a declaration, then the standardisation committee will not continue with the incorporation of the patented solution in the draft standard, unless the competent advisory council agrees.

c.) Should it become known after the publication of the international standard that licences for a patent or similar property rights will not be granted at reasonable terms, then the international standard will be withdrawn by the standardisation committee for revision.

The Commission of the European Communities' view of the licensing option was stated earlier in 1992: compulsory licensing would be likely to reduce investment in R&D in affected sectors; non-EC firms would keep their technologies away from the EC market, and low cost equipment manufacturers outside the EC would benefit from cheap licences to use indigenously developed technology (CEC 1992, p. 5.1.15). However, ETSI's policy requires holders of such rights to disclose them within 180 days after the standard is put into an ETSI work programme.[17] If the holder chooses not to license, and no other technical design is found, then a dispute settlement mechanism is provided.

The tension between this procedure and the Commission's desire not to restrict a property right holder's freedom except in exceptional circumstances is evident. Only after a "relevant market" has been legally specified and the intellectual property right claimant has been found to have prevented the production and marketing of a new product for which there is potential consumer demand, and to have withheld a licence in order to secure a monopoly in a derivative market, can a finding be made in favour of a challenging party. Mazzoleni and Nelson (1998) therefore question the economic benefit of strong patent protection in systems technologies where development relies mainly on their efficient and fast diffusion by means of standards.

Not only is the likelihood of a finding in favour of a challenger low because of the difficulties inherent in specifying a relevant market and in demonstrating the presence

[17] Cf. Prins and Schiessl (1993).

or absence of potential consumer demand for innovative technologies, the time required to process such disputes can result in de facto monopoly for the right holder during the period in which a technical design remains of high priority in the technical design and pre-standardisation process. The linkage between long-run competition strategies and the technical specification of designs as candidates for standards agreement are clearly visible, although no in-depth research on the implications has been carried out as yet (Mansell 1995, p. 221ff).

4 Theoretical Hypothesis concerning the Impact of Intellectual Property Rights on the Intensity to Standardise at Official Standards Development Organisations

The standardisation process can be regarded as the extension of the competitive product development process.[18] After the decision concerning the R&D budget [19] is taken, the firm has to decide, in a second step, about the protection of its product innovation at all and if so by going through the formal patenting process or by using others of the above presented strategies. Finally, the firm has to decide its involvement concerning standardisation processes. It may either propose product and process innovations for a new standardisation process or to transfer in its knowledge into ongoing standardisation processes.

The expected benefits of a standardised product are advantages in its diffusion and therefore a higher anticipated demand. On the supply side, the participation in the standardisation process may reduce the distance and therefore the switching costs between the specifications of the standard and the technical features of the firms products and processes.[20] Additionally, outsiders of the standardisation process face higher adaptation costs and probably a competitive disadvantage.[21]

The costs include the actual financial cost of a standardisation process, including the opportunity costs of a delayed marketing of the product.[22] Finally, the company has to publish their R&D results, which makes private knowledge public know-ledge, first available to the participants of the standardisation process, later to all buyers of the documents. The knowledge spill-overs will be high when there is no protection of the R&D results at all. However, due to the outlined institutional framework, the patent protection cannot prevent other companies using the know-how of the technology, but it may at least control the knowledge spill-overs, because the interested companies have to buy a licence of the patent. It has to be mentioned that the standards published by standard development institutions contain mostly technical specifications of components or of intermediate goods and only hardly details of final products. Therefore, patents on the latter are rarely in conflict with standardisation processes. Furthermore, owners of final product patents have little incentives to initiate standardisation processes due to infinitesimal additional sales enhancing effects in comparison to the greater threats of an easier product imitation.

[18] Cf. Weiss (1993), p. 36ff and Thiard and Pfau (1991).
[19] See Harhoff (1997), p. 349.
[20] Cf. Antonelli (1994), p. 207.
[21] See Salop and Scheffman (1983), p.267.
[22] See Farrell and Saloner (1985) and Katz and Shapiro (1985).

Based on these considerations, the following sector-specific hypotheses concerning innovation and standardisation are postulated. Because standardisation is a part of the R&D process, the higher the R&D intensity of a sector, the higher the annual standardisation output will be. Therefore, both the input indicator R&D expenditure and the output indicator patent applications should positively explain the annual output of standards. However, because of the spill-over problem of the standardisation process, the sectoral propensity to standardise should be explained better by the number of patent applications compared to the R&D expenditure. Furthermore, the higher the ratio of patents to R&D expenditure, the more of the R&D results are protected by property rights and the higher the incentives to participate in standardisation processes. However, due to the intellectual property rights problem, the standardisation process can be prolonged or can even fail because patent holders are not willing to licence their intellectual property rights.[23] Therefore, sectors with a very high number of patents tend to standardise more slowly because of the negotiations concerning the licensing questions and in the case of unwilling patent holders not at all. Consequently, the total output of standards will be lower.[24] These effects are expected to be stronger for international standard processes because they are likely to be affected by a higher number of potential patent holders. However, the subgroup of idiosyncratic standards should be explained better by the proposed variables compared to the stock of international standards integrated into the national standardisation systems, because of the looser link between national R&D and international standardisation and the obligation to take over European standards.

Especially, this last relationship may be disturbed by other more relevant factors which will be discussed briefly. These other explaining factors for standardisation may also improve the significance of the empirical model. Therefore, the following variables will also be considered. Standards play an important part in the international sourcing and distribution of goods. Therefore, both the import and the export ratio of the sector are explicitly recognised. Furthermore, the capital intensity and the employment intensity of the sectors are included. The first variable is indicating the use of capital intensive process technologies goods which may need adequate standards. The second indicator assumes that in labour intensive sectors standards for protecting the labour force are needed. Finally, the concentration index and the average company size are accomplished supposing that in sectors with only a few large companies the standardisation process may be easier. However, sectors with many small companies may have a higher need for standards.

5 The Data

The theoretical hypotheses on possible explanatory factors for sectoral standards output will be empirically tested on the basis of the following 20 industrial branches in table 1, for which the data has been compiled and matched from various secondary statistics.

[23] Compare Farrell (1989), pp. 43ff.

[24] The other informal protection strategies are disregarded, because they are not suitable to prevent standardisation. However, the insufficient participation in standardisation processes because of using the secrecy strategy can lead to smaller numbers of standardisation processes and eventually to a lower standard output.

Table 1: List of 20 Industry Sectors with ISIC-code

3100	FOOD, DRINK & TOBACCO
3200	TEXTILES, FOOTWEAR & LEATHER
3300	WOOD, CORK & FURNITURE
3400	PAPER & PRINTING
351+352-3522	INDUSTRIAL CHEMICALS
353+354	PETROLEUM REFINING
355+356	RUBBER & PLASTICS PRODUCTS
3600	STONE, CLAY & GLASS
3700	BASIC METAL INDUSTRIES
3810	FABRICATED METAL PRODUCTS
382-3825	NON-ELECTRICAL MACHINERY
3825	OFFICE MACHINERY & COMPUTERS
383-3832	ELECTRICAL MACHINERY
3832	ELECTRONIC EQUIPMENT & COMPONENTS
3841	SHIPBUILDING
3843	MOTOR VEHICLES
3845	AEROSPACE
3842+3844+3849	OTHER TRANSPORT EQUIPMENT
3850	INSTRUMENTS
3900	OTHER MANUFACTURING

In order to measure the extent of standardisation, the stock[25] of standardisation documents in the year 1995 will be referred to, because in the standards databank PERINORM a database is available for the selected countries[26] which very well reflects the output of the standardisation process regarding both the content and time perspective.[27] The database does not only include documents of the main national standardisation institute like DIN in Germany, BSI in the United Kingdom, or AFNOR in France, but also of the other national standardisation institutes. The standards data also contain those European and international standards, which have been adopted in the domestic market. However, on the basis of the database information alone, it is not possible to identify in which country the initiative for an international or European standard originated, so this fact cannot be used as additional information. Nevertheless, the total stock of standards can be divided in two sub-groups of idiosyncratic standards and standards which have a reference to an international or European standard.

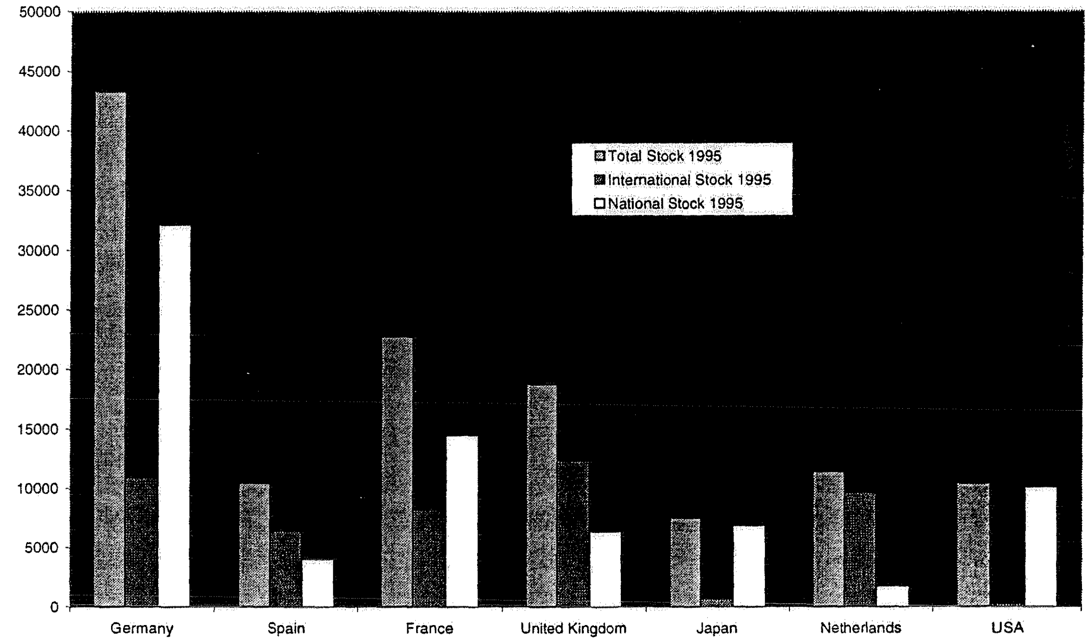
Figure 1 underlines the differences in the amounts and the internationalisation of standards. As an example, Germany possesses a large stock of standard which is dominated by national standards. On the other hand, the United Kingdom owns only the half of the total German stock, but more international standards.

[25] The stock of standards is equal to the totality of previous annual standard outputs corrected by the number of withdrawn documents.

[26] The data for Japan are taken from the database of Japanes Industrial Standards edited by the Japanes Industrial Standards Committee.

[27] There is no adequate qualitative and quantitative information available on the input in the standardisation processes.

Figure 1: Stocks of Standards in the Selected Countries



The explanatory factors were compiled from the following data sources. On the basis of these 20 industrial branches, the R&D expenditure (in million US dollar) of the enterprises in 1994 were taken from the ANBERD database, published by the OECD. The output indicator patents is depicted by the sum of patent applications by the inventors of the seven countries at the European Patent Office in the years from 1993 until 1995. The other data concerning the export and import intensities, the labour input and the capital formation compared to total production stem from the OECD STAN Database 1997. Because there are no data available about the concentration indices and the average company sizes in the industries of all seven countries, it is assumed that the data available for Germany is representative for the situation in all other six countries.

6 Empirical Results

In order to broaden the statistical basis to test the theoretical hypotheses, the following general pooling model over the seven countries and the 20 industries is used and tested first by the OLS approach applying cross section weights[28] and secondly by the seemingly unrelated regression method SUR, which is more efficient, if the disturbances of the country equations are correlated, because it takes account of the entire matrix of correlations of all the equations:

$$\log ST_{ic} = f\left(a_{0c}, \log Pat_{ic}, RDI_{ic}, Ex_{ic}, \mathrm{Im}_{ic}, Ca_{ic}, Em_{ic}, Co_{ic}, Siz_{ic}, e_{ic}\right)$$

It is assumed that the proposed hypotheses are equally valid in the seven countries selected, in order to obtain up to 140 observations.

[28] In order to avoid heteroscedasticity the weights are estimated in a preliminary regression with equal weights and then applied in weighted least square in then second round.

The variables are defined as follows:
ST_{ic} = stock of standard (either total T, or national N or adopted international I) in country c in industry i;
a_{0c} = fixed effect of country c;
Pat_{ic} = patent application of industry i in country c;
RDI_{ic} = expenditure of enterprises for R&D divided by value added in industry i in country c;
Ex_{ic} = export ratio (exports divided by total production) in industry i in country c;
Im_{ic} = import ratio (import divided by total production) in industry i in country c;
Ca_{ic} = capital intensity (gross capital formation divided by value added) in industry i in country c;
Em_{ic} = employment intensity (number of employees divided by value added) in industry i in country c;
Co_i = Gini coefficient of Germany in industry i[29];
Siz_i = average turnover of the enterprises in Germany in industry i;
e_{ic} = error term iid $N(0, \sigma_e)$.
The results of the different pool estimations are presented in table 2.

Table 2: Explanatory Factors for the Different Stocks of Standards

Method	WLS	WLS	WLS	SUR	SUR	SUR
Dependent Variable	STT_{ic}	STN_{ic}	STI_{ic}	STT_{ic}	STN_{ic}	STI_{ic}
Patents	0,376*** [4,363]	0,220*** [4,092]	0,088** [2,164]	0,355*** [5,021]	0,234*** [4,490]	0,076** [2,352]
(Patents)^2	-3,59E-05*** [-3,467]	-1,56E-05** [-2,411]	-1,19E-05** [-2,431]	-3,09E-05*** [-3,489]	-1,66E-05** [-2,608]	-8,98E-06** [-2,301]
R&D intensity	-898,710 [-1,525]	-1286,866*** [-3,609]	419,509 [1,358]	-1124,183*** [-2,627]	-1492,401*** [-4,763]	550,197** [2,200]
Export rate	27,717 [0,218]	50,448 [0,854]	-17,728 [-0,193]	93,824 [1,303]	85,333** [2,063]	91,229 [1,945]
Import rate	-1,492 [-0,017]	-13,228 [-0,300]	26,117 [0,454]	-9,875 [-0,181]	-6,509 [-0,206]	-48,966 [-1,536]
Capital intensity	353,924 [0,764]	199,805 [0,740]	148,026 [0,626]	185,991 [0,542]	16,817 [0,077]	-8,925 [-0,044]
Employment intensity	-958966,8 [-0,199]	1593545 [0,656]	-3590944 [-1,238]	-742069,6 [-0,216]	1810714 [0,868]	-23777864 [-1,395]
Enterprise concentration	30464,67*** [3,263]	12335,75** [2,417]	9390,285* [1,799]	28193,24*** [4,103]	17860,63*** [3,677]	5244,292 [1,141]
(Enterprise concentration)^2	-19914,78*** [-3,347]	-8373,510** [-2,567]	-5981,693* [-1,802]	-18581,45*** [-4,264]	-11980,03*** [-3,890]	-3419,250 [-1,166]
Enterprise size	2,708*** [4,212]	2,165*** [6,187]	0,066 [0,182]	2,695*** [5,795]	2,426*** [7,180]	0,209 [0,645]
(Enterprise size)^2	-0,001*** [-4,570]	-0,001*** [-6,411]	-7,13E-05 [-0,459]	-0,001*** [-6,147]	-0,001*** [-7,410]	-0,0001 [-0,779]
R^2(adj)	0,52	0,49	0,37	0,50	0,59	0,30
F	16,56***	14,83***	9,60***			

(t-values in brackets; *** level of significance < 0,01; ** level of significance < 0,05; * level of significance < 0,10)

The hypothesis of the standards as part of the R&D process can be affirmed by the empirical results of the pool model. Especially, the patent applications are very

[29] Because of lack of internationale data concerning concentration indices and average enterprise size, the German variables are used and assumed to be representative for the industries of the other countries.

significant in explaining the standard variable. In order to show the negative impact of too many patents for the standardisation process, we add additionally the squared number of patents in the estimated equation. The empirical results underline the theoretical hypothesis that patent protection makes it easier for companies to propose a new standardisation project or to participate in an already ongoing standardisation process. Additionally, too many patents increase the probability that one part of the technical standard is injuring the patent rights of a company which may be not willing to licence the patent for a reasonable amount. Then the standardisation process will fail. Sectors with an high R&D intensity generally tend to standardise less because of the uncontrollable spill-over effects on other participants and competitors. However, the international stock of standards is higher in sectors with a high R&D intensity as the SUR approach makes evident.

The export rate has the expected positive coefficient, however this is only in the SUR model explaining the national stock of standard significant. As already derived from the theoretical hypotheses, the import rate has an ambiguous effect on explaining the production and therefore the stock of standards. The same is true for the capital and the employment intensities. The enterprise concentration is positively explaining the stock of standards, whereas the square of it has a negative impact in concordance with the theoretical considerations. The average enterprise size matters, because in the approaches explaining both the total and the national stock of standards the coefficient is significantly positive, whereas the coefficient of the square of the enterprise size is significantly negative.

Concerning the quality of the estimations, the stock of international standards can be less well explained compared to the national stock of standards by the different variables. Here, the institutional factors like the obligation to adopt European standards into the national stock of standards represent influences which are not captured in the regression equation by the industry specific characteristics.

7 Summary and Policy Recommendations

The paper focused on the role of intellectual property rights and R&D as variables for explaining standardisation activities. The econometric analysis confirmed this and showed that the stock of standards in seven countries can be explained primarily by the branch-specific patent applications and the R&D expenditure. More patent-intensive branches tend towards a higher number of standards, whereas R&D-intensive sectors with low patenting tendencies are, in principle, more reserved towards standardisation. In addition, the export rate was merely a significantly positive explanatory factor, which underlines the importance of standards for the export-intensive branches. Furthermore, the enterprise concentration of the industries fosters the development of standards up to a certain threshold. Above it, the concentration is so high, that the companies are more likely to choose the alternative way of informal industry consortia to elaborate industry standards.

Derived from these results some recommendations for the standardisation policy of national standardisation organisations can be formulated. First, the growing importance and speed of R&D and innovations for the national competitiveness in the age of globalisation should be taken into account in the standardisation strategies by setting priorities on innovative areas and by adjusting the existing stock of standards to keep up with the state of the art of science and technology. In order to keep abreast of the higher speed of technical change, the standardisation process needs to be closer to the R&D process. In this context, with the development accompanying standardisation and prestandards, a first step is made in the right direction. However, these developments are still questioning the role of intellectual property rights especially in standard-intensive system technologies. First of all, patented innovations are in general a driving force for standardisation. However, too much intellectual property rights protection reduces the set of possible technical specifications which can be integrated in a standard, if the patent holder is not willing to licence the rights to interested companies. This means also that often a standard cannot be based on the optimal technical solution. Because it is not useful for the incentives to innovate in general to consider limitations of the patent protection, the concerned companies or the whole sector, or even the government in case of benefits for the whole society, should acquire the necessary licences. First of all, market solutions should be preferred. In the above mentioned Qualcomm case, the European mobile phone company Ericsson and Qualcomm have reached a consensus by giving away licences to each other for their patents. Furthermore, Ericsson will buy besides others the R&D department of Qualcomm. Another strategy is the way Intel goes by asking regularly the companies taking licenses to its open specifications to agree to offer royalty-free licenses to other participants for any patents that would block the specified technology.[30]

Other initiatives favour the obligated licensing, especially in the case of interface technologies (Beck 1995) with no fees at all or at least a reasonable amount in fees. However, this regulative procedure is violating the incentives for inventors and is therefore economically not efficient. In network industries, where old versions of software or hardware are substituted by up-dates, Kleinemeyer (1998, p. 209ff) suggests that the patent protection for the old version should expire when the newest version is introduced into the market, because competitors could use the old versions in order to develop superior compatible solutions. Since in network industries the installed base can create a monopoly for the supplier with the intellectual property right for the relevant technology.

By contrast with the problems caused by too much patents protection, solutions for companies should be developed which do not have the protection of intellectual property rights for the R&D results, to give them incentives to release their knowledge for the standardisation process. In these cases, the innovative companies should receive a compensation for their knowledge inputs in order to give them incentives to release their innovations. However, effective and efficient ideas and strategies which tackle this problem are challenges for future research.

Because of the low propensity to standardise in sectors with a small market concentration on the one hand and the higher demand for compatibility in these sectors, strategies should be elaborated which improve the access to standardisation in general for the small and mediumsized enterprises of these sectors and facilitate the standardisation process. Furthermore, although the de facto standardisation cannot be prevented, at least incentives should be provided to make the details of the technical specifications public in order to reduce information asymmetries and wasted R&D

[30] Compare Shapiro and Varian (1999), p. 25.

invested in incompatible solutions by other companies which are not members of the consortium. A first approach is the new opportunity to publish so-called public available specifications (PAS).

Finally, export-intensive sectors and companies should be supported to start European or international standardisation projects, in order to transform or integrate their R&D results into technical standards and to provide them with at least temporary cost and quality advantages compared to their competitors abroad without being non-tariff trade barriers.

However, these general recommendations have to be implemented by specific measures. In order to reach effective and efficient solutions, in-depth analyses for the different sectors are needed, which represent a challenge for further research activities.

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